MAC–HGLP 1.6.5
Revision 0

Hanford Geophysical Logging Project

Logging System Operating Procedures

May 2001

U.S. Department of Energy

Work Performed Under DOE Contract Number DE–AC13–96GJ87335 for the U.S. Department of Energy

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Prepared for
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

Prepared by
MACTEC-ERS
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Grand Junction, Colorado

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1.0 Introduction

In 1994, the U.S. Department of Energy (DOE) Richland Operations Office (DOE-RL) requested the DOE Grand Junction Office (DOE-GJO), Grand Junction, Colorado, to perform a baseline characterization of gamma-emitting radionuclides in the vadose zone beneath and around the single-shell tanks (SSTs) at the Hanford Site. To collect these measurements, Greenspan, Inc., of Houston, Texas, built three passive spectral gamma-ray logging system (SGLS) vehicles capable of acquiring spectral data from cased boreholes up to 600 feet (ft) deep employing high purity germanium (HPGe) detectors. Once the Hanford Tank Farms vadose zone baseline characterization was completed in fiscal year (FY) 2000, DOE-GJO was tasked by DOE-RL to perform a baseline characterization of gamma-emitting radionuclides in the vadose zone beneath and around the liquid waste disposal sites and burial grounds in the 200 Area Plateau at the Hanford Site.

1.1 Purpose

This logging procedure provides guidelines and instructions for conducting passive gamma-ray and active neutron logging activities employing these tools on the Hanford Site. These procedures include descriptions of all vehicle components, their operation as a system, and data acquisition using HPGe and neutron moisture detectors.

1.2 Objective

This logging procedure ensures that quality data are collected by using approved procedures. These procedures include knowledge from lessons learned since acquiring the first SGLS spectra in FY 1995.

2.0 Logging System Fact Sheet

Truck Designation:	**GAMMA 1 (γ1)**	**GAMMA 2 (γ2)**
License Numbers:	E-37579 U.S. Govt.	E-37577 U.S. Govt.
V.I.N.:	1FDXK84E6RVA08340	1FDXF84E8RVA08338
Hanford Identification No.:	HO-68B-3574	HO-68B-3572
Vehicles:	1994 Ford F800, 6-cylinder turbo diesel, 6-speed manual transmission with a high-low range transfer case gearbox.	
Dimensions:	8 ft 4 in. wide, 24 ft 6 in. long, 11 ft 6 in. high (12 ft 2 in. high with rear lights up)	

Gross Vehicle Weight Rating (GVWR):	27,500 lbs
Gross Axle Weight Rating Front (GAWR FRT)	10,000 lbs
Gross Axle Weight Rating Rear (GAWR RR)	17,500 lbs
Gross Actual Load (12-19-97)	22,360 lbs
Gross Load Front, est.	7,850 lbs
Gross Load Rear, est.	14,510 lbs

Winch:	Greenspan, Inc.	
Drum size	24.0-in. flange diameter, 24.8-in. barrel length, 14.3-in. barrel diameter	
Cable speed, min/max	1 in. per minute to 30 feet per minute	
Cable	0.875-in.-diameter, 14-conductor, flexible steel tubing, Kevlar reinforced, polyurethane jacket.	
Cable length	600 ft	
Cable breaking strength	5,000 lbs force	
Cable weight in air	34.8 lb/100 ft	
Crane:	Ferrari S.p.a.	
Model	535 A-2	
Serial Nos.	18572 (γ1)	18573 (γ2)
Weight rating, maximum	3,197 lbs (1,450 kg)	
Outreach	21 ft (6.3 m)	
Hydra-Gen®	Harrison Equipment Co., Inc.	
Model	HPU 15.0 MPC-160D	
Power Output	15 kVa	
Phase	Single phase, 120/240 Volts	
Frequency	60 Hertz, 62.5 Amps	
Detectors:		
Type	EG&G Ortec, 35% p-Type HPGe Coaxial Photon Detector	
Serial Nos.	34-TP20893A (γ1)	34-TP11019B (γ2)
	34-TP21095A (γ1B)	34-TP21095A (γ2B)
Weight	47 lbs (empty, no LN_2 in dewar)	
Length	58.9 in.	

Outside diameter	3.375 in.
Type	EG&G Ortec, planar n-Type HPGe Coaxial Photon Detector
Serial No.	39-A314 (γ1C)
Type	CPN International Inc., Soil Moisture Gauge
Model	503
Serial No.	H380932510

<u>Tungsten Shield:</u>

Weight	35.25 lbs
Outside diameter	4.08 in.
Length and Thickness	16.0 in. long and 0.30 in. thick
Composition	90% Tungsten (W), 6% Nickel (Ni), 4% Copper (Cu)

<u>KUTh Field Verifier</u>:	AEA Technology QSA, Inc.	
Serial No.	118 (γ1)	082 (γ2)
Part No.	188701	
Source Strength	2.453 μCi (1.662 μCi ^{40}K, 0.46 μCi ^{238}U, and 0.331 μCi ^{232}Th)	
Composition	11.7% potassium, 80 ppm ^{238}U, and 180 ppm ^{232}Th	
Weight	64 lbs	

<u>^{137}Cs Calibration Check-Source</u>:

Serial No.	1013
Source Strength	200 μCi
Composition	Cesium-137
Weight, est.	80 lbs

<u>Neutron Calibration Standard</u>: CPN International, Inc.

Serial No.	H380932510
Source Strength	50 mCi
Composition	Americium/Beryllium
Weight, est	20 lbs

<u>Portable Fire Extinguishers</u>:

Instrument Cabin	One, 15 lbs, Type BC, dry chemical
Driver's Cabin	One, 2.5 lbs, Type ABC, dry chemical

3.0 Logging System Equipment Description

3.1 Logging System Vehicles

The SGLS vehicles, designated Gamma 1 and Gamma 2, are mounted on 1994 Ford F-800 truck chassis powered by FD-1460 diesel motors and are equipped with 6-speed manual transmissions, air brakes, and Marmon-Herrington all-wheel-drive (Figure 1). The spectral gamma-ray logging system is comprised of specialized electronic equipment housed in a separate instrument cabin that includes a personal computer and logging program capable of controlling all aspects of the logging process. To support the logging system the vehicles are also equipped with a hydraulic generator, hoist, crane, and liquid-nitrogen storage and dispensing system. For logging, spectroscopic amplifiers and multi-channel buffers are employed to process and record electronic pulses collected from various detectors. Enough logging cable is carried on each vehicle to log boreholes up to 600 ft deep.

3.2 Marmon-Herrington All-Wheel-Drive

In June of 1993, the truck chassis were modified from two-wheel to all-wheel-drive using kits manufactured by the Marmon-Herrington Co. of Louisville, Kentucky. A new front drive axle, transfer case, drivelines, shocks, and support assemblies were added to complete the conversion.

Air switches, located in the drivers cabin, are used to select the various power train combinations for driving and operating the SGLS (Figure 2). All-wheel-drive is selected using the 2-position switch labeled “Front Axle.” A 3-position shifter for the transfer case labeled “Trans Case” allows the driver to move the system between high, neutral, and low ranges. The power-take-off (PTO) gearbox is engaged using the 2-position switch labeled “PTO.” Included with each switch are red pilot lights that illuminate when a switch is in the ON position. The combinations of these switches and how they affect the operation of the SGLS are presented in the table below.

Air-Switch Name	Normal Driving	All-Wheel-Driving	Data Acquisition
	Air-Switch Position		
Transfer Case	High	High or Low	Neutral
Front Axle	Off	On	Off
PTO	Off	Off	On

In addition, when the PTO is engaged, a red LED located on the Operations Console (Section 4.2) in the Instrument Cabin (Section 4.0) illuminates.

Owners’ and operation manuals are on file at the MACTEC-ERS office for additional detail of the vehicle’s equipment.

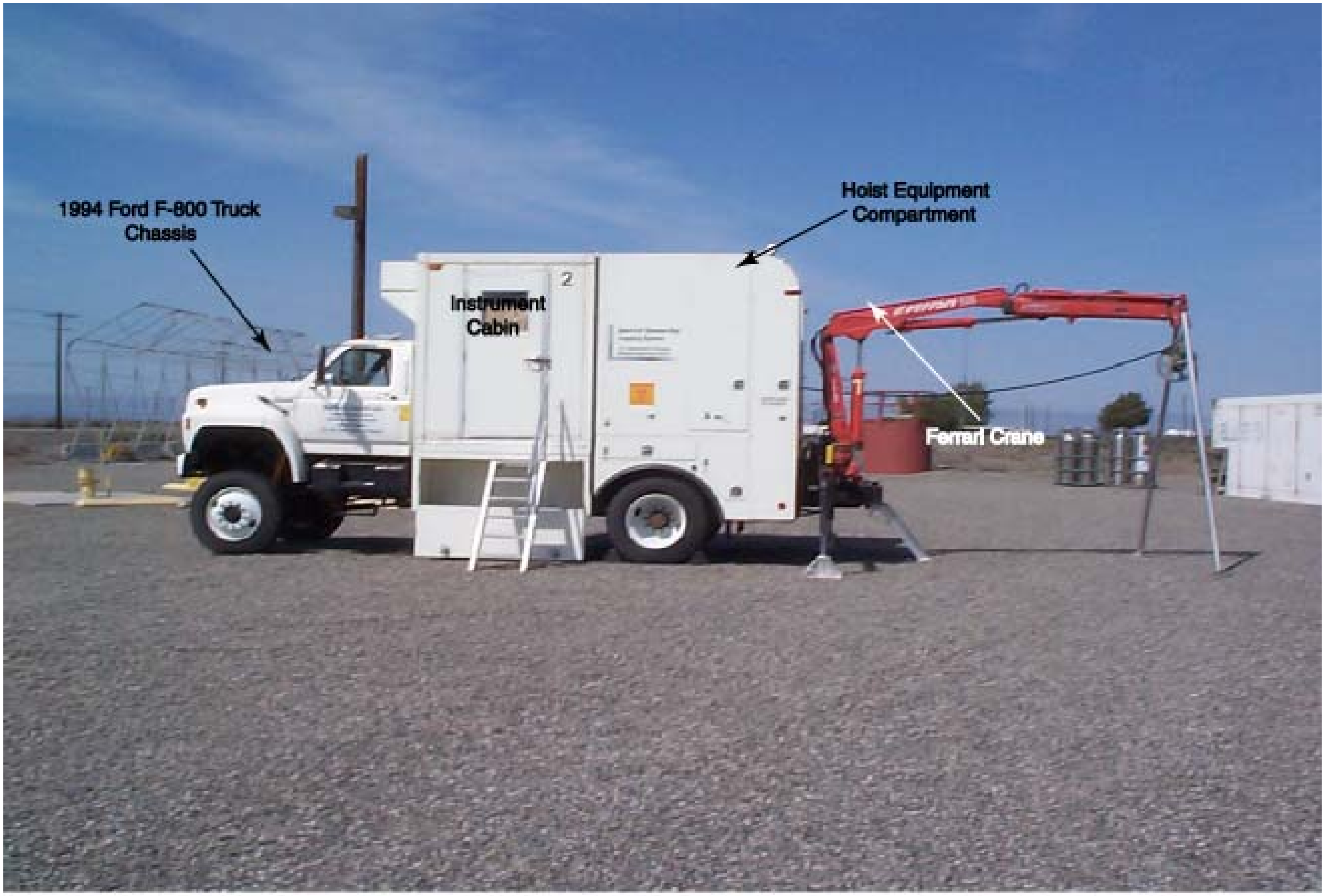

Figure 1. Logging System Vehicle

Figure 2. Air Switches and Vehicle Gauges

3.3 Hydraulic Systems

Hydraulic pressure is used to drive a generator, hoist, and crane, which support the logging operations and data acquisition process. Engaging the PTO initiates the hydraulic system. Mechanical power from the PTO drives a model 762 gearbox manufactured by Hub City. Attached to the gearbox are two hydraulic pumps. By design, the hydraulic pumps develop their optimal flow when the engine speed is operating between 1,100 and 1,400 revolutions per minute (RPM) or the "operating RPM." One pump is dedicated to the generator while the other pump supplies hydraulic pressure to both the hoist and crane. At operating RPM, the pumps generate the hydraulic force that provides mechanical power to the generator, hoist, and crane.

These systems are comprised of several components including pumps, motors, gearboxes, clutches, brakes, and fluid reservoirs. Hydraulic system maintenance is specified in the *Preventive Maintenance Procedure for the Spectral Gamma Logging System* (DOE 1997) and the *Hydraulic Maintenance Manual* (Greenspan).

A hydraulic pressure transducer, manufactured by Data Instruments, is affixed to the hoist and crane pump that relays the hydraulic pressure to a digital display located on the Operations Console (Section 4.2) and to the logging computer through the Sensor Panel (Section 4.3.8).

3.3.1 Harrison Equipment Co. Hydra-Gen® Generator System

Gamma 1 and Gamma 2 are each equipped with a 15-kilowatt (kW) hydraulic generator, or Hydra-Gen® manufactured by the Harrison Equipment Co. (Figure 3). This is the main generating source of alternating current (AC) for electrical systems operating on the vehicles.

Mechanical power is derived from a dedicated PTO-driven hydraulic pump, manufactured by Volvo, which supplies hydraulic pressure to a motor that rotates the generator. When the PTO is engaged and the engine speed is increased to operating RPM, the Hydra-Gen® produces 120-volt AC current at a frequency of 60 cycles (Hz). Two analog meters display the AC voltage and frequency from inside the instrument cabin.

The Hydra-Gen® is mounted under the vehicle on the outside of the frame in a vented compartment and is secured by a locking door. Included inside the compartment are the main circuit breaker box and the main power receptacle (Figure 3). These two devices are used to isolate the generator from the Power Distribution Panel (Section 4.1) and for connecting shore power directly to the vehicle. A special power cable and receptacle are needed if shore power is required. Shore power is not used during logging activities.

The Hydra-Gen® is equipped with a small fluid reservoir filled with synthetic automatic transmission fluid (ATF) to lubricate the generator's moving parts. A thermometer and see-through liquid-level gauge are used to view the status of this reservoir. To cool the ATF, the Hydra-Gen® is equipped with a cooling fan and radiator assembly that are automatically actuated by thermostat control (Figure 3). A large reservoir, filled with synthetic AFT, is located under the back of the vehicle and supplies the pumps with hydraulic fluid for operation. These fluid levels need monitoring. The Hydra-Gen® is subject to the following constraints:

Figure 3. Harrison Hydra-Gen Generator System

- The Hydra-Gen® will not operate if the PTO is not engaged.

- If the PTO is engaged but the engine speed is below operating RPM, the Hydra-Gen® will not produce sufficient power output to support the 120-volt AC systems.

- Shore power can be connected to the SGLS to operate the AC systems. Turn OFF the vehicle and the Power Distribution Panel circuit breakers. Turn OFF the main circuit breaker. Disconnect the power cable from the Hydra-Gen® at the main power receptacle and replace it with the special shore power cable. Turn ON the main circuit breaker.

Owners' manuals on file at the MACTEC-ERS office describe the Hydra-Gen® in more detail.

3.3.2 Hoist

Gamma 1 and Gamma 2 are each equipped with a custom-built two-speed hydraulic hoist (Figure 4) manufactured by Greenspan, Inc., of Houston, Texas. The hoist stores the logging cable on a spool assembly, conveys the logging sonde in and out of boreholes, and controls the rate of sonde movement. Stringent engineering design criteria were required for hoist speed. These requirements were that the rate of sonde movement achieves accurate and repeatable speeds between 1 inch per minute (in./min) and 30 feet per minute (ft/min).

Hydraulic power for the hoist is derived from a PTO-driven, variable-speed, Sundstrand series 90 pump and Sundstrand series 51 motor, which rotates a model 763 gearbox manufactured by Hub City (Figure 4). To achieve design speed, gear ratios are adjusted using two gear reducing gearboxes manufactured by SEW Eurodrive. Depending upon the desired hoist speed, each gear reducer can rotate a separate hydraulic clutch. When engaged, a clutch's power is supplied to a second model 763 gearbox, which is attached by a heavy-duty chain to the spool assembly. Hoist speed is controlled by solenoids that adjust fluid volume inside the variable-speed series 90 pump.

Failsafe braking (hydraulic pressure to release) is actuated when insufficient hydraulic pressure is present to release springs inside a brake unit manufactured by Asuco (Figure 4). The hydraulic brake is affixed to the gearbox driving the spool assembly. The brake can be actuated manually from the instrument cabin, automatically by a photoelectric sensor, or by computer control.

The photoelectric sensor, manufactured by Omron, is located between the hoist frame and drum (Figure 4). This is a safety device that alerts the logging program when a cable overwrap condition occurs. During logging operations, if the logging cable breaks the plane of the sensor the logging program automatically applies the hoist brake and interrupts logging. Before logging can resume, the cable wrap has to be checked, corrected if necessary, and the hoist brake reset.

Trained personnel can manually operate the hoist and hoist brake from the Operations Console in the Instrument Cabin. The hoist and hoist brake are subject to the following constraints:

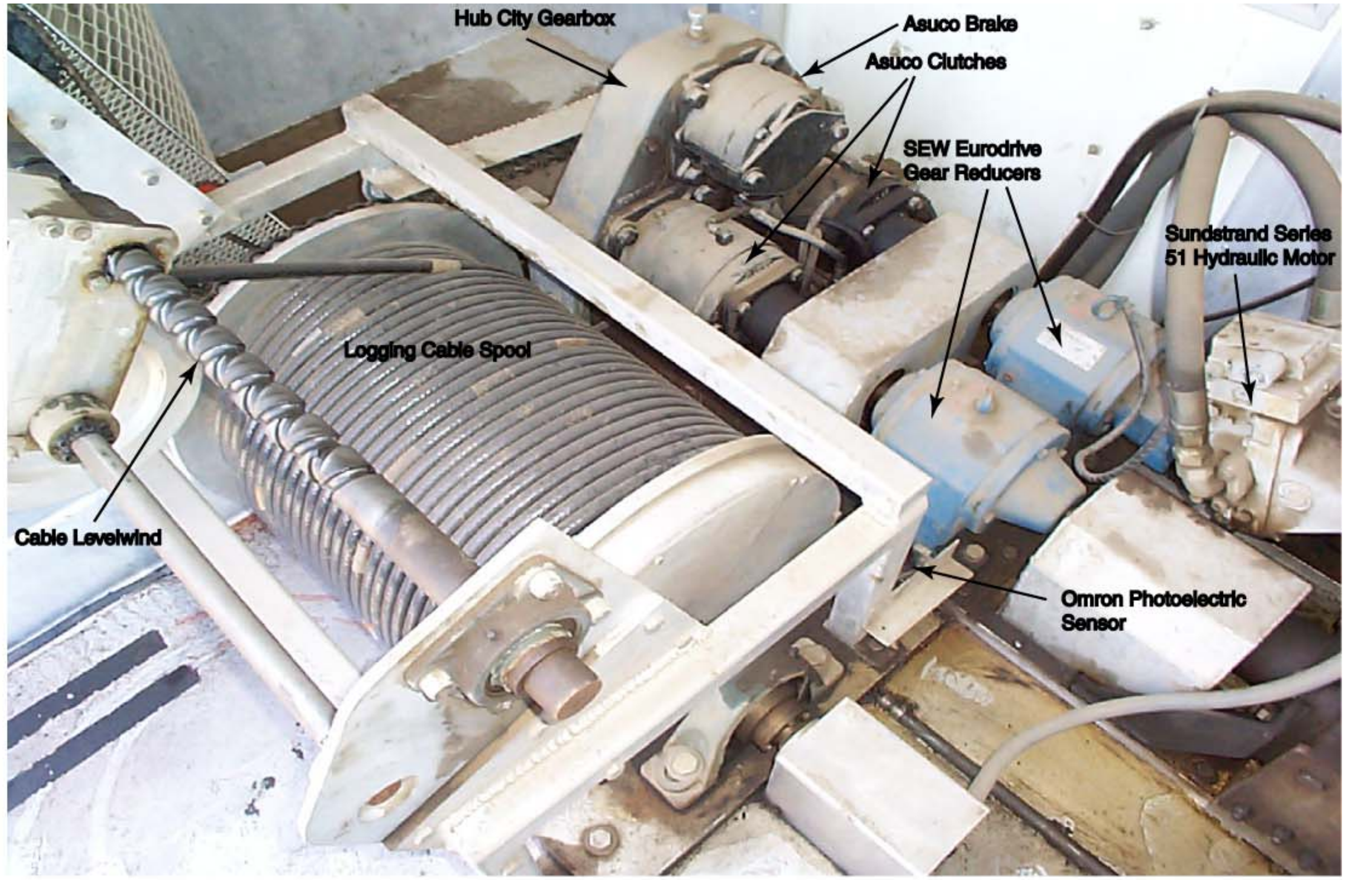

Figure 4. Hydraulic Hoist System Components

- The hoist will not operate if the PTO is not engaged or if the motor is OFF.

- The hoist will not operate if the PTO is engaged but the “Sensor” and “Console” DC circuit breakers are OFF.

- If the PTO is engaged and the logging computer is ON but the engine speed is below operating RPM, the hoist will operate very slowly.

- The hoist brake can be applied at any time during logging operations. To release the brake and resume logging, the hoist brake must be cycled twice as follows, ON-OFF-ON-OFF.

- **NOTE:** The hoist brake should always be ON when not logging to prevent the sonde from spooling into the sheave wheel.

Technical specifications for the hoist components are on file at the MACTEC-ERS office.

3.3.3 Ferrari Crane

Each vehicle is equipped with an articulated 3-piece crane with two extensions manufactured by Ferrari S.p.a., Italy (Figure 1). Fully extended, the crane’s hydraulic outreach is almost 21 ft (6.3 meters). When logging, the crane is used to align and support the sheave wheel, logging cable, and sonde over the borehole (Figure 5). For mobility, the crane is stowed in a folded position. Ground stabilizers (outriggers) are deployed to level the crane while two poles supply support for the end of the crane during logging operation.

Hydraulic power for the crane is derived from the PTO-driven Sundstrand series 90, variable-speed pump. This pump also provides the hydraulic pressure to the hoist. A lever at the base of the crane column selects the crane’s two control modes (Figure 6).

- Manual Mode: Switch the lever toward the crane (right hand). This is the normal position for the crane’s control mode.

- Remote Pendant: Switch the lever away from the crane (left hand). The remote pendant control is currently disabled.

The crane is controlled in manual mode by five levers located on the side Distributor Panel (Figure 6). Each lever performs a specific function to rotate, extend, and contract the rams and extensions. Color-coded handles, symbols, and arrows indicate the movement and direction each lever controls.

The crane is subject to the following constraints:

- The crane will not function if the crane is extended and the PTO is not engaged.

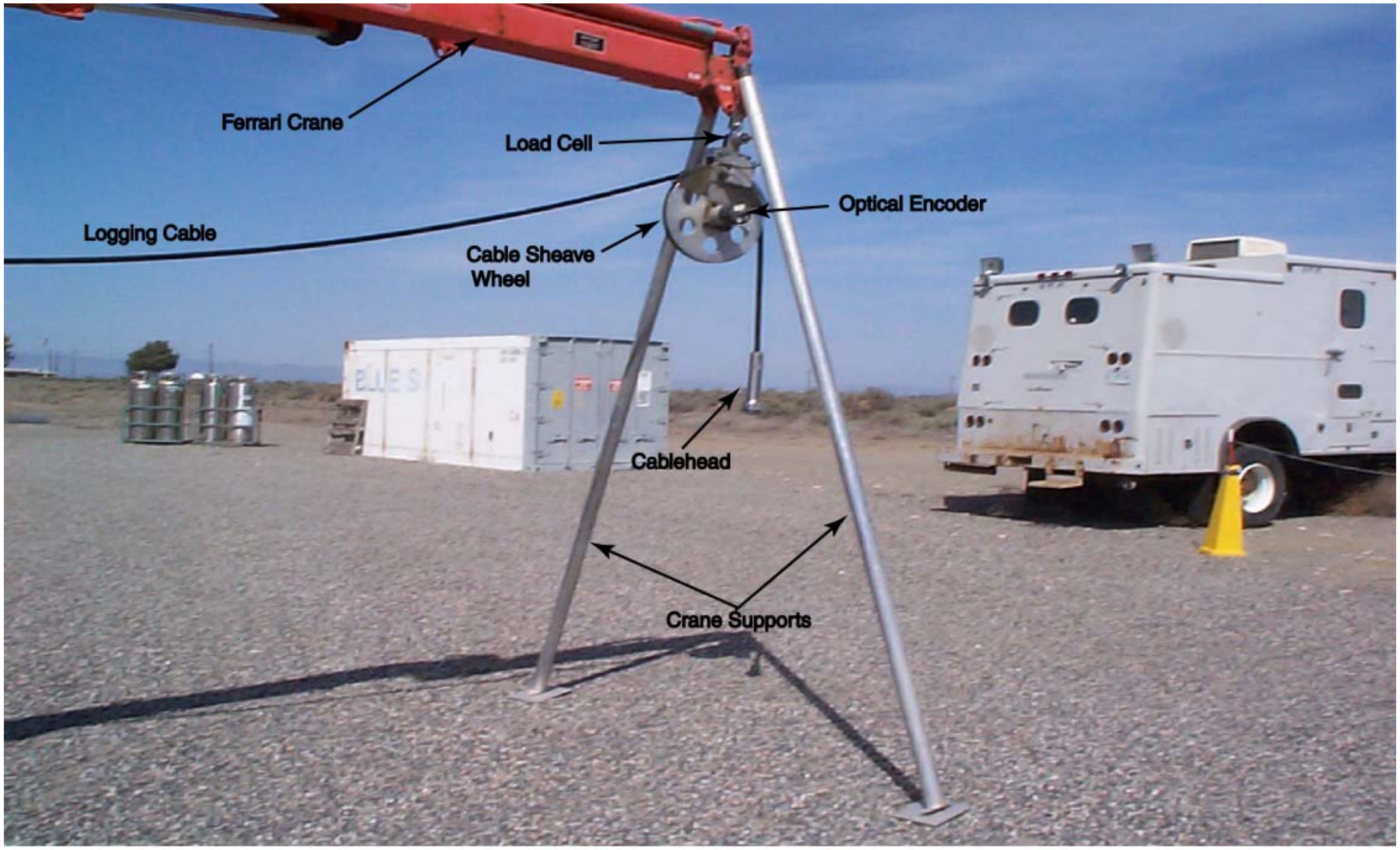

Figure 5. Sheave Wheel, Logging Cable, and Crane Supports

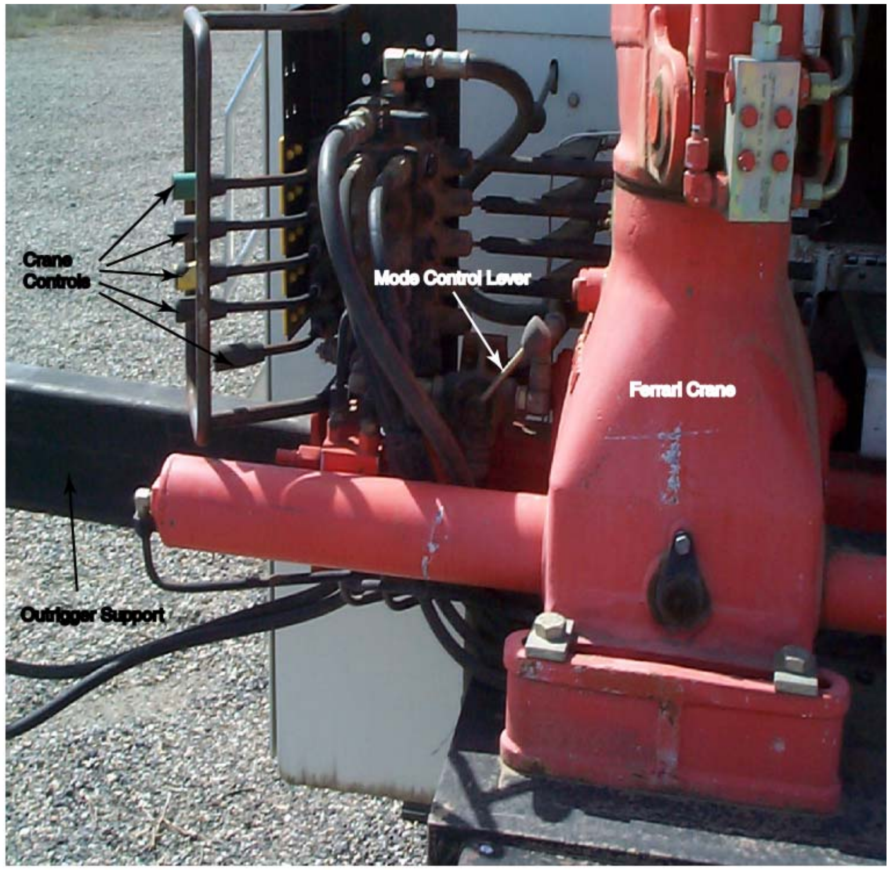

Figure 6. Ferrari Crane Controls

- If the crane is extended and the PTO is engaged but the engine speed is below operating RPM, the crane will move very slowly.

- If the motor is OFF and the crane is extended, the hydraulic fluid in the supply lines will slowly bleed back into the fluid reservoir but the crane will not suddenly fall.

Operators' and parts manuals for the Ferrari crane are on file at the MACTEC-ERS office.

3.4 Liquid Nitrogen Storage and Dispensing System

Caution: LIQUID NITROGEN (LN_2) can cause severe frostbite (boiling point -320 °F) and asphyxiation by displacing air. A Material Safety Data Sheet describing hazards associated with LN_2 is found in Appendix G. A Shipping Document is required to be carried and made available by the driver whenever LN_2 is stored or shipped on the logging vehicles. This document is carried in a clear view plastic folder in the driver's cabin.

Gamma 1 and Gamma 2 are each equipped with a LN_2 storage vessel or dewar that is located inside the hoist compartment and permanently affixed to the compartment's structural frame (Figure 7). These are standard size commercial dewars capable of holding approximately 180 lbs. of cryogenic fluid at low pressures. The LN_2 stored in these dewars vents continuously through a 22 lb. per square inch (PSI) pressure relief valve. Dewars are equipped with various gauges, valves, and connections to safely transfer and dispense LN_2, including the following components:

- Liquid-level gauge
- Pressure gauge
- 22-PSI pressure relief valve
- Vent ball valve - connector combination
- Liquid ball valve - connector combination

The LN_2 dispensing system or auto-fill is comprised of a timer, solenoid valve, liquid valve, sonde connector, copper tubing, and a cryogenic hose (Figure 7). The auto-fill is used to fill the dewars carried on the high-purity germanium (HPGe) detectors with LN_2 in the field. During logging activities, the LN_2 is vented to the atmosphere through the logging cable and the exhaust flow is monitored in the Instrument Cabin (Section 4.0).

A hydraulically controlled tray is located on the outside of the hoist compartment near the dewar where two logging tools or sondes can be carried and stored in a vertical position (Figure 8). The tray is accessible through a secured door from outside the vehicle. The tray is raised and lowered by using a lever located by the crane.

A multifunctional timer, located inside the hoist compartment, is used to activate the auto-fill system and set the cycle interval (time between fills). Connect the cryogenic hose to the sonde (hose/sonde connector), open the liquid ball valve, and activate the timer. This opens the solenoid valve and copper tubing carries the low pressure LN_2 to the sonde. As the sonde fills, exhaust gas is vented through an electrical sensor located on the hose/sonde connector. The

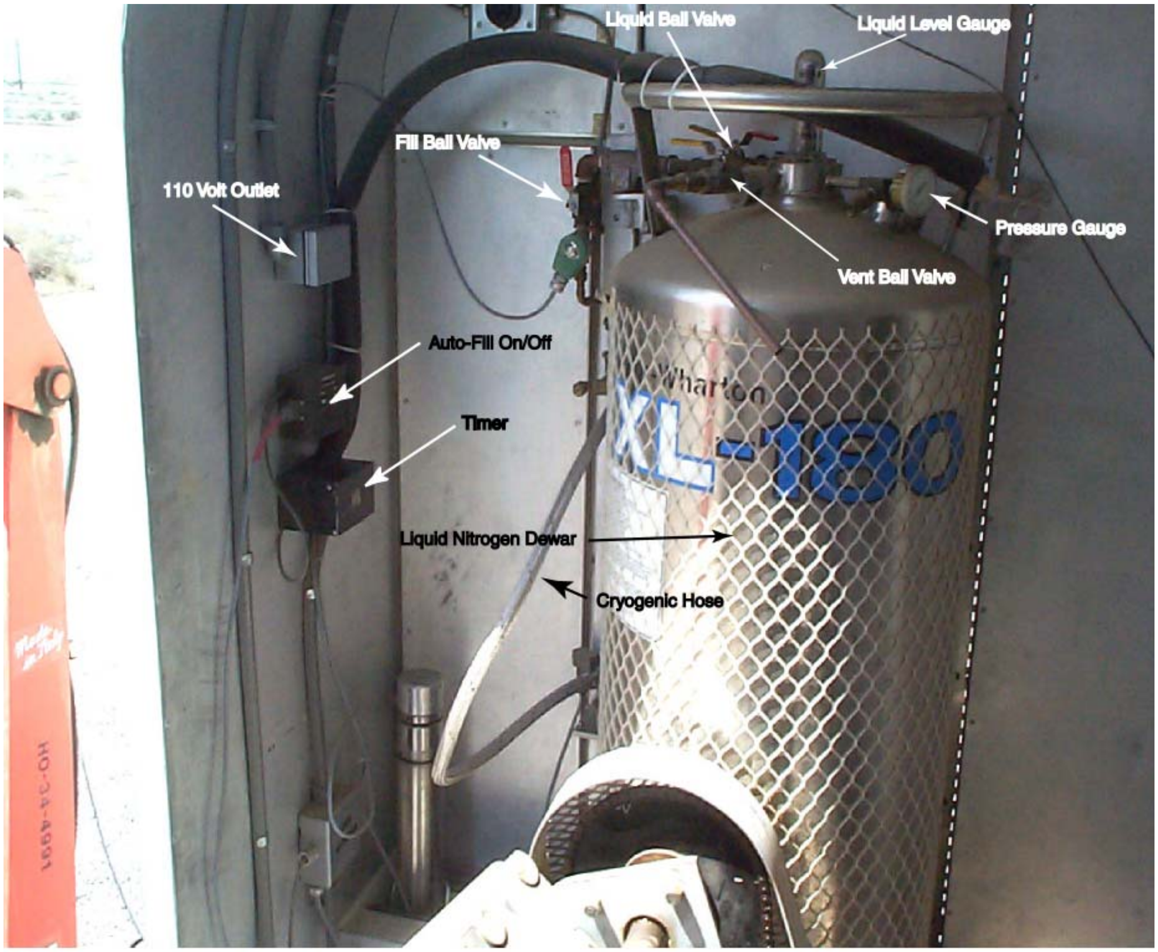

Figure 7. Liquid Nitrogen Storage and Distribution System

Figure 8. Sonde Trays and Liquid Nitrogen Dewar Access

auto-fill turns itself OFF when the sensor detects LN_2. The timer will continue to activate and cycle the auto-fill until it is switched OFF. A dewar normally has to be cycled every 8 hours to keep the HPGe detector cold; it takes from 12 to 20 minutes to fill an HPGe dewar.
Dewars carried on the vehicles have to be refilled from supply dewars. To transfer LN_2, follow the *Transferring Liquid Nitrogen to Truck Mounted Dewar* procedure found in Appendix G.

4.0 Instrument Cabin

The Instrument Cabin is the control center for conducting logging operations (Figure 1). From the instrument cabin, trained personnel perform all aspects of the data collection process including set up, operation, and monitoring. The following components inside the Instrument Cabin are used to control the logging process (Figure 9).

- Power Distribution Panel
- Operations Console
- Instrument Equipment Rack
- Support Equipment

As-built schematics for these components are described in the *Bill of Material* (Greenspan).

4.1 Power Distribution Panel

Sixteen circuit breakers control the power distribution for the various AC and DC electrical systems operating on Gamma 1 and Gamma 2. These circuit breakers are located on the "Power Distribution Panel" affixed to the wall inside the instrument cabin (Figure 10). Each breaker is labeled to identify which circuit it controls along with an amperage rating to identify the size of the breaker. AC and DC circuits are separated into two columns: AC circuits are on the left and DC circuits are on the right. The circuits are as follows:

AC Circuits
- Computer
- Wall-1
- Air Conditioner
- Wall-2
- Internal Lights
- Back Lights
- Drum Lights
- Vacuum

DC Circuits
- Sensor
- Console
- Telephone
- HEPA Filter
- Heater Fan
- Step Lights
- Drum Light
- Dome Light

A voltage and frequency meter, located at the top of the Power Distribution Panel, shows the power output of the Hydra-Gen®.

The logging system has a specific "Power Up, Power Down Sequence" that is outlined in Appendix C. The order in which the circuit breakers are turned ON and OFF can affect supporting systems and can damage electrical circuitry if done out of sequence.

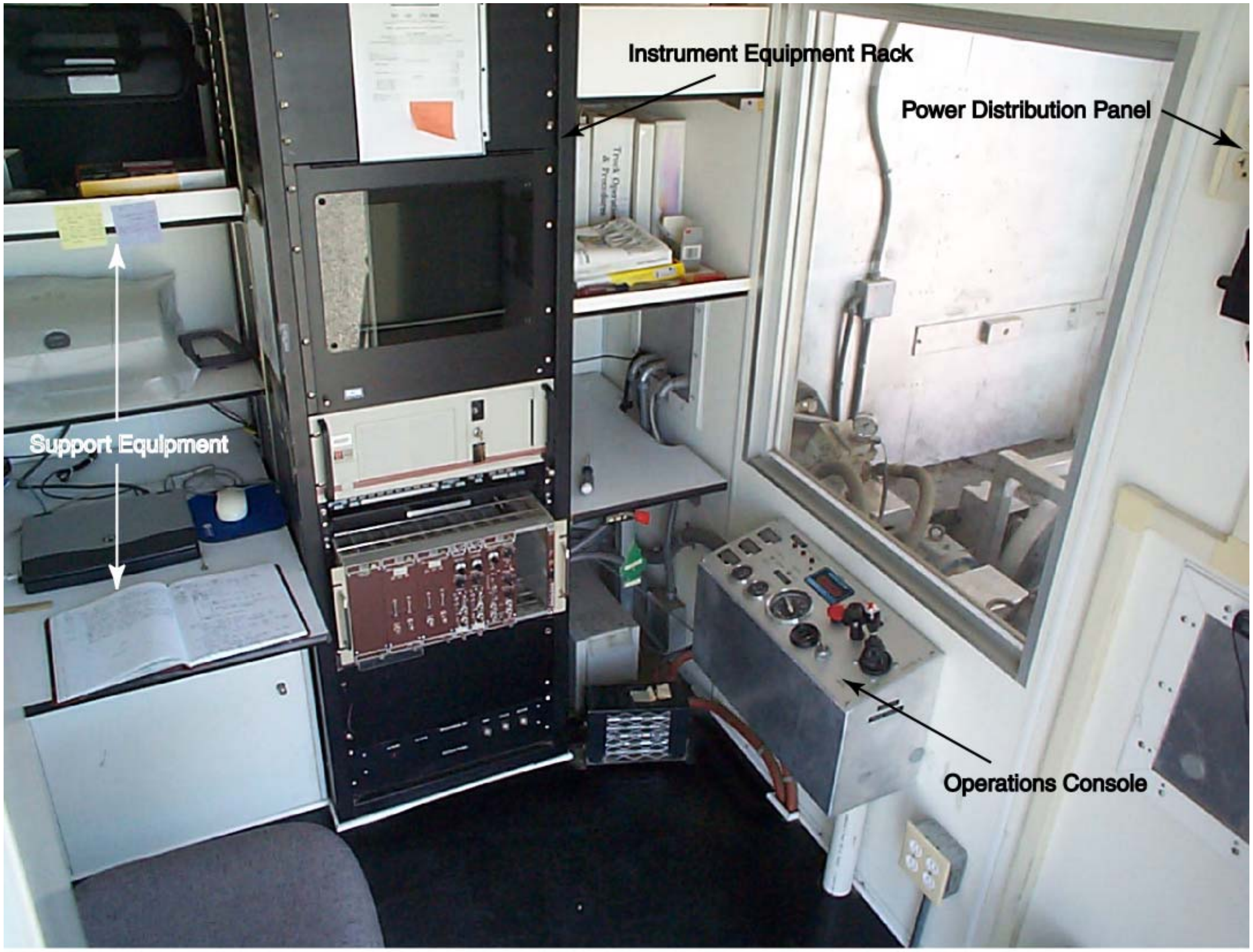

Figure 9. Instrument Cab

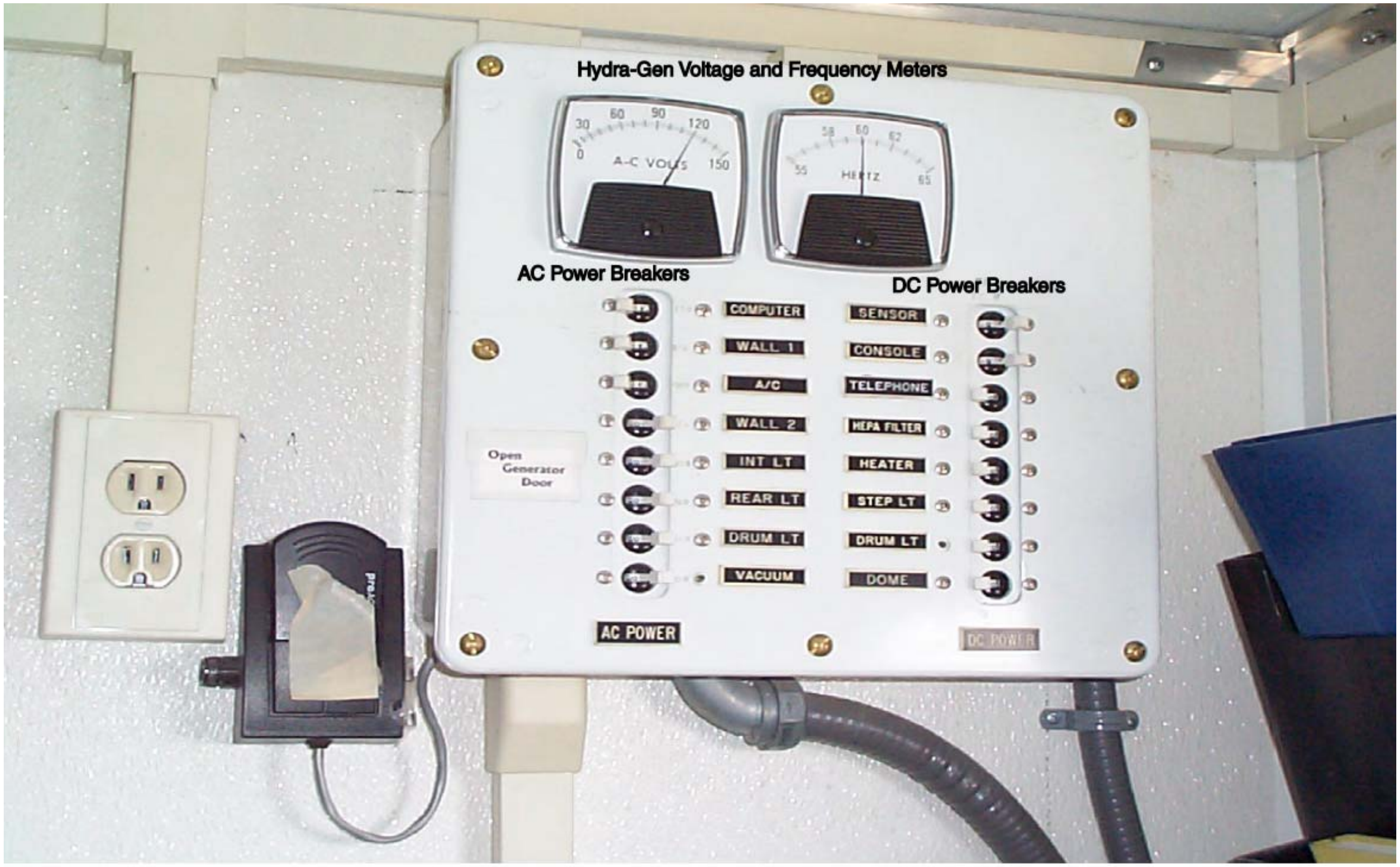

Figure 10. Power Distribution Panel

4.2 Operations Console

The Operations Console (OC) represents the control interface where trained personnel control and monitor the various operations affecting the vehicle and hoist (Figure 11).

DC power is supplied to the OC by the circuit breaker labeled "Console" on the Power Distribution Panel. When the Console circuit breaker is ON, two red LEDs illuminate, which are located on the OC and Sensor Panel (Section 4.3.8) labeled "Console" and "DC Power," respectively.

The following components are found on the OC, which are grouped together under headings indicating their main function.

Power

- Red LED labeled *Console*

Remote Engine Operation and Monitoring

- Diesel Fuel Level Gauge
- Engine Coolant Temperature Gauge
- Engine Oil Pressure Gauge
- Remote Ignition Key
- Tachometer Gauge
- Engine Throttle Knob
- *Manual/Automatic* Shutdown Toggle Switch
- Red *Computer* LED
- Red *PTO* LED

Hoist Operation and Monitoring

- Hoist Control Handle
- Hoist Brake Button
- Red Hoist *Brake* LED
- *Crane/Computer* Hoist Toggle Switch
- Red *Crane* LED
- Hydraulic Fluid Pressure Digital Display
- Weight Digital Display
- Depth Digital Display
- Liquid Nitrogen Flow Meter

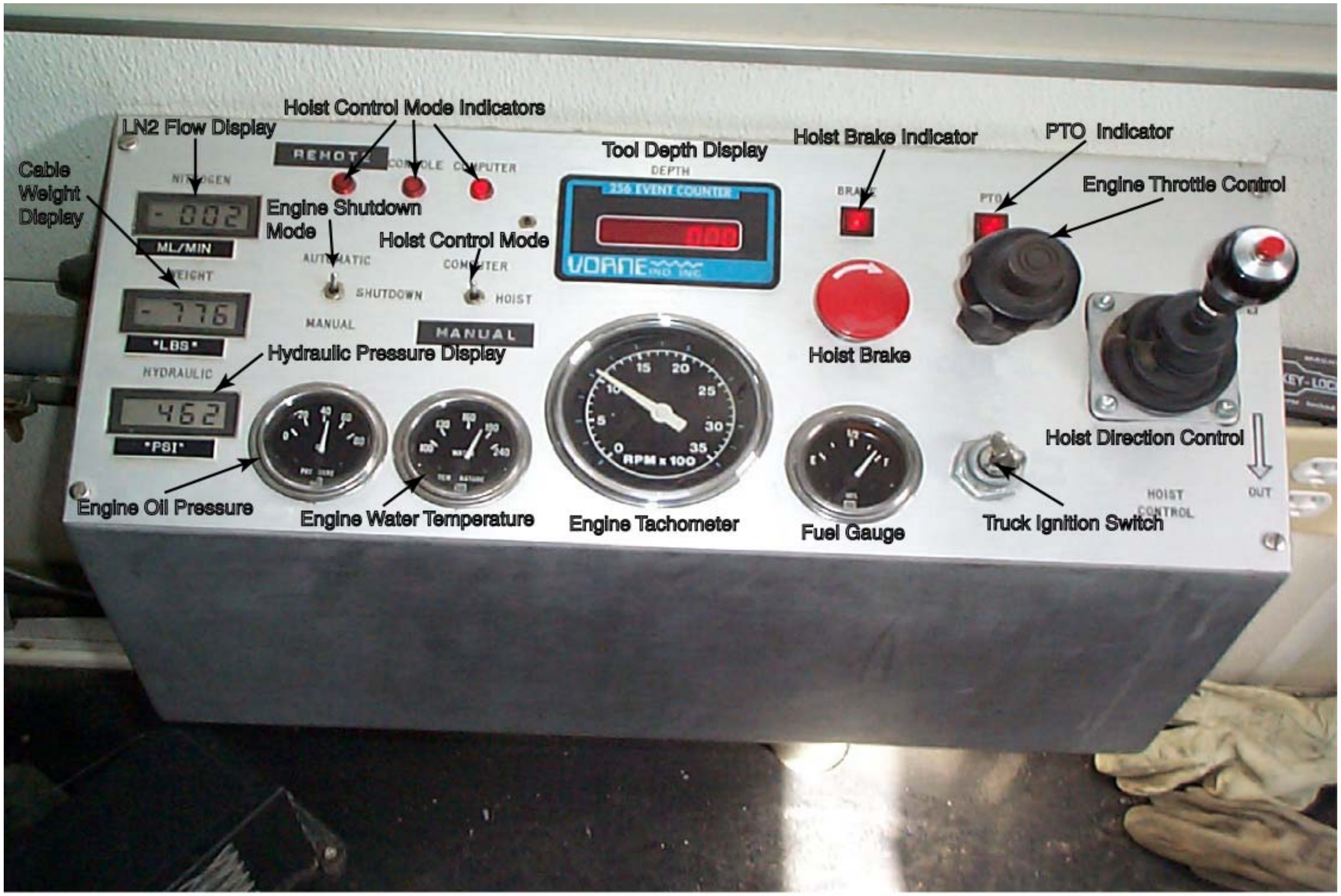

Figure 11. Operations Console

4.2.1 Remote Engine Operation and Monitoring

During logging operations users can monitor and operate the vehicle's engine from the OC. Remote vehicle operation and monitoring is an important safety feature. With the PTO engaged, the red LED labeled "PTO" illuminates on the OC.

4.2.1.1 Fuel, Oil Pressure, and Temperature Engine Gauges

Basic engine status can be monitored from the OC using the gauges listed below. These are standard motor vehicle gauges and should be monitored during logging operations for normal and/or off-normal conditions.

- Diesel Fuel Level Gauge
- Engine Coolant Temperature Gauge
- Engine Oil Pressure Gauge

Engine operating parameters are relayed to the OC and Computer Automated Spectral Acquisition System II (CASASII) LOG program (Section 7.1) through the Sensor Panel (Section 4.3.8) for monitoring.

4.2.1.2 Remote Ignition Key

The remote ignition key can be used to start and stop the vehicle engine.

4.2.1.3 Tachometer Gauge and Engine Throttle Knob

From the OC, a tachometer gauge and multi-functional throttle knob control the vehicle's engine speed (Figure 11). The tachometer displays the vehicle engine speed in units of RPM and the throttle knob increases or decreases the engine's speed. The remote throttle control is connected directly to the engine; consequently, engine speed can be adjusted independently of the vehicles configuration from this control.

To increase or decrease engine speed, the throttle is twisted clock- or counter-clockwise. The throttle is designed to stay in place by friction-resistance when the desired RPM is reached. To release the throttle back to idle a large spring-loaded button is depressed on top of the throttle body. When depressed, the engine speed immediately drops down to an idle.

Minimum operating speed for data acquisition is 1,100 RPM, which can be maintained by manipulating the throttle and observing the response of the tachometer. After logging is completed, the throttle is released to idle.

4.2.1.4 Shutdown Toggle Switch - Manual/Automatic

Select *Manual* engine shutdown mode. The *Automatic* operating mode is not currently used.

4.2.2 Hoist Operation and Monitoring

Hoist functions can be manipulated and monitored from the OC using a control handle, brake knob, digital displays, and red LEDs (Figure 14). During logging, the CASASII LOG program controls the hoist function.

4.2.2.1 Hoist Control Handle

A multi-directional control handle or joystick labeled “Hoist Control” is used for operating the hoist (Figure 11). Three functions are performed with the control handle including reeling ON and/or OFF logging cable and engaging the high-speed (30 ft/min) side of the hoist. High-speed is engaged by depressing the small red button on top of the joystick and terminated when the button is released. The functionality of the hoist is described in Section 3.3.2.

During logging, the CASASII LOG program controls the hoist function. Hoist movement is signaled to the logging computer through the Sensor Panel from the depth encoder, weight, and hydraulic pressure sensors.

4.2.2.2 Hoist Brake

A large red knob on the OC is the hoist brake (Figure 11). To apply the brake, depress the knob until it locks in place and a red LED labeled “Brake” above the knob illuminates. Twisting the knob releases the brake. The functionality of the hoist brake is described in Section 3.3.2.

During logging, the CASASII LOG program controls the hoist brake. If a hoist problem is sensed, such as an overwrap or snag, the CASASII LOG program will signal an alarm through the Sensor Panel and apply the hoist brake.

The hoist brake should always be ON when the vehicle is set up and standing by to begin logging. This will prevent the hoist from accidentally moving and avoid a cable warp condition.

4.2.2.3 Hoist Toggle Switch - Computer/Manual

The hoist operates in either *Computer* or *Manual* mode; select *Computer* mode (Figure 11). In *Computer* mode, the CASASII LOG program is in control of the hoist and a red LED labeled “Computer” illuminates on the OC. The joystick also operates under *Computer* mode.

In *Manual* mode, the remote pendant is used to move the hoist. *Manual* mode is currently disabled; consequently, *Computer* mode is the only method to reel ON and/or OFF logging cable.

4.2.2.4 Hydraulic Fluid Pressure

A digital display, labeled “Hydraulic,” shows the hydraulic fluid pressure in pounds per square inch (PSI) in the PTO-driven pump that powers the hoist and crane (Section 3.3.2) (Figure 11). A hydraulic pressure transducer relays the hydraulic pressure to the OC and CASASII LOG program through the Sensor Panel. Hydraulic pump pressure varies during logging and should be monitored during logging operations.

4.2.2.5 Weight Display

A digital display labeled "Weight" shows the weight in pounds being exerted on the logging cable (Figure 11). A load cell between the crane and sheave wheel (Figure 5) relays the weight to the OC and CASASII LOG program through the Sensor Panel. Too much weight will invoke the hoist brake by the CASASII LOG program and interrupt logging. The hardware and alarm limit data file is set up to invoke the hoist brake if the load sensor exceeds 3,000 lbs.

A glass fuse is located on the Sensor Panel, labeled "Load Pin," as an electrical safety device for this circuit.

4.2.2.6 Depth Display

A digital event counter labeled "Depth," manufactured by Vorne Industries, displays sonde depth (Figure 11). An optical sensor on the sheave wheel assembly counts electronic pulses as the sheave wheel turns (Figure 5). The counts are scaled and displayed as depth in real time in units of feet. Data signals are sent to the OC and CASASII LOG computer through the Sensor Panel. To reset depth to "0.00 ft" a button on the display's faceplate is depressed that clears the last value displayed.

A glass fuse is located on the Sensor Panel, labeled "Encoder," as an electrical safety device for this circuit.

4.2.3 Liquid Nitrogen Flow Meter

A digital display labeled "Nitrogen" is used to monitor the exhaust flow of LN_2 (Figure 11). LN_2 is monitored when spectral gamma-ray data are acquired using high-purity germanium (HPGe) detectors. To measure LN_2 flow, a model 100-7 Flo-Sensor, manufactured by McMillan Co., is located inside the OC. Once measured, the LN_2 is <u>safely</u> vented to the atmosphere through the floor of the instrument cabin. The Flo-Sensor is capable of measuring LN_2 flows ranging between 400 – 2,000 milliliters per minute (ml/min) and sending data in real time to the OC and CASASII LOG program through the Sensor Panel.

The "Nitrogen" display on the OC conveys the general operating condition of the sonde. The following LN_2 flow scenarios can affect data acquisition:

- Normal range for LN_2 flow is between 600 and 1,400 ml/min depending upon which HPGe detector is used.

- Between 8 and 12 hours is a maximum operating time for a dewar. For a detector to continue operating, the LN_2 has to be replenished within this time.

- If LN_2 flow drops from normal range to 00.0 ml/min, the detector will stop operating in approximately 30 minutes if the LN_2 is not replenished. A temperature-sensing element attached to the detector will automatically reduce the bias supply voltage to zero, effectively shutting OFF the detector, when the detector begins to warm up.

- If LN_2 flow is greater than 1,700 ml/min, the detector's bias supply voltage won't turn ON. A high flow indicates that the LN_2 has not had enough time to stabilize the low temperature-sensing element on the monitoring circuit. Approximately 6 to 8 hours is needed to stabilize HPGe detectors for use if they have been stored at room temperature.

- If LN_2 flow remains high and/or won't stabilize, even after 6 hours, a faulty dewar on the sonde is indicated.

4.3 Instrument Equipment Rack

An equipment rack located in the instrument cabin holds the various components of the logging system (Figure 12). A generalized diagram of the logging system is presented in Figure 13. Components in the equipment rack include:

- Logging Computer and Monitor
- EG&G Ortec Model 4001C Modular System Bin
- EG&G Ortec Model 672 Spectroscopy Amplifier
- EG&G Ortec Model 921 *Spectrum Master* High-Rate Multichannel Buffer
- EG&G Ortec Model 973 Spectroscopy Amplifier
- EG&G Ortec Model 918 Dual Port Fanout
- Signal Monitor Panel
- Sensor Panel

4.3.1 Logging Computer and Monitor

A personal computer (PC) and monitor are used to operate the *Computer Automated Spectral Acquisition System II* (CASASII) LOG program (Section 7.1) and store the acquired data on a hard disk (Figure 14). For an operating system, the PC utilizes Microsoft Windows® 95. Other hardware systems interfaced to the PC include hoist control, vehicle status monitoring, and data acquisition via a Signal Monitor Panel (Section 4.3.7) and Sensor Panel (Section 4.3.8).

4.3.2 EG&G Ortec Model 4001C Modular System Bin

The Model 4001C Modular System Bin (NIM Bin) is a device capable of holding up to 12 interchangeable modules while simultaneously distributing AC and DC power through a common bus bar (Figures 13 and 15). All components of the modular system are built in accordance with *Standard NIM Instrumentation System* Report DOE/ER-0457T. This standard dictates the size of the modules, power tolerances, type, and location of connectors. A small control panel is located at the right side of the NIM Bin with the following control functions:

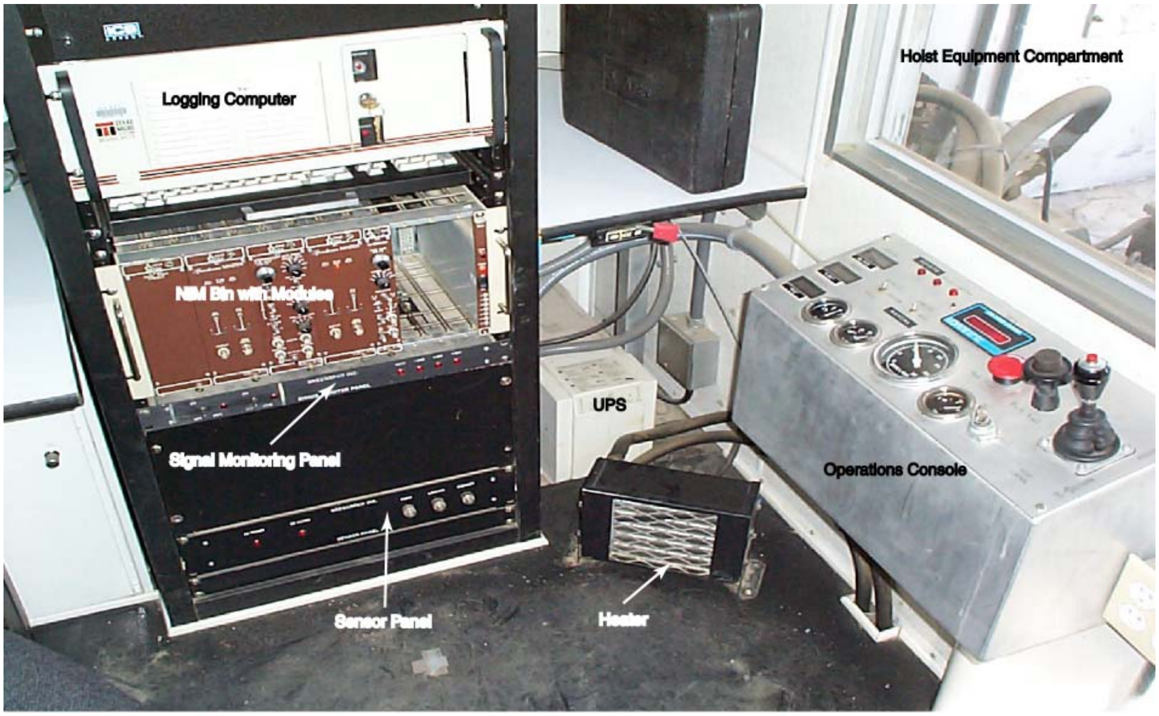

Figure 12. Instrument Equipment Rack and Operations Console

Figure 14. Instrument Equipment Rack

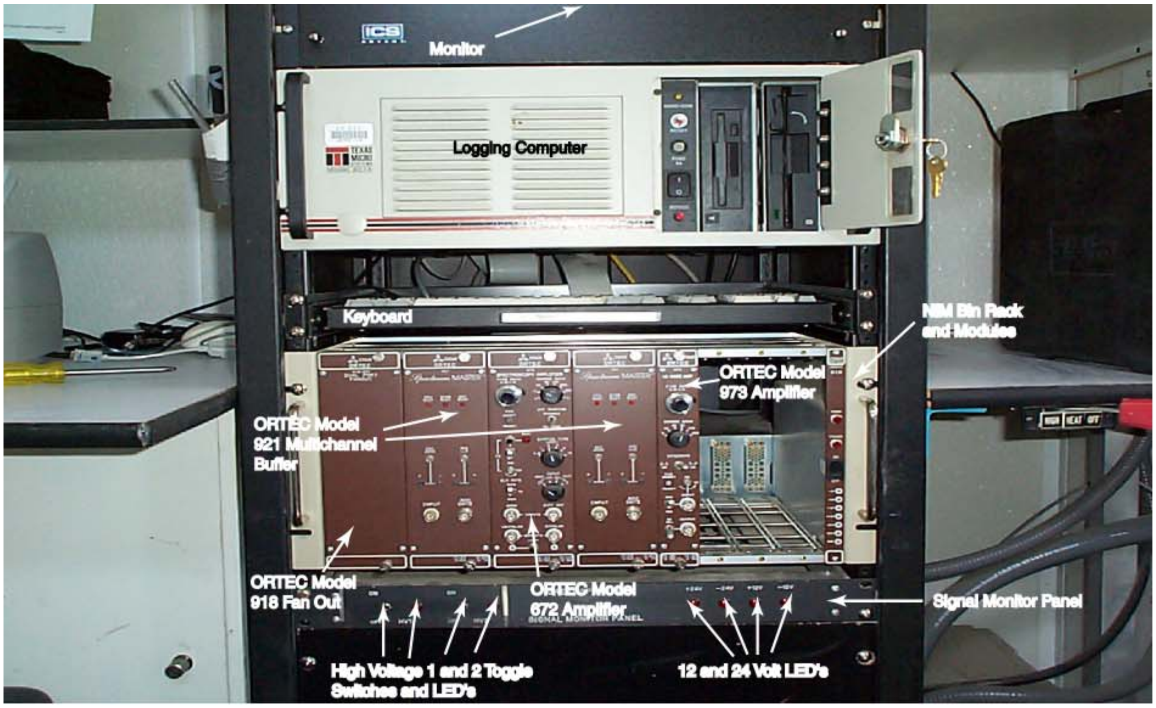

Figure 15. Instrument Rack Components

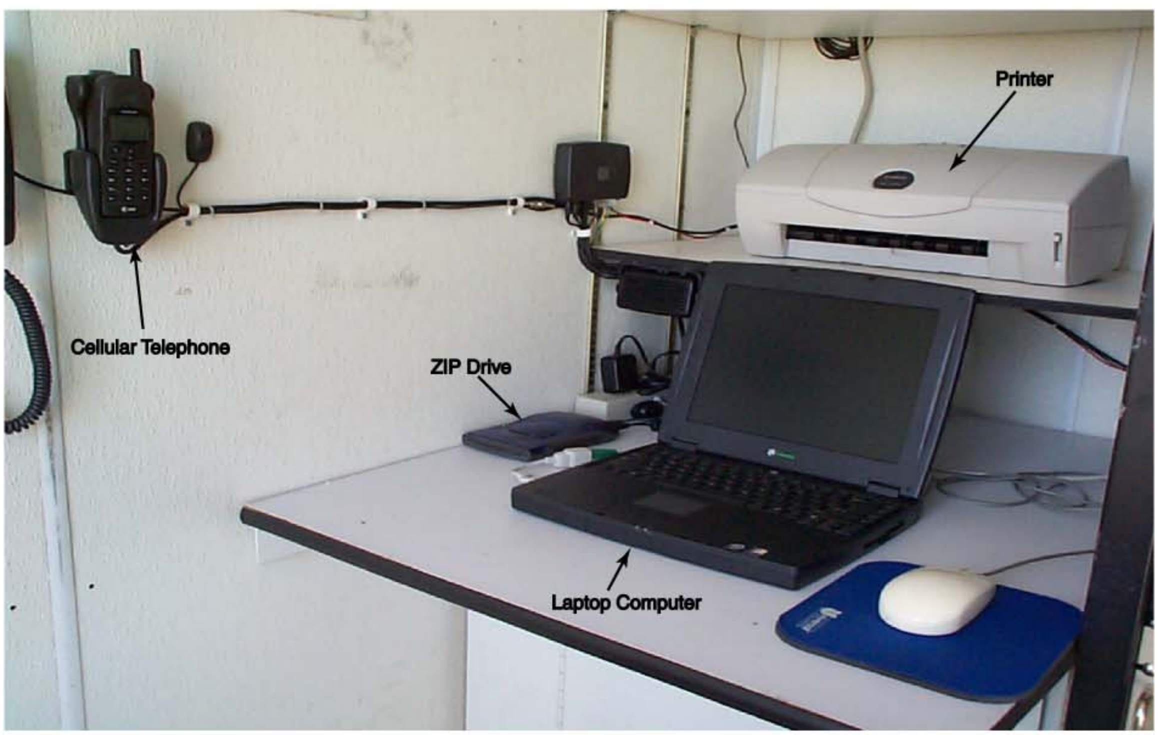

Figure 16. Instrument Cabin Work Area

- An ON/OFF switch controls power input to the NIM Bin module.
- When the power switch is ON an amber color pilot lamp illuminates.
- Test Jacks are provided for checking power supply voltages across the bus bar.

AC power to the NIM Bin module is supplied through the Uninterruptible Power Supply (UPS) (Section 4.5), which is controlled by the circuit breaker labeled “Computer” on the Power Distribution Panel. Power to the detector is supplied through the logging cable via the NIM Bin module so a Power Up, Power Down Sequence (Appendix C) is followed to avoid damage to their sensitive electrical circuitry.

The NIM Bin module’s power should always be OFF when a sonde is being connected or disconnected from the logging cable. Operate the NIM Bin module as follows when AC input power is ON.

- Turn ON the NIM Bin module’s power switch after connecting the logging cable and sonde.

- Turn OFF the NIM Bin module’s power switch before disconnecting the logging cable and sonde.

The Model 4001C Modular System Bin operating and service manual is on file at the MACTEC-ERS office.

4.3.3 EG&G Ortec Model 921 *Spectrum Master* High-Rate Multichannel Buffer (MCB)

The Model 921-MCB is an instrument that collects output signals from a spectroscopy amplifier, performs pulse-height-analysis (PHA) on those signals, and displays the results in real time on the PC’s monitor as spectra. The MCB is a multi-functional instrument that is the heart of the data acquisition system (Figures 13 and 15). The MCB emulates the function of a multichannel analyzer, analog to digital converter, and a pulse-height-analyzer independently of PC operation.

Two MCBs are located in each vehicle; these are doublewide modules and have dedicated spectroscopy amplifiers. During logging, the MCB’s control the signal acquisition, while the CASASII LOG program controls the hardware to move the sonde, record the data, and monitor the vehicle.

Configuration of a MCB is through a specialized computer program written by EG&G Ortec named MAESTRO II. This program is used to set up the gain stabilization feature of the 921-MCB. MAESTRO II is located on a directory named MCA on the logging computer’s hard drive but will not be explained further in this document.

The Model 921 Spectrum Master operating and service manual is on file at the MACTEC-ERS office.

4.3.4 EG&G Ortec Model 672 Spectroscopy Amplifier

The Model 672 spectroscopy amplifier accepts input signals from a detector preamplifier and provides output signals suitable for use with the MCB (Figures 13 and 15). This amplifier is employed when either the neutron moisture gauge or sodium iodine (NaI) sondes are used for logging.

This is a doublewide module located in the NIM Bin. Configuration, controls, and indicators regarding the application of this module are discussed in the Neutron Moisture Gauge Logging Procedure (Appendix F).

The Model 672 spectroscopy amplifier operating and service manual is on file at the MACTEC-ERS office.

4.3.5 EG&G Ortec Model 973 Spectroscopy Amplifier

The Model 973 spectroscopy amplifier accepts input signals from a detector preamplifier and provides output signals suitable for use with the MCB (Figures 13 and 15). The logging system employs this singlewide amplifier when HPGe sondes are used for logging. Configuration, controls, and indicators regarding the application of this module are discussed in the SGLS and HRLS Logging Procedures, Appendices D and E, respectively.

The Model 973 spectroscopy amplifier operating and service manual is on file at the MACTEC-ERS office.

4.3.6 EG&G Ortec Model 918 Fanout

The model 918 Fanout is an electronic signal splitter (Figures 13 and 15). This doublewide instrument allows either one or both MCBs to communicate with the logging computer without physically changing any modules in the NIM Bin. Both MCBs are connected to the Fanout with one ribbon cable each and one ribbon cable from the Fanout is connected directly to the logging computer. There is no set up for the Fanout because it possesses only hardware connections. The different MCBs are selected when Log Initialization is set up using the CASASII LOG program (Section 7.1).

4.3.7 Signal Monitor Panel

A Signal Monitor Panel is located in the equipment rack to indicate if data signals are being conveyed from the sonde to the spectroscopy amplifiers during logging (Figure 15). The signal monitor panel is used as an interface between the sonde and the modules in the NIM Bin. DC power to the Signal Monitor Panel is supplied by the circuit breaker labeled “Sensor” on the Power Distribution Panel.

The panel consists of two sets of side-by-side toggle switches and red LED pilot lights. The labels “HV1” and “HV2” distinguish each toggle switch. HV is an abbreviation for “high voltage” and represents the HV bias supply carried on the detector’ wiring harness. Currently, only HV1 toggle switch is used. Signal monitor scenarios are discussed below that can affect logging.

- Switch HV1 ON only after the logging cable and sonde are attached or circuitry on the detector can be damaged. Follow the Power Up, Power Down Sequence in Appendix C.

- If HV1 is ON, then the corresponding red LED should illuminate when operating under normal circumstances.

- If HV1 is ON, without a corresponding red light, then no data signals are being sent from the detector and may require repair or indicate a warm tool.

Other red LEDs, labeled +24V, -24V, +12V, and –12V, are included on the Signal Monitor Panel that indicate the condition of the power signal between the NIM Bin and sonde (Figure 15).

4.3.8 Sensor Panel

A Sensor Panel is located at the bottom of the equipment rack where the various signal and sensor wiring harnesses converge so their real time data can be conveyed to the CASASII LOG program for monitoring and control (Figure 12). These various data signals include the vehicle status, hoist, signal monitor panel, LN_2 flow, weight, depth, data acquisition system, and other electronic sensors. The Sensor Panel is completely enclosed and secured in the equipment rack and requires no set up.

Two red LEDs, labeled “AC Power” and “DC Power,” are located on the faceplate of the Sensor Panel. When the AC breaker switch labeled “Computer” on the Power Distribution Panel and the NIM Bin power switch are ON, the red “AC Power” LED illuminates. When the DC breaker switches labeled “Sensor” and “Console” on the Power Distribution Panel are ON, the red “DC Power” LED illuminates.

Three glass fuses, labeled “Horn,” “Load Pin,” and “Encoder” are located on the faceplate of the Sensor Panel as electrical safety devices for these circuits.

4.4 Instrument Cabin Work Area

Inside the instrument cabin is a work area for the operator to sit, perform simple analysis, operate the hoist, and monitor logging activities. The following office items are found in the work area (Figure 16).

- Laptop Computer
- Mass Storage Device
- Cellular Phone
- Printer

4.4.1 Laptop Computer

A model 5300 Solo laptop computer, manufactured by Gateway Corporation, is located in the work area. The laptop is networked to the logging computer and is used to analyze verification spectra and data, control printing, and transfer data files to the mass storage device.

4.4.2 Mass Storage Device

Data files are transferred from the PC's hard drive to a 250-megabyte mass storage device or zip drive manufactured by Iomega (Figure 16). The zip disk is conveyed to the office where the data are transferred and copied to a compact disk for storage.

4.4.3 Cellular Telephone

Each vehicle has one cellular telephone attached to the wall of the instrument cabin (Figure 16). DC power to the cellular telephone is supplied by the circuit breaker labeled "Telephone" on the Power Distribution Panel. This standard cellular telephone can store multiple phone numbers in memory. Normal and standard operating practices will be used and will not be explained in this document.

The Operation and Maintenance Instructions for the cellular telephone are in the vehicles and are also on file at the MACTEC-ERS office.

4.4.4 Printer

A color printer is attached to the laptop computer so preliminary field data can be printed after being analyzed (Figure 16). This is a small color printer for use in the field; normal and standard operating practices will be used and will not be explained in this document.

4.5 Uninterruptible Power Supply (UPS)

A model 1250 Smart-UPS, manufactured by American Power Conversion, is secured to the instrument cabin floor on the right side of the equipment rack (Figure 17). AC power to the UPS is supplied by the circuit breaker labeled "Computer" on the Power Distribution Panel. The UPS is an integrated device that provides both on-line voltage regulation and on-line battery recovery for the data acquisition system. Components affected by the UPS include the logging computer and monitor, NIM Bin module, sonde, and AC circuitry supported through the Signal Monitor and Sensor Panels.

An enable switch is located on back of the UPS that puts the unit in service and is left ON at all times. A pushbutton on the faceplate labeled "Test" is used to energize the UPS. Below the Test button is a second unlabeled button, which turns OFF the UPS after logging is finished. The UPS performs an internal system check when first energized and recharges the battery pack automatically by special circuitry when the UPS is energized. Two green-segmented LEDs graphically display the power output and available battery capacity.

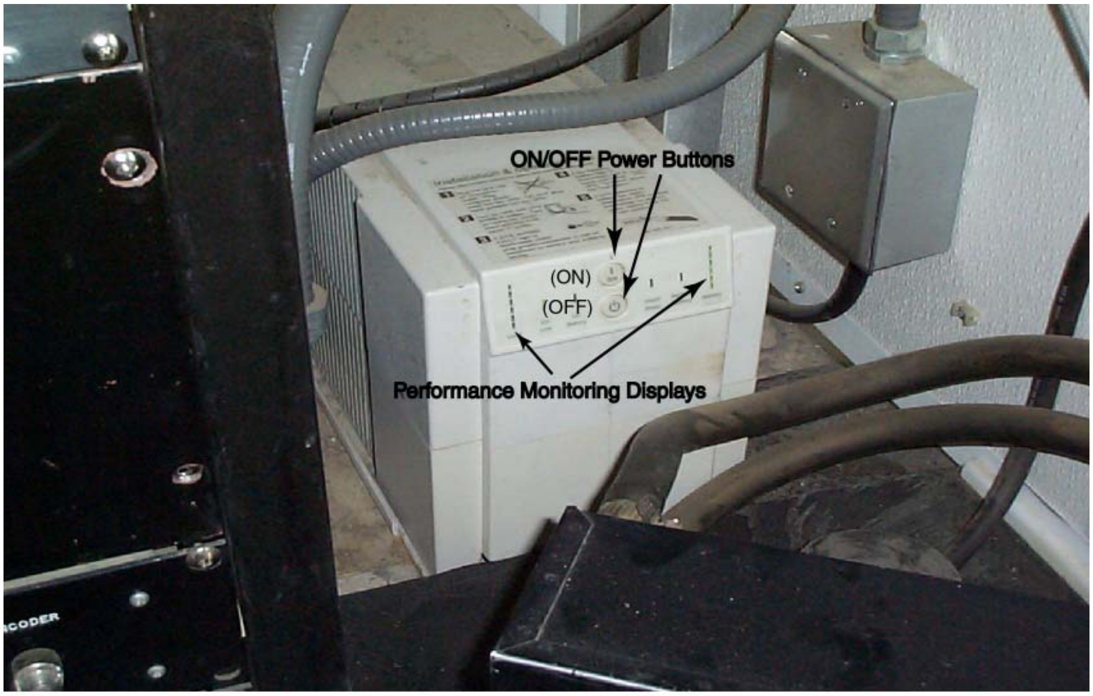

Figure 17. Uninterruptible Power Supply (UPS)

If AC power is disrupted, the UPS automatically transfers to on-line battery recovery in less than two milliseconds. Typically, on-line battery power will support electrical loads for 20 minutes or less. An audible alarm will beep for about 2 minutes before the low battery shut down occurs and the UPS turns OFF.

When distances between boreholes are short and equipment storage and set up can be accomplished in less than 20 minutes, the UPS can be kept ON to supply power to the data acquisition system (turn OFF the monitor). The UPS recovers automatically and switches to on-line voltage regulation when the Hydra-Gen® is brought back on-line.

The UPS User's Manual is on file at the MACTEC-ERS office.

4.6 Air Conditioner

A 7000 series air conditioner/heating unit, manufactured by Coleman®, is mounted on the wall of the Instrument Cabin. AC power is supplied by the circuit breaker labeled "Air Conditioner" on the Power Distribution Panel. A control panel regulates the fan speed and selects between fan, heating, or cooling modes. This unit is used to heat and cool the work area and does not affect the operation of the electronic modules in the equipment rack. This is a standard air conditioner; therefore, normal operating procedures will be followed and will not be explained in this document.

The air conditioner's Operation and Maintenance Instructions are on file at the MACTEC-ERS office.

4.7 Smoke Alarm

Each vehicle is equipped with one smoke alarm permanently affixed to the ceiling of the instrument cabin. DC power to the smoke alarm is supplied by the circuit breaker labeled "Sensor" on the Power Distribution Panel.

The smoke alarm should be tested on a regular basis (monthly) by pressing the test button on the detector. The piezo-horn should sound, indicating that the unit is functioning. Use of the test button will not activate the alarm relay.

The smoke alarm Owner's Manual is on file at the MACTEC-ERS office.

4.8 Portable Fire Extinguishers

One 15-lb, B-C rated, dry-chemical portable fire extinguisher is located in the Instrument Cabin and secured to the floor with a permanent fixture. A second, 2.5-lb, ABC rated, dry-chemical portable fire extinguisher is carried in the driver's cabin as required by U. S. Department of Transportation (DOT) regulation.

MACTEC-ERS will ensure that the fire extinguishers meet the portable fire extinguisher inspection, testing, and maintenance program outlined in the *Hanford Fire Protection System*

Testing/Inspection and Maintenance Procedure, HNF-PRO-351, Revision 3. An inspection tag that is affixed to the fire extinguishers will be completed at monthly inspections.

Access to the fire extinguisher should not be blocked with equipment and/or stored materials. Applying good housekeeping practices in the instrument cabin allows access to the fire extinguisher at all times.

5.0 Detectors

Various types of detectors can operate from Gamma 1 and Gamma 2. An individual detector and housing together make up a logging tool or sonde. Detectors are listed below.

- 35 Percent HPGe Detector
- Planar HPGe Detector
- Neutron Moisture Gauge

5.1 35 Percent HPGe Detector

MACTEC-ERS is the DOE qualified custodian of three 35% efficiency, passive gamma ray, p-type HPGe detectors manufactured by EG&G Ortec. Each detector is capable of recording gamma-ray spectra while operating in medium to low intensity gamma-ray fluxes up to 8,000 pCi/g cesium-137 (^{137}Cs). LN_2 is required to keep these detectors at their operational design.

When these detectors are employed with Gamma 1 or Gamma 2, they make up the Spectral Gamma-Ray Logging System (SGLS). SGLS logging procedures are included in Appendix D. These detectors were used extensively during the FY 1995-2000 Hanford Vadose Zone Baseline Characterization Project conducted in the 200 East/West Tank Farms. The detectors are assigned to vehicles and identified by the following serial numbers:

- Gamma 1: 34-TP20893A (γ1)
- Gamma 2: 34-TP11019B (γ 2)
- Gamma 1B and Gamma 2B: 34-TP21095A (γ1B, γ 2B)

Information for the detectors is on file at the MACTEC-ERS office.

5.2 Planar HPGe Detector

MACTEC-ERS is the DOE qualified custodian of a low efficiency, passive gamma ray, n-type planar HPGe detector. This detector is capable of recording gamma-ray spectra while operating in intense gamma-ray fluxes up to 100 million pCi/g ^{137}Cs. The detector is a 6-mm by 8-mm, planar HPGe model number IGLET-06XXX-S manufactured by EG&G Ortec.

When this detector is employed with Gamma 1, it is referred to as the High Rate Logging System (HRLS). HRLS logging procedures are included in Appendix E. This detector is identified by the following and serial number and assigned to the following vehicle:

- Gamma 1C: 39-A314 (γ1C)

Information for the detectors is on file at the MACTEC-ERS office.

5.3 Neutron Moisture Gauge

MACTEC-ERS uses a nuclear soil moisture gauge, model 503 manufactured by CPN International. This tool is neutron-activated. A neutron source and detector are manufactured together, and the interaction between the source and the borehole environment is measured. The source material is Americium-241/Beryllium. This device detects the neutrons emitted by its own source that are scattered back to the detector by collisions primarily from hydrogen atoms surrounding the borehole. The measurements indicate relative moisture content.

When this detector is employed with Gamma 1 or Gamma 2, it is referred to as the Neutron Moisture Logging System (NMLS). NMLS logging procedures are included in Appendix F. This detector is identified by the following serial number:

- H380932510

6.0 Portable Calibration and Field Verification Check Sources

The Gamma 1 and Gamma 2 logging systems currently have the capability to acquire data using the different sondes described previously. Before and after logging, a system check is performed to judge the quality of the system's efficiency and energy resolution. These system checks are called verification or calibration spectra and data collected from verifications are compared to published acceptance criteria. The vehicles employ different field verifiers depending upon the type of sonde being utilized and are as follows:

- Portable KUTh Field Verifier
- HRLS ^{137}Cs Calibration Check-Source
- Neutron Calibration Standard

6.1 Portable KUTh Field Verifier

A low-intensity (exempt quantity) gamma-ray source, called a KUTh Field Verifier, is used to check system performance when acquiring data using the 35% HPGe sonde for SGLS logging. Two KUTh Field Verifiers manufactured by Amersham Corporation and identified by serial numbers 082 and 118 are used for system checks (Figure 18).

Figure 18. Portable KUTh Field Verifier

Figure 19. Verifier Compartment

Amersham certifies that the verifiers contain potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th) in such minute quantities that the U.S. Nuclear Regulatory Commission and the radiation control agencies of the various states do not impose licensing requirements. The quantity of radioisotopes and the dose rate at the surface of the verifier are below limits for limited quantity radioactive material established by the DOT.

The verifiers are approximately 11 in. in diameter by 13.5 in. in length. The KUTh mixture is encapsulated in a standard aluminum clam-shell configuration with a 4-in.-diameter access hole in the center; the verifiers weigh approximately 64 lbs. The following table is a summary of the source test report received from Amersham Corp. with the verifiers. Activities for both verifiers are approximately the same.

Isotope	Activity	Concentration
^{40}K	1.68 µCi	11.7%
^{238}U	0.23 µCi	40 ppm
^{232}Th	0.17 µCi	90.5 ppm

The KUTh Field Verifier is a portable device that is carried in a compartment and secured behind a locking door. An Onsite Routine Radioactive Shipment Record (ORRSR), issued by site transportation, safety and radiological control will accompany the KUTh verifier at all times. Duratek Federal Service, (509) 342-1120, is the source custodian and they are responsible for arranging semi-annual source integrity testing.

6.2 High Rate Logging System ^{137}Cs Calibration Check-Source

A planar HPGe detector is used for acquiring spectral data from boreholes with very high gamma flux that saturates a SGLS sonde, making that data unusable for analysis. To measure radiation intensity in this environment, a planar detector was manufactured utilizing a very small HPGe crystal (6 mm x 8 mm). Testing determined the gamma-ray intensity from the portable KUTh field verifiers described above was of insufficient strength to employ them as a verification source for calibrating the HRLS sonde.

A 200-µCi ^{137}Cs source, identified as 1013, was procured and a steel and tungsten container was built to provide shielding and accommodate sonde calibration (Figure 19). The HRLS check-source is affixed to a pair of sliding rails on Gamma 1 in a locking compartment and weighs approximately 80 lbs. A steel lid shields and secures the top.

The ^{137}Cs source is encapsulated in a 2-in.-long by 0.25-in.-diameter aluminum tube sealed in the side of the container 3 in. off the bottom. This configuration makes the gamma radiation a point source where detector/container alignment is important for acquiring consistent calibration spectra. Two reference marks, one each on the sonde and container, are aligned when the sonde is placed inside the container from the top.

An Onsite Routine Radioactive Shipment Record (ORRSR), issued by site transportation, safety and radiological control will accompany the 200-μCi ^{137}Cs verifier at all times. Duratek Federal Service, (509) 342-1120, is the source custodian and they are responsible for arranging semi-annual source integrity testing.

6.3 Neutron Calibration Standard

The neutron moisture gauge employs a 50-mCi Americium-241/Beryllium source that is a part of the 503-model detector manufactured by CPN International, Inc. As an active component of the 503-detector, the source is used for both calibrating the sonde and measuring formation moisture (Figure 20). A specially designed container filled with paraffin is the source shield and calibration standard and fits on the end of the detector where the source is located. When performing verification, a spectrum is collected with the source in the calibration standard/shield and a count rate check is performed. When logging, the calibration standard/shield is removed so the neutron source can actively interact with the borehole environment.

Both the detector and calibration standard/shield are carried in a Type A instrument container. An Onsite Routine Radioactive Shipment Record (ORRSR), issued by site transportation, safety and radiological control will accompany the 50-mCi Americium-241/Beryllium neutron moisture gauge at all times. Duratek Federal Service, (509) 342-1120, is the source custodian and they are responsible for arranging semi-annual source integrity testing.

7.0 Logging

7.1 Computer Automated Spectral Acquisition System II LOG Program

CASASII LOG is a comprehensive logging program that integrates both equipment and software. This program is based on the EG&G Ortec Advanced Data Collection and Management System (Greenspan).

The CASASII LOG program has the ability to monitor the vehicle's action while acquiring data, receiving and storing acquired data, and controlling sonde depth via automatic hoist control in a borehole over a depth interval specified by the user. To accomplish this work, the CASASII LOG program is interfaced to the logging system. If equipment breakdown occurs or is missing, the CASASII LOG program alerts the user and/or suspends further work progression until the equipment is repaired or sensed to be present, thus completing a set of checks and balances within the CASASII LOG program.

Detailed operating procedures are included in the *CASASII LOG User's Manual* (Greenspan) on file at the MACTEC-ERS office. A copy of that manual is also maintained in both Gamma 1 and Gamma 2.

Figure 20. Moisture Gauge in Calibration Standard/Shield

7.2 Field Logbooks

Each logging vehicle carries a field logbook where the user can record the day's activities and observations. Entries include date, times, and names as well as vehicle operation and performance. Start and stop time, file names, and depth intervals are also recorded. Field logbooks are kept on the vehicles to track and record pertinent information that is unique to a specific day.

7.3 Log Data Sheets

Log Data Sheets (Figure 21) are a record of the user's actions, set up, and assumptions when a borehole is logged. Log Data Sheets are kept to track and record pertinent information that is unique to a specific borehole logging event. He/she is responsible for filling out the record with filenames, depth, actions, and observations that would affect the analysis and interpretation of the acquired data.

Every new log run has a separate Log Data Sheet entry. Original Log Data Sheets are kept with the borehole file at the MACTEC-ERS office as a permanent record.

7.4 Field Verification Spectra and Acceptance Criteria

Field verification spectra are collected during normal logging operations before and after acquiring borehole data as a component of the logging system's quality control. These spectra are collected and analyzed to establish an energy calibration and verify the following:

- Full spectrums were collected.
- Gaussian shaped peaks.
- Energy resolution.

The results of pre- and post-verification spectra are compared to acceptance criteria. Acceptance criteria are ranges of acceptable values for intensities and full width at half maximum (FWHM) of selected spectral peaks in the field verification spectra (DOE 1999a). For logging using 35% HPGe detectors and KUTh Field Verifiers, the system passes or fails an acceptance test depending on how the intensity and FWHM of the 609.3-, 1460.8-, and 2614.5-keV spectral peaks compare to established acceptance criteria. Similar tests are applied to HRLS verification spectra using the 661.6-keV spectral peak when collected from the ^{137}Cs Calibration Check-Source.

New acceptance criteria are established annually from data collected in the various check-sources at the Hanford borehole calibration standards during Gamma 1 and Gamma 2 calibration. Acceptance criteria are published in the annual calibration reports.

Spectrum analysis is performed in accordance to the *Hanford Tank Farms Vadose Zone Data Analysis Manual* (DOE 2000a).

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Log Data Sheet

Page 1 of ___

Borehole ____________________ Date __________

Borehole Information

Area:____________________ Facility:______________________________
N-Coord:__________________ W-Coord:__________________ TOC Elevation:__________________
Water Level, ft:____________ Date Drilled:__________________ Drill Rig Type:__________________

Casing Record

Type:____________________ Thickness:__________________ ID, in.:__________________
Top Depth, ft.:____________ Bottom Depth, ft:______________ Stickup, ft.:__________________
Type:____________________ Thickness:__________________ ID, in.:__________________
Top Depth, ft.:____________ Bottom Depth, ft:______________ Stickup, ft.:__________________
Type:____________________ Thickness:__________________ ID, in.:__________________
Top Depth, ft.:____________ Bottom Depth, ft:______________ Stickup, ft.:__________________

Equipment Information

Logging System:___________ Detector Type:__________________ Detector Efficiency:______________
Detector SN:_____________ Calibration Date:________________ Calibration Reference:______________
Zip Disk #:________ Pathname:______________________________ Logging Procedure:______________

Log Run Information

Log Run Number:___________ Log Run Date:__________________ Logging Engineer:______________
File name:________________ Start Depth, ft.:________________ Finish Depth, ft:______________
Sample Interval, ft.:________ Counting Time, sec.:_________ L/R:____ Log Speed, ft/min.:__________
Pre-Survey Verif. File:________________ (P/F):____ Post-Survey Verif. File:________________ (P/F):____
Shield (Y/N):_____ Shield SN:_______________ Centralizer (Y/N):_____ Depth Return Error (ft):_________

Log Run Number:___________ Log Run Date:__________________ Logging Engineer:______________
File name:________________ Start Depth, ft.:________________ Finish Depth, ft:______________
Sample Interval, ft.:________ Counting Time, sec.:_________ L/R:____ Log Speed, ft/min.:__________
Pre-Survey Verif. File:________________ (P/F):____ Post-Survey Verif. File:________________ (P/F):____
Shield (Y/N):_____ Shield SN:_______________ Centralizer (Y/N):_____ Depth Return Error (ft):_________

Log Run Number:___________ Log Run Date:__________________ Logging Engineer:______________
File name:________________ Start Depth, ft.:________________ Finish Depth, ft:______________
Sample Interval, ft.:________ Counting Time, sec.:_________ L/R:____ Log Speed, ft/min.:__________
Pre-Survey Verif. File:________________ (P/F):____ Post-Survey Verif. File:________________ (P/F):____
Shield (Y/N):_____ Shield SN:_______________ Centralizer (Y/N):_____ Depth Return Error (ft):_________

Comments

Signature: ____________________________________ Date: ___________

Figure 21. Log Data Sheet

7.5 Repeat Log Runs

A repeat log run is a method of checking the data acquisition system by verifying depth control and data quality between one log run and another. Repeat log run data are collected regularly and usually cover a 10- to 16-ft interval.

7.6 Depth Return Error

At the completion of logging, the accuracy of the zero-depth reference is checked. The sonde is returned to the sonde/borehole zero-depth reference. Once the reference is aligned, depth readouts on the Acquire Screen and OC should both display 0.00 ft. If the sonde/borehole reference is not at 0.00 ft, the sonde is moved until 0.00 ft is displayed on the acquire screen. The distance between the sonde/borehole is measured and the value is recorded on the Log Data Sheet. This information will be utilized during analysis and comparison of log data acquired from different surveys.

If the sonde mark is above the zero-depth reference, the error is recorded as +X.XX ft; if the mark is below the zero-depth reference, the error is recorded as –X.XX ft. A return error that is greater than or equal to 0.5 ft in a 100-ft borehole may indicate a depth encoder, sheave wheel, or crane control problem.

7.7 35 Percent HPGe Detectors and High Activity Zones

During logging, the 35% HPGe detectors can become saturated in zones of high gamma-ray flux. Detector saturation occurs when the logging system is unable to record spectra with distinct full energy peaks (DOE 1999b). The records of these zones indicate extremely high-count rates, but no analyzable or blank spectra are collected. In these cases, the dead time is tracked during logging and the log run is terminated when the high activity causes the dead time to exceed 50 percent or saturate the detector.

The depth, file number, count rate, and percent dead time are noted on the Log Data Sheet. A new log run is initiated by changing the collecting time parameter from *Live Time* to *Real Time* using the CASASII LOG program Acquire Spectra window. Overlap 1 ft and continue with a new log run.

Continue logging through the high activity zone even though no usable data are acquired so a record is made. Terminate the log run when a low activity boundary is reached and the dead time falls to less than 50 percent. In the low activity zone, initiate a new log run by changing back the collecting time parameter from *Real Time* to *Live Time*. The depth, file number, count rate, and percent dead time are noted on the Log Data Sheet so the interval can be relogged with the HRLS. Overlap 1 ft and continue with a new log run.

At the logging engineer's discretion, high activity zones can be logged using the tungsten shield if the dead time is not excessive or if the zone is not extremely thick. This involves moving the sonde to the surface, making a depth return check, placing the tungsten shield on the sonde, and starting a new log run. The depth, file number, count rate, and percent dead time are noted on the Log Data Sheet.

8.0 References

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9.0 Glossary

The terms in this glossary are defined as they relate to the logging system and logging operations conducted using Gamma 1 and Gamma 2 vehicles on the Hanford Site.

Acceptance Criteria: Ranges of acceptable values of selected spectral peaks in field verification spectra against which measurements collected by the logging system are compared for accuracy and repeatability.

Borehole: A small diameter hole dug in the ground by a drilling rig and completed using steel casing of various size for monitoring a portion of the vadose zone.

Cable Wrap: A condition where the logging cable fails to be tightly spooled onto the hoist drum. This condition could cause the logging cable to snag or unreel if the hoist continued to move. An electronic sensor located on the hoist automatically applies the hoist brake if an overwrap condition occurs.

Calibration: A process where a series of measurements are recorded by the logging system from a model of known strength and composition from which concentrations and error measurements can be determined.

CASASII: Acronym for *Computer Automated Spectral Acquisition System II,* which is the main logging program (LOG) that controls and monitors the data acquisition process.

Clock Time: Real time.

Count: A measured pulse of radiation.

Crossover Sub: A housing configured to fit, adapt, or attach to different connections, making a complete sonde.

Data Directory: Where all files, which contain spectral and verification data, are stored. A directory is entered on the File/Directory command screen from the CASASII Main Menu.

Data acquisition: A process where signals from a detector are collected then sent to an amplifier/analyzer and stored on a computer for analysis and interpretation. A.K.A. logging.

Dead time: The time that an electrical device spends processing electrical signals and is automatically written on spectrum files by the CASASII LOG program. Dead time is calculated by subtracting live time from clock time and dividing the result by clock time.

Detector: A device that senses the interactions from radiation and converts the interaction to a measurable signal.

File Header: The first through fifth characters of all data filenames and is entered by the user on the LOG Initialization screen from the CASASII Main Menu. The CASASII LOG program will determine the sixth through eight characters and attach the <*.CHN> suffix extension to the data file.

Gain: A factor by which a pulse is amplified.

Log Run: A term used to describe a single set of data that were acquired from a borehole in consecutive order, without interruptions or breaks, and inclusive to a specific depth interval. Log runs are numbered numerically starting with number "1" and progress forward if multiple log run data are acquired.

Log Event: A term used to describe all log run data acquired from a specific borehole, sonde, and calendar date. Log events are recorded alphabetically starting with "A" and progress forward if multiple log events are conducted.

Live Time: The elapsed time a system requires to process detector pulses. The CASASII LOG program displays live time on the Acquire Screen during logging.

Logging: The process of acquiring geophysical data from a borehole.

Log Run: A single logging event where data are recorded from a specific borehole and depth interval. Data are recorded using a unique file root name, numbered sequentially, and bound by a start and stop depth.

Multi Channel Buffer (MCB): An instrument that collects output signals from a spectroscopy amplifier, performs pulse-height-analysis (PHA) on those signals and displays the results in real time as spectra.

Operating RPM: Represents the optimal engine speed between 1,100 and 1,400 RPM so the hydraulic pumps can adequately supply the fluid force to power the Hydra-Gen®, crane and hoist.

Post Verification: The process of collecting a spectrum at the end of a log run or end of the day in a calibration or field verification check-source to record and check the performance of the logging system. Verification spectra are compared to acceptance criteria.

Pre Verification: The process of collecting a spectrum at the beginning of a log run or beginning of the day in a calibration or field verification check-source to record and check the performance of the logging system. Verification spectra are compared to acceptance criteria.

Pulse: Emitted energy that a detector can count given enough time.

Pulse Height Analyzer (PHA): An electrical device that collects counts from a detector and converts them into a record as a function of energy.

Real Time: Clock time. The CASASII LOG program displays real time on the Acquire Screen during logging.

Repeat Log Run: A method of observing the performance of the logging system by comparing data and depth control measurements between one log run and another.

Sheave Wheel: A mechanical device used for hoisting, guiding, or routing a cable.

Sonde: Electronic or mechanical device(s) inside a cylindrical housing that are conveyed within a borehole used for collecting geophysical data.

Spectra: Recordings of physical measurements collected with a sonde. Spectra are graphically displayed and saved as files on the logging computer by the CASASII LOG program.

Total Count Rate: The sum of radiation pulses collected by a single spectrum, divided by its collection time, and expressed in units of counts per second. The CASASII LOG program displays total counts on the Acquire Screen during logging.

Trained Personnel: A person trained by MACTEC-ERS to log and collect geophysical data while operating Gamma 1 and Gamma 2.

Vadose Zone: A geologic term used to describe the interval that exists above the water table and below the ground surface.

Appendix A
Vehicle Preparations Procedure

Vehicle Preparation Procedure

Inspection: Qualified drivers will perform the following inspection.

- A pre-trip vehicle safety inspection following the D.O.T. *Federal Motor Carrier Safety Regulations* and Washington State's *Commercial Driver's Guide* to be satisfied that the motor vehicle is in safe operating condition.

Document the inspection: Drivers prepare, date, and sign the following documents.

- Driver's Vehicle Inspection Report. Leave one copy of the report in the booklet and submit one copy with that day's work documents.
- Daily Inspection Log. Leave for review by the MACTEC-ERS Project Coordinator and turn in monthly.

Vehicle start up: Go to the driver's cab and prepare to start the vehicle.

- Place the vehicle's 6-speed transmission in NEUTRAL.
- Switch OFF the PTO (right hand position, red LED OFF).
- Switch the Front Axle to Disengage (right hand position, red LED OFF).
- Switch the Transfer Case to HIGH (left hand position).
- Push in the clutch.
- Start the engine and monitor the gauges.

Air brakes: With the engine running observe the following.

- Ensure that the air-pressure warning buzzer is operating and air pressure is increasing.
- Wait for the air tank pressure to reach the "cut-out" level around 70 PSI.

Parking brake control: Getting ready to move the vehicle.

- Release the parking brakes by pushing IN the diamond shaped, yellow, push-pull control knob located on the right side of the dash.

Driving:

- Licensed drivers will drive the vehicle according to normal and standard operating rules of the road obeying traffic laws at all times.

Drive to the borehole location:

- Drive to the borehole location.
- Stop the vehicle and engage the parking brake.
- Place the vehicle's transmission in NEUTRAL.

Proceed with the *Borehole Set Up Procedure* (Appendix B).

Appendix B
Borehole Setup Procedure

Borehole Set Up Procedure

Position the vehicle over a borehole:

- Walk around the borehole, look for ground and overhead hazards.
- Select a level location between 11 and 16 ft away from the borehole.
- Carefully back up the vehicle to that area - use a spotter if possible. When backing, align the borehole and centerline of the vehicle.
- Stop when the rear bumper reaches the 11- to 16-ft range. Check the alignment of the centerline again and adjust as necessary.
- Engage the parking air brake; pull the yellow diamond OUT.
- Leave motor ON and idling.
- Place the vehicle's transmission in NEUTRAL.
- Set out wheel chocks.
- Set up instrument cabin ladder, hoist equipment ladder, and open canvas drape.
- Top-off the Dewar if necessary by turning ON the auto-fill system.

Go to the Hydra-Gen® compartment:

- Open and latch the generator's compartment door against the vehicle.
- Check that main power cable coming from the Hydra-Gen® is connected to the main power receptacle.
- Main circuit breaker switch is ON.

Go to the driver's cabin - perform the power train and air switch set up:

- Depress vehicle clutch.
- Switch PTO air switch ON (left hand position, red LED illuminates).
- Switch transfer case air switch to NEUTRAL (middle position).
- Switch front axle to disengaged (right hand position).
- Shift the vehicle's transmission into 6^{th} gear.
- Slowly engage vehicle clutch.

Attach the sheave wheel assembly to the crane:

- Go to the Power Distribution Panel and turn ON the circuit breaker labeled Console.
- Increase the engine speed to operating RPM.
- Turn OFF the circuit breaker labeled Console.
- Go to the crane, extend and deploy the outriggers.
- Level the crane using the leveling sight gauge on the back bumper.
- Move the crane from its folded position.
- Place the sheave wheel jig in the holder on the bumper and place the sheave wheel assembly in the jig. Note: the encoder box faces toward the driver's side of the vehicle.
- Manipulate the crane over the jig and attach the sheave wheel's shackle securely to the end of the crane.

- Connect the retractile cord to the encoder receptacle found on the side of the encoder box.

Extend the crane over the borehole:

- Use the levers on the Distributor Panel to position the sheave wheel/crane over the borehole.
- Loop the logging cable through the sheave wheel.
- Lift the crane boom to the horizontal position and hook the vertical support poles to the end of the crane.
- Apply a light down force on the vertical poles with the boom to set the poles firmly in place.

Option 1: Attach SGLS/HRLS sonde to the cable head and position in verifier:

- Check that the NIM Bin power switch is OFF before connecting the sonde to the cable head.
- Disconnect and remove the SGLS/HRLS sonde from the auto-fill system.
- Align the 22-pin and step-up connector on the sonde to the notch and step-down connector on the cable head.
- Attach the two pieces together being careful not to break or damage the pin connectors and O-ring seal.
- Hand-tighten the cable head nut to the sonde.
- Use a spanner wrench to securely tighten the sonde and cable head.
- Position the centralizer on the sonde.
- Remove the KUTh verifier from the locked compartment and position it over or near the borehole. Place the sonde in the verifier.

Option 2: Attach neutron moisture sonde to the cable head:

- Check that the NIM Bin power switch is OFF before connecting the crossover sub to the cable head.
- Attach the crossover sub to the cable head.
- Align the 22-pin and step-up connector on the crossover sub to the notch and step-down connector on the cable head.
- Attach the two pieces together, being careful not to break or damage the pin connectors and O-ring seal.
- Hand-tighten the cable head nut to the crossover sub.
- Use a spanner wrench to securely tighten the crossover sub and cable head.
- Position the **centralizer** on the crossover sub when logging 6-, 8-, and 10-in. boreholes.
- Remove the detector/source/shield assembly from the instrument/storage case keeping the shield/calibration standard ON.
- Attach the detector/source/shield assembly to the crossover sub and secure.

Perform the Power Up, Power Down Sequence:

- Enter the Instrument Cabin.
- Check that all switches and circuit breakers are in the OFF position.
- Perform the Power Up, Power Down Sequence included in Appendix C.

Appendix C
Power Up, Power Down Sequence

Power Up, Power Down Sequence

The logging system has a specific "Power Up, Power Down Sequence" that is followed when applying electrical power to the system. The order in which the circuit breakers and equipment switches are turned ON and OFF can affect supporting systems and possibly damage electrical circuitry if performed out of sequence.

The following Power Up, Power Down Sequence assumes that both the *Preparations Procedure* (Appendix A) and the *Borehole Set Up Procedure* (Appendix B) are completed. Go to the Instrument Cabin and perform the follow steps:

- All circuit breakers and individual power switches should be in the OFF position at the beginning of this sequence.

- Turn ON the Sensor and Console circuit breakers on the DC side - red LED labeled "Console" on the OC illuminates and a red LED labeled "DC Power" on the Sensor Panel illuminates.

- Apply the Hoist Brake on the Operations Console - red LED labeled "Brake" illuminates.

- Increase engine speed to Operating RPM between 1,100 and 1,400 RPM. Check the Hydra-Gen® frequency meter to ensure nominal 60 Hz.

- Turn ON the Computer, Wall-1, Air Conditioning, and Wall-2 circuit breakers on the AC side.

- Energize the Uninterruptible Power Supply, (top button labeled "Test" for ON, bottom unlabeled button is OFF) hold for 1 second – two green-segmented LED graph displays illuminate on the UPS and a red LED labeled "AC Power" on the Sensor Panel illuminates.

- Turn ON the EG&G NIM Bin module in the equipment rack - an amber color pilot light illuminates. (Be sure a sonde is attached to the logging cable).

- Turn ON the Computer CPU – red LED illuminates and the operating system initiates. The computer monitor also turns ON with the CPU.

- Turn ON the toggle switch labeled "HV1" on the Signal Monitor Panel - a red LED illuminates.

- When shutting the system down, the above sequence should be followed in reverse order.

Appendix D
SGLS Logging Procedure

SGLS Logging Procedure

This procedure assumes that the following assumptions are met:

- Gamma 1 or Gamma 2 is the vehicle acquiring spectral gamma-ray data.
- The 35% HPGe detector is one of the following serial numbers: 34-TP20893A (γ1), 34-TP11019B (γ 2), or 34-TP21095A (γ1B, γ 2B).
- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is complete.
- HV1 is ON and LN_2 is flowing.
- The settings on the 973-amplifier match Figure D-1.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring spectral gamma-ray data employing the SGLS. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User's Manual*, 1994 by Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.

- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

Invoke the CASASII LOG program:

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.

- Press <CTRL+ESC> to display the Start Menu.
- Point to "Shut Down . . ." using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to "Restart the computer in MS-DOS mode?" <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.
- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu screen.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.
- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the screen "Alarms Off."

Make a new or select an existing Data Directory:

From the CASASII Main Menu:

- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.

Option 1:

- Press **F1** – *Set Default Data Directory*. Select a directory that already exists. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.

Option 2:

- Press **F3** – *Make Data Directory*. Create a new directory. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↵.
- Press **F1** – *Set Default Data Directory*. Select the new directory created from the above step using the <Arrow Keys>, press the keyboard <Spacebar> to invoke it.
- Press <ESC> to return to the CASASII Main Menu.

SGLS set up and borehole information:

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <SGLS.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. This will load the correct 921-MCB setup, check the 973-amplifier settings. The CASASII Main Menu reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the SGLS set up. The LOG program will prompt an Y/N response to edit entries. Enter yes (Y) and edit the fields as necessary, include a new File Header name. <Return↵.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization* indicating the data was successfully completed.

Option:

- Press **F9** – *Save Initialization Defaults.* Save this edited initialization file, if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↵.

Detector pre calibration and system warm-up:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.

- Press **F2** – *Live Time* and enter **1,000** seconds in the Acquire request. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Start the **30-minute** warm up period. Proceed with the fine-gain adjustment.

Fine-gain adjustment:

From the Calibration Screen: The 921-MCB is set up to stabilize the1461-keV gamma-ray peak on the graphical display between channels 2120 and 2130. If gain drift has occurred, the 973-amplifier needs adjustment to meet this set up parameter.

- Wait **15 minutes** while the instruments in the equipment rack warm up.
- Analyze the post calibration spectrum <*CAA.CHN> from the previous day.
- Press **F12** – *Scale* while acquiring a calibration spectrum to display a new set of function keys that can zoom in and out and pan across the graphical display.
- Press **F1** - *<X1>* to expand scale and **F2** – *X1>>* to pan across the graphical display to the 1461-keV gamma-ray peak.
- Press **F12** – *Return.* Return to the previous set of Scale controls.
- Press **F11** - *Cur1a/Cur1b/Cur2a/Cur2b* and toggle to the cursor labeled **Cur1b**. Align cursor **Cur1b** over the centroid of the 1461-keV gamma-ray peak at about channel 2125. Note the Cur1b/1461-centroid channel number displayed on the screen.
- Rotate the pot labeled “fine gain” a few units on the 973-amplifer until the Cur1b/1461-centroid align. Note the channel number.
- Press **F5** – *Start/Stop* or **F10** – *Clear* to restart collecting a spectrum. After adjusting the fine gain note if the Cur1b/1461-centroid align and the channel number.
- Repeat the above steps until the Cur1b/centroid align. Gain drift usually stops after about 15 minutes.
- Press **F11** - *Cur1a/Cur1b/Cur2a/Cur2b* and toggle to the cursor labeled **Cur1a**. Align cursor **Cur1a** over the centroid of the 583-keV gamma-ray peak at about channel 850. Note the Cur1a/583-centroid channel number displayed on the screen.
- After the **30-minute** warm up period expires and the fine gain adjustments made, collect a calibration spectrum.
- Press **F10** – *Clear* again and collect a verification spectrum for the full **1,000** seconds.

Two-point calibration and save:

From the Calibration Screen: After a calibration spectrum is collected, align cursors **Cur1a** and **Cur1b** over the centroid of the **583.2**-keV gamma-ray peak (about channel 850) and **2614.5**-keV gamma-ray peak (about channel 3805), respectively.

- Press **F1 –** *Calibration.* Enter the following energy values in the LOG prompt boxes, **583.2** and **2614.5**. <Return↵.
- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Precal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAB.CHN>
- On the calibration screen, the LOG program prompts “Saved Data, Hit Any Key.”
- Note that the graphical area is now calibrated in units of energy (keV).
- Press **F9** – *Channel*. Toggle between units of channel and energy to check settings.
- Press <ESC> to return to the CASASII Main Menu.

- A check mark (✓) will appear to the right of **F2** – *Detector Calibration,* indicating the data was successfully completed.

Analyze the pre-calibration spectrum and compare the results to acceptance criteria:

- Copy the pre-calibration file <*CAB.CHN> to the laptop computer for analysis.
- See the desktop instructions for analyzing Field Verification Spectra and the most recent published acceptance criteria to complete this step in the guide.

Log Data Sheet and stow the KUTh check-source:

If the logging engineer's professional judgment indicates that the SGLS is ready to log, then he/she will do the following:

- Fill out the appropriate spaces on the **Log Data Sheet**.
- Place the KUTh check-source in the storage compartment, secure, and lock it.
- Position the **centralizer** on the sonde when logging 6-, 8-, and 10-in. boreholes.
- If needed, install logging accessories such as the tungsten shield or plastic wrap.

Zero-depth reference and setting the initial depth:

The zero-depth reference on the sonde is a scribe line marked around the bottom of the turned-down section of the housing. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable.

- Note the borehole's zero-depth reference on the **Log Data Sheet**.
- Place the sonde in the borehole.
- Release the hoist brake on the OC.
- Use the joystick and align the zero-depth references for both the sonde and borehole.
- Reset the depth counter on the OC to 0.00 ft.
- Note the LN2 flow.

Depth control:

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵.
- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (between 1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the **Log Data Sheet**.
- Press <ESC> to return to the CASASII Main Menu.

- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

Acquire spectra and begin logging:

From the CASASII Main Menu:
- Press **F4** – *Acquire Spectra.* The Acquire Screen appears. This command may only be invoked if data were successfully completed for *Log Initialization* (F1), *Detector Calibration* (F2), and *Depth Control* (F3), which are indicated by a check mark (✓) to the right of each title. Proceed with data acquisition parameters.
- Press **F1** – *Move-Stop-Acquire.* Input a depth increment (usually 0.5 ft), counting time (usually 100 sec. live time), and a stop logging depth.
- Press <Return↵. The software controlled log run starts. The LOG program automatically adds the file suffix <*.CHN> and sequentially numbers the data files.

From the Instrument Cabin monitor the following operations during logging:

- Spectrum collection
- Adjust gain stabilization as required and record those adjustments on the Log Data Sheet. List the affected depth and file number.
- Make entries as necessary on the Log Data Sheet and logbook.
- LN_2 flow
- Hydraulic fluid pressure
- Strain pressure
- Hydra-Gen® power output
- HV1 remains ON
- UPS power output
- Engine tachometer
- Engine gauges
- Hoist operation
- Crane position

Ending a log run and moving the sonde:

From the Acquire Spectra window: When the sonde reaches the stop depth, the LOG program automatically terminates the data acquisition process. The **F4** - *Acquire Spectra* window remains open, waiting on stand-by.
- Record on the **Log Data Sheet** the last file number recorded, depth achieved, and approximate time. All this information is found on the final spectra file.
- Press <ESC> to open to the CASASII Main Menu.
- If a Repeat Log Run is required, proceed to that section now, if not continue.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth.

- Press <ESC> to open to the CASASII Main Menu.

Check the zero-depth reference:

- After the sonde has returned to 00.0 ft, record on the **Log Data Sheet** the discrepancy between the original and return zero-depth references.

Option 1:
- Logging will continue with a new log run, a Repeat Log Run, or changing locations. Change file name as appropriate, move to new depth, and acquire data.

Option 2:
- Logging is finished for the day; proceed with collecting a post calibration spectrum.
- Remove the KUTh verifier from the storage compartment and position the sonde.

Post calibration spectrum:

From the CASASII Main Menu:
- Press **F2** – *Detector Calibration*. The calibration screen appears.
- Press **F2** – *Live Time* and enter **1,000** seconds. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Do **not** make any fine gain adjustments; acquire a spectrum until time elapses.
- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Postcal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAA.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Press <ESC> to return to the CASASII Main Menu.

Exit CASASII LOG program:

- Press <ESC> on the keyboard while the CASASII Main Menu is open.
- The LOG program prompts an Y/N box – Do you wish to quit now?
- Press yes (Y) to close CASASII Main Menu and exit to the MS-DOS window.
- This syntax appears, C:\LOG>_.
- Type EXIT. <Return↵. "Windows is starting" appears.

Transfer data files and shut down the logging computer:

- Copy the set of spectra files just collected from the logging computer to the mass storage device. Transfer this data to the MACTEC-ERS office for analysis.
- Complete and sign the **Log Data Sheet(s)**.
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to "Shut Down . . ." <Return↵.
- Wait for Windows 95 to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch.
- Turn OFF the NIM Bin power switch.

Equipment Rig Down:

- Stow and lock the KUTh verifier in the storage compartment.
- Remove the sonde from the cable head, stow the sonde in the tray, and attach the LN_2 dispensing system. Turn the LN_2 ON.
- Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position, and secure.
- Lift the outriggers and stow the pads.
- Stow portable stairs and secure.
- Close the Hydra-Gen® compartment door and secure.

Perform the Power Up, Power Down Sequence (Appendix C) to finish.

Safety: Walk around the vehicle and make a final equipment check before moving away from the borehole.

Appendix E
HRLS Logging Procedure

HRLS Logging Procedure

This procedure for the high rate logging system (HRLS) assumes that the following assumptions are met:

- Gamma 1 is the vehicle being employed to acquire high rate data.
- The planar HPGe detector is serial number 39-A314.
- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is **not** completed until the configuration of the input leads to the 973-amplifiers are checked and changed if necessary.
- Align the HRLS detector/container in the 200-µCi ^{137}Cs calibration check-source.
- The settings on the HRLS 973-amplifier match Figure E-1.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring HRLS data. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User's Manual,* 1994 by Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.

- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

Switch three leads between the SGLS 973- and HRLS 973-amplifer if necessary:

- Check that all circuit breaker switches on the Power Distribution Panel are OFF.
- Remove the two screws holding the NIM Bin in the equipment rack.
- Carefully move the NIM Bin out of the compartment. CAUTION: the NIM Bin is not built on sliding rails and can fall out of the rack if not supported. If dropped or pulled out too far, electrical leads will tear away from their connections.
- Go to the back of the 973-amplifier labeled SGLS. Three leads have to be relocated between the SGLS and HRLS 973-amplifiers. They are labeled "Chn1," "Inh1," and "Power."
- Disconnect and reconnect the leads matching Figure E-2.
- Move the NIM Bin back into the rack and secure.

Complete the *Power Up, Power Down Sequence* (Appendix C):

- HV1 is ON
- LN2 is flowing. Note: LN_2 flow will be approximately half the rate of what is normal for a 35% HPGe sonde (approx. 350 ml/min) and can take more time before it is sensed flowing through the LN_2 meter.

Invoke the CASASII LOG program:

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.

- Press <CTRL+ESC> to display the Start Menu.
- Point to "Shut Down . . ." using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to "Restart the computer in MS-DOS mode?" <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.
- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.
- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the screen "Alarms Off."

Make a new Data Directory:

From the CASASII Main Menu:

- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.
- Press **F3** – *Make Data Directory*. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↵.
- Press **F1** – *Set Default Data Directory*. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.
- Press <ESC> to return to the CASASII Main Menu.

HRLS set up and borehole information:

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <HRLS.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. The CASASII Main Menu reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the HRLS set up. The LOG program will prompt an Y/N response to edit entries. Answer yes (Y) and edit the fields as necessary, include a new File Header name. <Return↵.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization,* indicating the data was successfully completed.

- Press **F9** – *Save Initialization Defaults*. Optional. Save this edited initialization file, if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↵.

Detector pre calibration and system warm-up:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.
- Press **F2** – *Live Time* and enter **1,000** seconds. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Start the **30-minute** warm up period. Proceed with the fine-gain adjustment.

Fine-gain adjustment:

From the Calibration Screen: The 921-MCB is not set up to stabilize any gamma-ray peaks on the graphical display when acquiring HRLS data. A fine gain adjustment is made to center the 662-keV gamma-ray peak at approximately channel 1019.

- Wait **15 minutes** while the instruments in the equipment rack warm up.
- Analyze the post calibration spectrum <*CAA.CHN> from the previous day.
- Press **F12** – *Scale*. A new set of function keys are displayed that can zoom in and out and pan across the graphical display.
- Press **F1** - *<X1>* to expand scale and **F2** – *X1>>* to pan across the graphical display to the 662-keV gamma-ray peak.
- Press **F12** – *Return*. Return to the previous set of Scale controls.
- Press **F11** - *Cur1a/Cur1b/Cur2a/Cur2b* and toggle to the cursor labeled **Cur1a**. Move cursor **Cur1a** to channel 1019.
- Rotate the pot labeled "fine gain" a few units on the 973-amplifer labeled HRLS until the Cur1a/662-centroid align. Note the channel number.
- Press **F5** – *Start/Stop* or **F10** – *Clear* to restart collecting a spectrum. After adjusting the fine gain note if the Cur1a/662-centroid align and the channel number.
- Repeat the above steps until the Cur1a/662-centroid align. Gain drift usually occurs when the power is first applied and stops after about 15 minutes.
- Remove the cursors off the screen and note the total count rate. A properly aligned detector/container will detect a total count rate at or above **1,000 counts per second**.
- After the **30-minute** warm up period expires and the fine gain adjustments made, collect a calibration spectrum.
- Press **F10** – *Clear* again and collect a verification spectrum for the full **1,000** seconds.

Two-point calibration and save:

From the Calibration Screen: After a calibration spectrum is collected, align cursor **Cur1a** over the centroid of the **661.7**-keV gamma-ray peak at channel **1019**. Move cursor **Cur1b** over the centroid of **1332.5**-keV gamma-ray peak at channel **2046**. Note the 1333-keV peak will not appear during the calibration. For this step in the procedure channel 2046 is a placeholder and was determined by experiment when the HRLS base calibration was conducted.

- Press **F1** – *Calibration.* Enter the following energy values in the LOG prompt boxes, 661.7 and 1332.5. <Return↵.
- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Precal**.
- Press **F6** – *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAB.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Note that the graphical area is now calibrated in units of energy or keV.
- Press **F9** – *Channel*. Toggle between units of channel and energy to check settings.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F2** – *Detector Calibration,* indicating the data was successfully completed.

Analyze the pre calibration spectrum and compare the results to acceptance criteria:

- Copy the pre calibration file <*CAB.CHN> to the laptop computer for analysis.
- See the desktop instructions for analyzing High Rate Field Verification Spectra and the most recent published acceptance criteria to complete this step in the guide.

Log Data Sheet and stow the 200-µCi ^{137}Cs check-source:

If the logging engineer's professional judgment indicates that the HRLS is ready to log, then he/she will do the following.

- Fill out the appropriate spaces on the **Log Data Sheet**.
- Slide the 200-µCi ^{137}Cs check-source into the storage compartment, secure, and lock.
- Position the **centralizer** on the sonde when logging 6-, 8-, and 10-inch boreholes.
- If needed, install logging accessories such as the tungsten shield or plastic wrap.

Zero-depth reference and setting the initial depth:

The zero-depth reference on the sonde is a scribe line marked around the bottom of the turned-down section of the housing. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable.

- Note the borehole's zero-depth reference on the **Log Data Sheet**.
- Place the sonde in the borehole.
- Release the hoist brake on the OC.
- Use the joystick and align the zero-depth references for both the sonde and borehole.
- Reset the depth counter on the OC to 0.00 ft.
- Note the LN2 flow.

Depth control:

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵.

- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (between 1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the **Log Data Sheet**.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

Acquire spectra and begin logging:

From the CASASII Main Menu:

- Press **F4** – *Acquire Spectra.* The Acquire Screen appears. This command may only be invoked if data were successfully completed for *Log Initialization* (F1), *Detector Calibration* (F2), and *Depth Control* (F3), which are indicated by a check mark (✓) to the right of each title. Proceed with data acquisition parameters.
- Press **F1** – *Move-Stop-Acquire.* Input a depth increment (usually 0.5 ft), counting time (usually **300 sec. live time**), and a stop logging depth.
- Press <Return↵. The software controlled log run starts. The LOG program automatically adds the file suffix <*.CHN> and sequentially numbers the data files.

Logging zones of extremely high gamma flux:

If the dead time exceeds 40% stop the log run and change the collecting time parameter from *Live Time* to *Real Time*. Initiate a new log run and acquire data using **100-second real time**. Overlap 1 ft and continue with a new log run. Record changes on the Log Data Sheet.

From the Instrument Cabin monitor the following operations during logging:

- Spectrum collection
- Adjust fine gain as necessary keeping the 662-centroid at or near channel 1019. Record depth and file number if adjustments are made on the Log Data Sheet.
- Make entries as necessary on the Log Data Sheet and logbook.
- LN_2 flow
- Hydraulic fluid pressure
- Strain pressure
- Hydra-Gen® power output
- HV1 remains ON
- UPS power output
- Engine tachometer
- Engine gauges
- Hoist operation
- Crane position

Ending a log run and moving the sonde:

From the Acquire Spectra window: When the sonde reaches the stop depth, the LOG program automatically terminates the data acquisition process. The **F4** - *Acquire Spectra* window remains open, waiting on stand-by.

- Record on the **Log Data Sheet** the last file number recorded, depth achieved, and approximate time. All this information is found on the final spectra file.
- Press <ESC> to open to the CASASII Main Menu.
- If a Repeat Log Run is required, proceed to that section now, if not continue.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth.
- Press <ESC> to open to the CASASII Main Menu.

Check the zero-depth reference:

- After the sonde has returned to 00.0 ft, record on the **Log Data Sheet** the discrepancy between the original and return zero-depth references.

Option 1:

- Logging will continue with a new log run, a Repeat Log Run, or changing locations. Change file name as appropriate, move to new depth or location, and acquire data.

Option 2:

- Logging is finished for the day; proceed with collecting a post calibration.
- Slide the 200-µCi ^{137}Cs calibration check-source from the storage compartment and align the detector/container.

Post calibration spectrum:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The calibration screen appears.
- Press **F2** – *Live Time* and enter **1,000** seconds. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Do not make fine gain adjustments - acquire a spectrum until time elapses.
- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Postcal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAA.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Press <ESC> to return to the CASASII Main Menu.

Exit CASASII LOG program:

- Press <ESC> on the keyboard while the CASASII Main Menu is open.

- The LOG program prompts an Y/N box – Do you wish to quit now?
- Press Y (yes) to close CASASII Main Menu and exit to the MS-DOS window.
- This syntax appears, C:\LOG>_.
- Type EXIT. <Return↵. "Windows is starting" appears.

Transfer data files and shut down the logging computer:

- Copy a set of spectra files from the logging computer to a mass storage device. This data is transferred to the MACTEC-ERS office for storage and analysis.
- Complete and sign the **Log Data Sheet(s)**.
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to "Shut Down . . ." <Return↵.
- Wait for Windows to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch and the NIM Bin power switch.

Equipment Rig Down:

- Stow and lock the 200-µCi ^{137}Cs calibration check-source in the storage compartment.
- Remove the sonde from the cable head, stow the sonde in the tray, and attach the LN_2 dispensing system. Turn the LN_2 ON.
- Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position and secure.
- Lift the outriggers and stow the pads.
- Stow portable stairs and secure.
- Close the Hydra-Gen® compartment door and secure.

Perform the Power Up, Power Down Sequence (Appendix C) to finish.

Safety: Walk around the vehicle and make a final equipment check before leaving the borehole.

Appendix F
Neutron Capture Logging Procedure

Neutron Capture Logging Procedure

F1.0 Purpose

This logging procedure provides guidelines for performance of neutron capture borehole logging. Data acquired by the logging are used to delineate radioactive and non-radioactive components of waste sites during site characterization and other environmental investigations.

F2.0 System Preparation

F2.1 Inspection

Qualified drivers will perform the following inspection.

- A pre-trip vehicle <u>safety</u> inspection following the D.O.T. *Federal Motor Carrier Safety Regulations* and Washington State's *Commercial Driver's Guide* to be satisfied that the motor vehicle is in <u>safe</u> operating condition.

F2.2 Document the Inspection

Drivers prepare, date, and sign the following documents.

- Driver's Vehicle Inspection Report. Leave one copy of the report in the booklet and submit one copy with that day's work documents.
- Daily Inspection Log. Leave for review by the Project Coordinator and turn in monthly.

F2.3 Vehicle Start-Up

Go to the driver's cab and prepare to start the vehicle.

- Place the vehicle's 6-speed transmission in NEUTRAL.
- Switch OFF the PTO (right hand position, red LED OFF).
- Switch the Front Axle to Disengage (right hand position, red LED OFF).
- Switch the Transfer Case to HIGH (left hand position).
- Push in the clutch.
- Start the engine and monitor the gauges.

F2.4 Air Brakes

With the engine running observe the following.

- Ensure that the air-pressure warning buzzer is operating and air pressure is increasing.

- Wait for the air tank pressure to reach the "cut-out" level around 70 PSI.

F2.5 Parking Brake Control

Getting ready to move the vehicle.

- Release the parking brakes by pushing IN the diamond shaped, yellow, push-pull control knob located on the right side of the dash.

F2.6 Driving

- Licensed drivers will drive the vehicle according to normal and standard operating rules of the road obeying traffic laws at all times.

F2.7 Drive to the Borehole Location

- Drive to the borehole location.
- Stop the vehicle and engage the parking brake; place the vehicle's transmission in NEUTRAL.

F3.0 System Setup

F3.1 Position the Logging Vehicle over a Borehole

- Walk around the borehole, look for ground and overhead hazards.
- Select a level location between 11 and 16 ft away from the borehole.
- Carefully back up the vehicle to that area - use a spotter if possible. When backing, align the borehole and centerline of the vehicle.
- Stop when the rear bumper reaches the 11- to 16-ft range. Check the alignment of the centerline again and adjust as necessary.
- Engage the parking air brake; pull the yellow diamond OUT.
- Leave motor ON and idling.
- Place the vehicle's transmission in NEUTRAL.
- Set out wheel chocks.
- Set up instrument cabin ladder, hoist equipment ladder, and open canvas drape.
- Top-off the Dewar if necessary by turning ON the auto-fill system.

F3.2 Go to the Hydra-Gen® Compartment

- Open and latch the generator's compartment door against the vehicle.
- Check that main power cable coming from the Hydra-Gen® is connected to the main power receptacle.
- Main circuit breaker switch is ON.

F3.3 Go to the Driver's Cabin - Perform the Power Train and Air Switch Setup

- Depress vehicle clutch.
- Switch PTO air switch ON (left hand position, red LED illuminates).
- Switch transfer case air switch to NEUTRAL (middle position).
- Switch front axle to disengaged (right hand position).
- Shift the vehicle's transmission into 6^{th} gear.
- Slowly engage vehicle clutch.

F3.4 Attach the Sheave Wheel Assembly to the Crane

- Go to the Power Distribution Panel and turn ON the circuit breaker labeled Console.
- Increase the engine speed to operating RPM.
- Turn OFF the circuit breaker labeled Console.
- Go to the crane, extend and deploy the outriggers.
- Level the crane using the leveling sight gauge on the back bumper.
- Move the crane from its folded position.
- Place the sheave wheel jig in the holder on the bumper and place the sheave wheel assembly in the jig. Note: the encoder box faces toward the driver's side of the vehicle.
- Manipulate the crane over the jig and attach the sheave wheel's shackle securely to the end of the crane.
- Connect the retractile cord to the encoder receptacle found on the side of the encoder box.

F3.5 Extend the Crane Over the Borehole

- Use the levers on the Distributor Panel to position the sheave wheel/crane over the borehole.
- Loop the logging cable through the sheave wheel.
- Lift the crane boom to the horizontal position and hook the vertical support poles to the end of the crane.
- Apply a light down force on the vertical poles with the boom to set the poles firmly in place.

F3.6 Attach Neutron-Capture Sonde to the Cable Head and Position in Verifier

- Check that the NIM Bin power switch is OFF before connecting the sonde to the cable head.
- Disconnect and remove the SGLS/HRLS sonde from the auto-fill system.
- Align the 22-pin and step-up connector on the sonde to the notch and step-down connector on the cable head.
- Attach the two pieces together being careful not to break or damage the pin connectors and O-ring seal.

- Hand-tighten the cable head nut to the sonde.
- Use a spanner wrench to securely tighten the sonde and cable head.
- Position the centralizer on the sonde.
- Remove the KUTh verifier from the locked compartment and position it over or near the borehole. Place the sonde in the verifier.

F3.7 Perform the Power Up, Power Down Sequence

- Enter the Instrument Cabin.
- Check that all switches and circuit breakers are in the OFF position.

F4.0 System Power/Up Down Sequence

The logging system has a specific "Power Up, Power Down Sequence" that is followed when applying electrical power to the system. The order in which the circuit breakers and equipment switches are turned ON and OFF can affect supporting systems and possibly damage electrical circuitry if performed out of sequence. The following Power Up, Power Down Sequence assumes that both the *Preparations Procedure* (Appendix A) and the *Borehole Set Up Procedure* (Appendix B) are completed.

Go to the Instrument Cabin and perform the follow steps:

- All circuit breakers and individual power switches should be in the OFF position at the beginning of this sequence.

- Turn ON the Sensor and Console circuit breakers on the DC side - red LED labeled "Console" on the OC illuminates and a red LED labeled "DC Power" on the Sensor Panel illuminates.

- Apply the Hoist Brake on the Operations Console - red LED labeled "Brake" illuminates.

- Increase engine speed to Operating RPM between 1,100 and 1,400 RPM. Check the Hydra-Gen® frequency meter to ensure nominal 60 Hz.

- Turn ON the Computer, Wall-1, Air Conditioning, and Wall-2 circuit breakers on the AC side.

- Energize the Uninterruptible Power Supply, (top button labeled "Test" for ON, bottom unlabeled button is OFF) hold for 1 second – two green-segmented LED graph displays illuminate on the UPS and a red LED labeled "AC Power" on the Sensor Panel illuminates.

- Turn ON the EG&G NIM Bin module in the equipment rack - an amber color pilot light illuminates. (Be sure a sonde is attached to the logging cable).

- Turn ON the Computer CPU – red LED illuminates and the operating system initiates. The computer monitor also turns ON with the CPU.

- Turn ON the toggle switch labeled “HV1” on the Signal Monitor Panel - a red LED illuminates.

- When shutting the system down, the above sequence should be followed in reverse order.

F5.0 Logging Operations

Implementation of this procedure assumes the following have been completed:

- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is complete.
- The high voltage to the sonde is ON and LN_2 is flowing.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring spectral gamma-ray data employing the neutron-capture sonde. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User’s Manual*, 1994 by Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.

- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

F5.1 Invoke the CASASII LOG Program

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.

- Press <CTRL+ESC> to display the Start Menu.
- Point to “Shut Down . . .” using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to “Restart the computer in MS-DOS mode?” <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.
- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu screen.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.

- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the screen "Alarms Off."

F5.2 Make a New or Select an Existing Data Directory

From the CASASII Main Menu:

- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.

Option 1:

- Press **F1** – *Set Default Data Directory*. Select a directory that already exists. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.

Option 2:

- Press **F3** – *Make Data Directory*. Create a new directory. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↵.
- Press **F1** – *Set Default Data Directory*. Select the new directory created from the above step using the <Arrow Keys>, press the keyboard <Spacebar> to invoke it.
- Press <ESC> to return to the CASASII Main Menu.

F5.3 Neutron Capture Logging Setup and Borehole Information

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <SGLS.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. This will load the correct 921-MCB setup, check the 973-amplifier settings. The CASASII Main Menu reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the SGLS set up. The LOG program will prompt an Y/N response to edit entries. Enter yes (Y) and edit the fields as necessary, include a new File Header name. <Return↵.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization* indicating the data was successfully completed.

Option:

- Press **F9** – *Save Initialization Defaults*. Save this edited initialization file, if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↵.

F5.4 Detector Pre-Survey Calibration and System Warm-Up

Verify the sonde is properly installed in the field verifier.

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.
- Press **F2** – *Live Time* and enter **1,000** seconds in the Acquire request. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Start the **30-minute** warm up period. Proceed with the fine-gain adjustment as required to align calibration peaks with the appropriate channel. As determined at the sonde calibration.
- Press F10 - *Clear* again and collect a verification spectrum for the full **1,000** seconds.

F5.5 Detector Pre-Survey Calibration

- Execute energy-calibration sequence per CASSAS procedures manual.
- Save the spectrum and analyze as described in the Data Analysis Manual (DOE 2003) to determine if the system has achieved the acceptance criteria. If acceptance is not achieved, allow the system to continue warm-up. If the system does not achieve acceptance following continued warm-up suspect system failure and take appropriate measure to correct the malfunction.
- If acceptance criteria are met, the system is ready for logging. Remove the sonde from the verifier and place the verifier in appropriate storage.
- Install a centralizer on the sonde when logging 6-, 8-, and 10-in. boreholes.

F5.6 Neutron Source Installation

- Remove neutron source in shipping shield from source storage compartment or designated source storage area and place it within easy reach of the well head.
- Position and zero the logging tool in the well to be logged. Then pull the tool out of the well so it is approximately 3 feet above ground level.
- Remove Cf^{252} source from source shipping shield, using source handling tool, install in source receptacle on logging tool and lightly tighten. Remove source-handling tool from source and immediately signal an assistant at the logging truck hoist lower the tool into the well to the top of the cable head and record depth registered on counter on the BSDS. The source handler shall have been trained on safe handling of the source (Appendix J, *Neutron Source Handling and Operation*).
- Reverse steps for source removal.

F5.7 Detector Pre-Survey Energy Calibration

- Execute *Detector Calibration* **F2** from the main menu screen for energy calibration.
- Select *Precal* **F7** on the calibration screen) and set up to acquire a spectrum for 1,000 seconds. Press **F5** to begin the collection.
- The 2.2 Mev Hydrogen peak shown in the displayed spectrum should be located within the range of channels 1820 to 2220 of the 8K-channel spectrum.
- Press **F12** again to toggle the acquisition controls.
- Select *Cur 1b*, using **F11**, and move it onto the centroid of the Hydrogen 2.2 Mev peak using the cursor control keys. Note the channel indicated on the screen.
- Adjust the fine gain on the 973 amp, as necessary, and press **F10** to restart the acquisition.
- Repeat this process until the 2.2 Mev Hydrogen is within the range of channels 1820 to 2220 of the 8K-channel spectrum. Typically the signal gain will stabilize near the end of the 10-minute warm-up period, so do not make these fine adjustments until the end of this period. When the peak has stopped drifting, let the system count for the full 1,000 seconds.
- The spectrum will be displayed on the computer monitor. The logging engineer will verify that a full spectrum has been acquired and that the neutron spectrum has the expected shape.
- Collect energy-calibration spectra (1,000 sec.).
- Execute energy-calibration sequence per CASSAS procedures manual.
- Evaluate the Fe Peak @ 7645 keV and the H Peak @ 2223 keV in the pre-survey calibration spectrum as described in the Data Analysis Manual to determine if the system is operating within the acceptance criteria. If acceptance criteria are not achieved fine gain adjustments may be required, or continued warm-up. If the system does not achieve acceptance following continued warm-up suspect system failure and take appropriate measure to correct the malfunction.
- If acceptance criteria are met, the system is ready for logging.

F5.8 Zero-Depth Reference and Setting the Initial Depth

Establish the zero depth reference on the sonde. It may be a scribe line marked around the bottom of the turned-down section of the housing or may be some other location on the sonde housing. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable.

- Note the borehole's zero-depth reference on the Log Data Sheet.
- Release the hoist brake on the OC.
- Use the joystick and align the zero-depth references for both the sonde and borehole.
- Reset the depth counter on the OC to 0.00 ft.

F5.9 Depth Control

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵.
- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (between 1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the Log Data Sheet.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

F5.10 Acquire Spectra and Begin Logging

From the CASASII Main Menu:

- Press **F4** – *Acquire Spectra.* The Acquire Screen appears. This command may only be invoked if data were successfully completed for *Log Initialization* (F1), *Detector Calibration* (F2), and *Depth Control* (F3), which are indicated by a check mark (✓) to the right of each title. Proceed with data acquisition parameters.
- Press **F1** – *Move-Stop-Acquire.* Input a depth increment (usually 0.5 ft), counting time (300 sec. live time), and a stop logging depth.
- Press <Return↵. The software controlled log run starts. The LOG program automatically adds the file suffix <*.CHN> and sequentially numbers the data files.

F5.11 From the Instrument Cabin Monitor the Following Operations During Logging

- Spectrum collection
- Adjust gain stabilization as required and record those adjustments on the Log Data Sheet. List the affected depth and file number.
- Make entries as necessary on the Log Data Sheet and logbook.
- LN_2 flow
- Hydraulic fluid pressure
- Strain pressure
- Hydra-Gen® power output
- HV1 remains ON
- UPS power output
- Engine tachometer
- Engine gauges

- Hoist operation
- Crane position

F5.12 Ending a Log Run and Moving the Sonde

From the Acquire Spectra window: When the sonde reaches the stop depth, the LOG program automatically terminates the data acquisition process. The **F4** - *Acquire Spectra* window remains open, waiting on stand-by.

- Record on the Log Data Sheet the last file number recorded, depth achieved, and approximate time. All this information is found on the final spectra file.
- Press <ESC> to open to the CASASII Main Menu.
- If a Repeat Log Run is required, proceed to that section now, if not continue.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth.
- Press <ESC> to open to the CASASII Main Menu.

F5.12.1 Repeat Surveys

- Logging system performance should be evaluated by performance of a repeat survey of at leat 10 percent of the length of the initial survey. Exceptions of this value may be granted based on specific project goals.

- Log interval that should be considered for repeat surveys are intervals of moderate detector response, intervals that include overlaps of consecutive log runs, or intervals within which the gamma-ray intensity increases or decreases.

- Interval of repeat surveys should be recorded on the Log Data Sheet as an ordinary log run and should be identified as a repeat survey.

F5.13 Check the Zero-Depth Reference

- After the sonde has returned to 00.0 ft, record on the Log Data Sheet the discrepancy between the original and return zero-depth references.

Option 1:

- Logging will continue with a new log run, a Repeat Log Run, or changing locations. Change file name as appropriate, move to new depth, and acquire data.

Option 2:

- Logging is finished for the day; proceed with collecting a post-survey calibration spectrum. The post-survey calibration is performed in the same location as the pre-survey calibration.

F5.14 Detector Post-Survey Calibration

Detector post survey calibration will be performed at the end of each log survey or daily as required for a particular project. Detector post-survey calibration shall be performed as described in Section 5.5, “Detector pre-survey calibration”, and in Section 5.7, “Detector pre-survey energy calibration.”

Remove the neutron source from the sonde with the handling tool and install in the storage container as discussed in Section 5.6.

F6.0 Termination of Logging

At the conclusion of logging the following procedures should be implemented:

F6.1 Exit CASASII LOG Program

- Press <ESC> on the keyboard while the CASASII Main Menu is open.
- The LOG program prompts an Y/N box – Do you wish to quit now?
- Press yes (Y) to close CASASII Main Menu and exit to the MS-DOS window.
- This syntax appears, C:\LOG>_.
- Type EXIT. <Return↵. “Windows is starting” appears.

F6.2 Transfer Data Files and Shut Down the Logging Computer

- Copy the set of spectra files just collected from the logging computer to the mass storage device. Transfer this data to the Stoller office for analysis.
- Complete and sign the Log Data Sheet(s), and complete entries in the system logbook and sign and date the appropriate page(s).
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to “Shut Down . . .” <Return↵.
- Wait for Windows 95 to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch.
- Turn OFF the NIM Bin power switch.

F6.3 Equipment Rig Down

- Stow and lock the KUTh verifier in the storage compartment.
- Remove the sonde from the cable head, stow the sonde in the tray, and attach the LN_2 dispensing system. Turn the LN_2 ON.

- Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position, and secure.
- Lift the outriggers and stow the pads.
- Secure loose items, stow portable stairs, and secure doors.
- Close the Hydra-Gen® compartment door and secure.

Walk around the truck before moving it.

F7.0 Decontamination

As directed in the RWP or other project documentation, the logging cable and sonde may be surveyed as they are withdrawn from the borehole(s). If contamination is detected, the RCT will direct decontamination of the affected components.

F8.0 References

Department of Energy (DOE) 2003. *Hanford Geophysical Logging Project, Data Analysis Manual*, prepared for the Department of Energy by the S. M. Stoller Corporation, GJO-HGLP 1.6.3, Rev. 0, Richland, WA.

Greenspan, 1994, *Computer Automated Spectral Acquisition System II (CASASII) User Manual*, Greenspan, Inc., Houston, Texas.

Appendix G
Directional Gamma Logging Procedure

Directional Gamma-Ray Logging Procedure

G1.0 Purpose

This procedure provides the guidelines for conducting directional gamma-ray surveys. Directional gamma-ray logging is conducted at discrete depths of interest in boreholes and may be used to identify the radial position of point source gamma-ray emitting radionuclides. The depth locations of interest shall be determined by passive gamma-ray logging.

G2.0 System Preparation

G2.1 Inspection

Qualified drivers will perform the following inspection.

- A pre-trip vehicle <u>safety</u> inspection following the D.O.T. *Federal Motor Carrier Safety Regulations* and Washington State's *Commercial Driver's Guide* to be satisfied that the motor vehicle is in <u>safe</u> operating condition.

G2.2 Document the Inspection

Drivers prepare, date, and sign the following documents.

- Driver's Vehicle Inspection Report. Leave one copy of the report in the booklet and submit one copy with that day's work documents.
- Daily Inspection Log. Leave for review by the Stoller Project Coordinator and turn in monthly.

G2.3 Vehicle Start-Up

Go to the driver's cab and prepare to start the vehicle.

- Place the vehicle's 6-speed transmission in NEUTRAL.
- Switch OFF the PTO (right hand position, red LED OFF).
- Switch the Front Axle to Disengage (right hand position, red LED OFF).
- Switch the Transfer Case to HIGH (left hand position).
- Push in the clutch.
- Start the engine and monitor the gauges.

G2.4 Air Brakes

With the engine running observe the following.

- Ensure that the air-pressure warning buzzer is operating and air pressure is increasing.
- Wait for the air tank pressure to reach the "cut-out" level around 70 PSI.

G2.5 Parking Brake Control

Getting ready to move the vehicle.

- Release the parking brakes by pushing IN the diamond shaped, yellow, push-pull control knob located on the right side of the dash.

G2.6 Driving

- Licensed drivers will drive the vehicle according to normal and standard operating rules of the road obeying traffic laws at all times.

G2.7 Drive to the Borehole Location

- Drive to the borehole location.
- Stop the vehicle and engage the parking brake; place the vehicle's transmission in NEUTRAL.

G3.0 System Setup

G3.1 Position the Logging Vehicle over a Borehole

- Walk around the borehole, look for ground and overhead hazards.
- Select a level location between 11 and 16 ft away from the borehole.
- Carefully back up the vehicle to that area - use a spotter if possible. When backing, align the borehole and centerline of the vehicle.
- Stop when the rear bumper reaches the 11- to 16-ft range. Check the alignment of the centerline again and adjust as necessary.
- Engage the parking air brake; pull the yellow diamond OUT.
- Leave motor ON and idling.
- Place the vehicle's transmission in NEUTRAL.
- Set out wheel chocks.
- Set up instrument cabin ladder, hoist equipment ladder, and open canvas drape.
- Top-off the Dewar if necessary by turning ON the auto-fill system.

G3.2 Go to the Hydra-Gen® Compartment

- Open and latch the generator's compartment door against the vehicle.
- Check that main power cable coming from the Hydra-Gen® is connected to the main power receptacle.
- Main circuit breaker switch is ON.

G3.3 Go to the Driver's Cabin - Perform the Power Train and Air Switch Setup

- Depress vehicle clutch.
- Switch PTO air switch ON (left hand position, red LED illuminates).
- Switch transfer case air switch to NEUTRAL (middle position).
- Switch front axle to disengaged (right hand position).
- Shift the vehicle's transmission into 6^{th} gear.
- Slowly engage vehicle clutch.

G3.4 Attach the Sheave Wheel Assembly to the Crane

- Go to the Power Distribution Panel and turn ON the circuit breaker labeled Console.
- Increase the engine speed to operating RPM.
- Turn OFF the circuit breaker labeled Console.
- Go to the crane, extend and deploy the outriggers.
- Level the crane using the leveling sight gauge on the back bumper.
- Move the crane from its folded position.
- Place the sheave wheel jig in the holder on the bumper and place the sheave wheel assembly in the jig. Note: the encoder box faces toward the driver's side of the vehicle.
- Manipulate the crane over the jig and attach the sheave wheel's shackle securely to the end of the crane.
- Connect the retractile cord to the encoder receptacle found on the side of the encoder box.

G3.5 Extend the Crane over the Borehole

- Use the levers on the Distributor Panel to position the sheave wheel/crane over the borehole.
- Loop the logging cable through the sheave wheel.
- Lift the crane boom to the horizontal position and hook the vertical support poles to the end of the crane.
- Apply a light down force on the vertical poles with the boom to set the poles firmly in place.

G3.6 Attach Directional Gamma Sonde to the Cable Head and Position in Verifier

- Check that the NIM Bin power switch is OFF before connecting the sonde to the cable head.
- Disconnect and remove the sonde from the auto-fill system.
- Align the 22-pin and step-up connector on the sonde to the notch and step-down connector on the cable head.

- Attach the two pieces together being careful not to break or damage the pin connectors and O-ring seal.
- Hand-tighten the cable head nut to the sonde.
- Use a spanner wrench to securely tighten the sonde and cable head.
- Position the centralizer on the sonde.
- Remove the KUTh verifier from the locked compartment and position it over or near the borehole. Place the sonde in the verifier.

G3.7 Perform the Power Up, Power Down Sequence

- Enter the Instrument Cabin.
- Check that all switches and circuit breakers are in the OFF position.

G4.0 System Power/Up Down Sequence

The logging system has a specific "Power Up, Power Down Sequence" that is followed when applying electrical power to the system. The order in which the circuit breakers and equipment switches are turned ON and OFF can affect supporting systems and possibly damage electrical circuitry if performed out of sequence. The following Power Up, Power Down Sequence assumes that both the *Preparations Procedure* (Appendix A) and the *Borehole Set Up Procedure* (Appendix B) are completed.

Go to the Instrument Cabin and perform the follow steps:

- All circuit breakers and individual power switches should be in the OFF position at the beginning of this sequence.

- Turn ON the Sensor and Console circuit breakers on the DC side - red LED labeled "Console" on the OC illuminates and a red LED labeled "DC Power" on the Sensor Panel illuminates.

- Apply the Hoist Brake on the Operations Console - red LED labeled "Brake" illuminates.

- Increase engine speed to Operating RPM between 1,100 and 1,400 RPM. Check the Hydra-Gen® frequency meter to ensure nominal 60 Hz.

- Turn ON the Computer, Wall-1, Air Conditioning, and Wall-2 circuit breakers on the AC side.

- Energize the Uninterruptible Power Supply, (top button labeled "Test" for ON, bottom unlabeled button is OFF) hold for 1 second – two green-segmented LED graph displays illuminate on the UPS and a red LED labeled "AC Power" on the Sensor Panel illuminates.

- Turn ON the EG&G NIM Bin module in the equipment rack - an amber color pilot light illuminates. (Be sure a sonde is attached to the logging cable).

- Turn ON the Computer CPU – red LED illuminates and the operating system initiates. The computer monitor also turns ON with the CPU.

- Turn ON the toggle switch labeled "HV1" on the Signal Monitor Panel - a red LED illuminates.

- When shutting the system down, the above sequence should be followed in reverse order.

G5.0 Logging Operations

Implementation of this procedure assumes the following have been completed:

- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is complete.
- The high voltage to the sonde is ON and LN_2 is flowing.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring spectral gamma-ray data employing the directional gamma sonde. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User's Manual*, 1994 by Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.

- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

G5.1 Invoke the CASASII LOG Program

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.

- Press <CTRL+ESC> to display the Start Menu.
- Point to "Shut Down . . ." using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to "Restart the computer in MS-DOS mode?" <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.

- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu screen.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.
- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the screen “Alarms Off.”

G5.2 Make a New or Select an Existing Data Directory

From the CASASII Main Menu:

- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.

Option 1:

- Press **F1** – *Set Default Data Directory*. Select a directory that already exists. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.

Option 2:

- Press **F3** – *Make Data Directory*. Create a new directory. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↵.
- Press **F1** – *Set Default Data Directory*. Select the new directory created from the above step using the <Arrow Keys>, press the keyboard <Spacebar> to invoke it.
- Press <ESC> to return to the CASASII Main Menu.

G5.3 Directional Gamma Logging Setup and Borehole Information

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <SGLS.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. This will load the correct 921-MCB setup, check the 973-amplifier settings. The CASASII Main Menu reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the directional gamma set up. The LOG program will prompt an Y/N response to edit entries. Enter yes (Y) and edit the fields as necessary, include a new File Header name. <Return↵.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization* indicating the data was successfully completed.

Option:

- Press **F9** – *Save Initialization Defaults*. Save this edited initialization file, if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↵.

G5.4 Detector Pre-Survey Calibration and System Warm-Up

Verify the sonde is properly installed in the field verifier.

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.
- Press **F2** – *Live Time* and enter **1,000** seconds in the Acquire request. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Start the **30-minute** warm up period. Proceed with the fine-gain adjustment as required to align calibration peaks with the appropriate channel. As determined at the sonde calibration.
- Press F10 - *Clear* again and collect a verification spectrum for the full **1,000** seconds.

G5.5 Detector Pre-Survey Calibration

- Execute energy-calibration sequence per CASSAS procedures manual.
- Save the spectrum and analyze as described in the Data Analysis Manual (DOE 2003) to determine if the system has achieved the acceptance criteria. If acceptance is not achieved, allow the system to continue warm-up. If the system does not achieve acceptance following continued warm-up suspect system failure and take appropriate measure to correct the malfunction.
- If acceptance criteria are met, the system is ready for logging. Remove the sonde from the verifier and place the verifier in appropriate storage.

G5.6 Zero-Depth Reference and Setting the Initial Depth

Establish the zero depth reference on the sonde. It may be a scribe line marked around the bottom of the turned-down section of the housing or may be some other location on the sonde housing. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable. Tool reference zero shall coincide with the reference used for the spectral gamma-ray log survey since these data define the depth location for the directional survey.

Casing specifications shall be verified with previous spectral gamma log survey, record differences on the Borehole Data Sheet. At active sites, where ground surface is estimated and/or borehole installation is recent, the casing stickup shall be recorded.

A directional azimuth position should be established and marked on the casing or other identifiable means.

G5.7 Depth Control

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵>.
- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵>; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (between 1-30 ft/min), <Return↵>. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the Borehole Data Sheet.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

G5.8 Acquire Spectra and Begin Logging

- Attach logging tool centralizer when the inside diameter of the casing is greater than 4.5 inches.

- Align well head directional fixture with casing reference mark and secure to well head.

- Attach alignment tubing to top of logging probe, lower probe into borehole and secure tubing in wellhead directional fixture.

- Position logging tool at "reference" position. (Center of primary detector is located at depth reference datum.)

- Move probe to predefined depth location for directional measurements.

- Acquire stationary measurements at each of 8 locations (points around the compass) at times specified by the project scientist. Document measurements on Borehole Data Sheet. Do not twist probe cable beyond 180 degrees in well head fixture.

- Review results and identify locations for intermediate measurement directions.

- Advance the probe to the next predefined depth location for directional measurement set and repeat the previous two steps.

- Return probe to surface, removing alignment tubes as required and removing well set directional measurement fixture. Verify well-head fixture retained orientation with casing reference mark.

G5.9 From the Instrument Cabin Monitor the Following Operations During Logging

- Spectrum collection
- Adjust gain stabilization as required and record those adjustments on the Borehole Data Sheet. List the affected depth and file number.
- Make entries as necessary on the Log Data Sheet and logbook.
- LN_2 flow
- Hydraulic fluid pressure
- Strain pressure
- Hydra-Gen® power output
- HV1 remains ON
- UPS power output
- Engine tachometer
- Engine gauges
- Hoist operation
- Crane position

G5.10 Ending a Log Run and Moving the Sonde

When all of the measurements at a particular depth location, move the sonde to another location or end the log run and return to the surface (zero reference point).

- Press <ESC> to open to the CASASII Main Menu.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth or to the zero reference point.
- Press <ESC> to open to the CASASII Main Menu.

G5.11 Check the Zero-Depth Reference

- After the sonde has returned to 00.0 ft, record on the Borehole Data Sheet the discrepancy between the original and return zero-depth references.

- If logging is finished for the day; proceed with collecting a post-survey calibration spectrum.

G5.12 Detector Post-Survey Calibration

Detector post survey calibration will be performed at the end of each log survey or daily as required for a particular project. Detector post-survey calibration shall be performed as described in Section 5.5, "Detector pre-survey calibration", and in Section 5.7, "Detector pre-survey energy calibration."

G6.0 Termination of Logging

At the conclusion of logging the following procedures should be implemented:

G6.1 Exit CASASII LOG Program

- Press <ESC> on the keyboard while the CASASII Main Menu is open.
- The LOG program prompts an Y/N box – Do you wish to quit now?
- Press yes (Y) to close CASASII Main Menu and exit to the MS-DOS window.
- This syntax appears, C:\LOG>_.
- Type EXIT. <Return↵. "Windows is starting" appears.

G6.2 Transfer Data Files and Shut Down the Logging Computer

- Copy the set of spectra files just collected from the logging computer to the mass storage device. Transfer this data to the Stoller office for analysis.
- Complete and sign the Borehole Data Sheet(s), and complete entries in the system logbook and sign and date the appropriate page)s)..
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to "Shut Down . . ." <Return↵.
- Wait for Windows 95 to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch.
- Turn OFF the NIM Bin power switch.

G6.3 Equipment Rig Down

- Remove the sonde from the cable head, stow the sonde in the tray, and attach the LN_2 dispensing system. Turn the LN_2 ON.
- Stow and lock the KUTh verifier in the storage compartment. Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position, and secure.
- Lift the outriggers and stow the pads. Secure loose items, stow portable stairs, and secure doors.
- Close the Hydra-Gen® compartment door and secure.

Walk around the truck before moving it.

G7.0 Decontamination

As directed in the RWP or other project documentation, the logging cable and sonde may be surveyed as they are withdrawn from the borehole(s). If contamination is detected, the RCT will direct decontamination of the affected components.

G8.0 References

Department of Energy (DOE) 2003. *Hanford Geophysical Logging Project Data Analysis Manual*, prepared for the Department of Energy by the S. M. Stoller Corporation, GJO-HGLP 1.6.3, Rev. 0, Richland, WA.

Greenspan, 1994, *Computer Automated Spectral Acquisition System II (CASASII) User Manual*, Greenspan, Inc., Houston, Texas.

Appendix H
NMLS Logging Procedure

Neutron Moisture Gauge Logging Procedure

This procedure for the Neutron Moisture Logging System (NMLS) assumes that the following assumptions are met:

- Gamma 1 or Gamma 2 is the vehicle acquiring the neutron moisture data.
- The detector is a CPN International Model 503 Neutron Moisture Gauge.
- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is complete.
- The neutron moisture shield/calibration standard in ON the detector.
- The settings on the 621-amplifier match Figure F-1.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring neutron moisture data. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User's Manual,* 1994 from Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.
- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

Invoke the CASASII LOG program:

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.
- Press <CTRL+ESC> to display the Start Menu.
- Point to "Shut Down . . ." using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to "Restart the computer in MS-DOS mode?" <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.
- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu screen.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.
- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the main menu screen "Alarms Disabled."

Make a new or select an existing Data Directory.

From the CASASII Main Menu:
- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.

Option 1:

- Press **F1** – *Set Default Data Directory*. Select a directory that already exists. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.

Option 2:

- Press **F3** – *Make Data Directory*. Create a new directory. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↵.
- Press **F1** – *Set Default Data Directory*. Select the new directory created from the above step using the <Arrow Keys>, press the keyboard <Spacebar> to invoke it.
- Press <ESC> to return to the CASASII Main Menu.

Neutron moisture initialization and set up:

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <MOIST.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. This will load the correct 921-MCB and 672-amplifier settings. The CASASII Main Menu screen reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the neutron moisture set up. The LOG program will prompt an Y/N response to edit entries. Enter yes (Y) and edit the fields as necessary, include a new File Header name. <Return↵.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization,* indicating the data was successfully completed.

Option:

- Press **F9** – *Save Initialization Defaults.* Save this edited initialization file if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↵.

Detector pre calibration and system warm up:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.
- Press **F2** – *Live Time* and enter **100** seconds in the Acquire request. <Return↵.
- Press **F5** – *Start/Stop*. Begin acquiring a spectrum. A single peak will appear on or about channel **255** and at or near **700** counts per second.
- Start the **30-minute** warm up period. After 15 minutes, proceed with the fine-gain adjustment.

Fine-gain adjustment:

From the Calibration Screen: The 921-MCB is set up with a 512-channel spectrum and will display the neutron moisture peak on or about channel 255. Check that a full spectrum is on the screen especially toward the lower channels that none is missing. If gain drift has occurred, then the 621-amplifier needs adjustment to meet this set up parameter.

- Wait **15 minutes** while the instruments in the equipment rack warm up.
- Press **F10** – *Clear*. Restart acquiring data when the acquisition time expires.
- Press **F12** – *Scale.* A new set of function keys are displayed that can zoom in and out and pan across the graphical display.
- Press **F3** - *<X2>* to expand scale and **F4** – *X2>>* to pan across the graphical display to the neutron moisture peak.
- Press **F12** – *Return.* Return to the previous set of Scale controls.
- Press **F11** - *Cur1a/Cur1b/Cur2a/Cur2b*. Toggle to the cursor labeled **Cur1b**. Align cursor **Cur1b** over the centroid of the neutron peak at about channel 255. Note the Cur1b/neutron centroid channel number displayed on the screen.
- Rotate the pot labeled "fine gain" a few units on the 672-amplifer until the Cur1b/neutron centroid align. Note the channel number.
- Press **F5** – *Start/Stop* or **F10** – *Clear.* Restart collecting a spectrum. After adjusting the fine gain note if the Cur1b/neutron centroid align and the channel number.
- Repeat the above steps until the Cur1b/centroid align. Gain drift usually occurs when the power is first applied and stops after about 15 minutes.
- After the **30-minute** warm up period expires and the fine gain adjustments made, collect a calibration spectrum.
- Press **F10** – *Clear*. Collect a calibration spectrum for the full **100** seconds.

From the Calibration Screen:

An energy calibration is **not** assigned to the neutron spectrum. Verify that a full spectrum has been acquired and that the neutron spectrum has the expected shape.

- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Precal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAB.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F2** – *Detector Calibration,* indicating the data was successfully completed.

Log Data Sheet and stow the shield/calibration standard:

If the logging engineer's professional judgment indicates that the NMLS is ready to log, then he/she will do the following.

- Fill out the appropriate spaces on the **Log Data Sheet**.
- Remove the shield/calibration standard from the detector/source and secure it.

Zero-depth reference and setting the initial depth:

The zero-depth reference on the sonde is a white line marked near the detector/neutron source near the bottom of the sonde. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable.

- Note the borehole's zero-depth reference on the **Log Data Sheet**.
- Place the sonde in the borehole.
- Release the hoist brake on the OC.
- Use the joystick and align the zero-depth references for both the sonde and borehole.
- Reset the depth counter on the OC to 0.00 ft.

Depth control:

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵.
- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value between 1-30 ft/min, <Return↵. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the **Log Data Sheet**.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

Acquire spectra and begin logging:

From the CASASII Main Menu:

- Press **F4** – *Acquire Spectra.* The Acquire Screen appears. This command may only be invoked if data were successfully completed for *Log Initialization* (F1), *Detector Calibration* (F2), and *Depth Control* (F3), which are indicated by a check mark (✓) to the right of each title. Proceed with data acquisition parameters.
- Press **F1** – *Continuous.* A velocity and sample interval must be specified. Those inputs are usually 1-ft per minute and a 0.25-ft sample interval. Enter a stop depth.
- Press <Return↵. The software controlled log run starts. The LOG program automatically adds the file suffix <*.CHN> and sequentially numbers the data files.

From the Instrument Cabin monitor the following operations during logging:

- Spectrum collection
- Adjust fine gain as required and record those adjustments on the Log Data Sheet.
- Make entries as necessary on the Log Data Sheet and logbook.
- Strain pressure

- Hydraulic fluid pressure
- Hydra-Gen® power output
- HV1 remains ON (subject to change)
- UPS power output
- Engine tachometer
- Engine gauges
- Hoist operation
- Crane position

Ending a log run and moving the sonde:

From the Acquire Spectra window: When the sonde reaches the stop depth, the LOG program automatically terminates the data acquisition process. The **F4** - *Acquire Spectra* window remains open, waiting on stand-by.

- Record on the **Log Data Sheet** the last file number recorded, depth achieved, and approximate time. All this information is found on the final spectra file.
- Press <ESC> to open to the CASASII Main Menu.
- If a Repeat Log Run is required, proceed to that section now, if not continue.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth.
- Press <ESC> to open to the CASASII Main Menu.

Check the zero-depth reference:

- After the sonde has returned to 00.0 ft, record on the **Log Data Sheet** the discrepancy between the original and return zero-depth references.

Option 1:

- Logging will continue with a new log run, a Repeat Log Run, or changing locations. Change file name as appropriate, move to new depth, and acquire data.

Option 2:

- Logging is finished for the day; proceed with collecting a post calibration.
- Remove the shield/calibration standard from the storage compartment and attach it to the detector/source.

Detector post calibration spectrum:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The calibration screen appears.
- Press **F2** – *Live Time* and enter **100** seconds. <Return↵.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Do not make fine gain adjustments - acquire a spectrum until time elapses.

- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Postcal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAA.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Press <ESC> to return to the CASASII Main Menu.

Transfer data files and shut down the logging computer:

- Copy a set of spectra files from the logging computer to a mass storage device. This data is transferred to the MACTEC-ERS office for storage and analysis.
- Complete and sign the **Log Data Sheet(s)**.
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to "Shut Down . . ." <Return↵.
- Wait for Windows to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch and the NIM Bin power switch.

Equipment Rig Down:

- Remove the sonde from the cable head.
- Remove the centralizer.
- Remove the crossover sub from the detector/source/calibration standard.
- Stow the detector/source/calibration standard in the instrument/storage case.
- Stow and lock the neutron moisture gauge in the source compartment.
- Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position and secure.
- Lift the outriggers and stow the pads.
- Stow portable stairs and secure.
- Close the Hydra-Gen® compartment door and secure.

Perform the Power Up, Power Down Sequence (Appendix C) to finish.

Safety: Walk around the vehicle and make a final equipment check before leaving the borehole.

Appendix I
Passive Neutron Logging Procedure

Passive Neutron Logging Procedure

This procedure for performing passive neutron logging assumes that the following assumptions are met:

- The *Preparations Procedure* (Appendix A) is complete.
- The *Borehole Set Up Procedure* (Appendix B) is complete.
- The *Power Up, Power Down Sequence* (Appendix C) is complete.

The steps outlined below demonstrate just one method of setting up the CASASII LOG program for acquiring passive neutron data. Use these steps as a guide to become familiar with the CASASII LOG program. For more detail, consult the *CASASII LOG User's Manual,* 1994 from Greenspan, Inc., Houston, Texas.

General keyboard strokes are listed below to maneuver through the CASASII LOG program.

- Pressing <ESC> returns the user to the CASASII Main Menu.
- Pressing <ALT+Arrow Key Right/Left> moves the cursors 20 channels.
- Pressing <CTRL+Arrow Key Right/Left> moves the cursors 200 channels.

Invoke the CASASII LOG Program:

Start from the Windows 95 desktop screen and restart in MS-DOS mode by performing the following keyboard stokes.

- Press <CTRL+ESC> to display the Start Menu.
- Point to "Shut Down . . ." using <Arrow Keys> and <Return↵.
- Use the <Arrow Keys> and move to "Restart the computer in MS-DOS mode?" <Return↵.
- A MS-DOS window appears displaying this syntax, C:\Windows>_.
- Change directories; type CD C:\ and <Return ↵.
- New syntax appears, C:\>_.
- Change directories; type CD LOG:\ and <Return ↵.
- New syntax appears, C:\LOG>_.
- Type LOG and <Return↵ to invoke the CASASII Main Menu screen.
- The CASASII Main Menu appears with twelve commands labeled F1-F12. The current File Header and Data Directory are also displayed.
- Press <CTRL+T> to disable the automated alarms. The LOG program makes a statement on the main menu screen "Alarms Disabled."

Make a New or Select an Existing Data Directory

From the CASASII Main Menu:

- Press **F6 -** *File/Directory Commands.* The File/Directory screen appears with six commands labeled F1-F6.

Option 1:

- Press **F1** – *Set Default Data Directory*. Select a directory that already exists. A list of directories that LOG can invoke appears. Use the <Arrow Keys> to select a directory, press the keyboard <Spacebar> to invoke it. Observe that the selected Data Directory name appears on the screen.

Option 2:

- Press **F3** – *Make Data Directory*. Create a new directory. Enter a directory name up to 8 characters. The LOG program automatically adds the directory suffix extension <*.DIR> <Return↲.
- Press **F1** – *Set Default Data Directory*. Select the new directory created from the above step using the <Arrow Keys>, press the keyboard <Spacebar> to invoke it.
- Press <ESC> to return to the CASASII Main Menu.

Passive Neutron Initialization and Setup:

From the CASASII Main Menu:

- Press **F8** – *Load Initialization Defaults*. A list of initialization files that LOG can invoke appears.
- Select <MOIST.INI> using the <Arrow Keys> and press the <Spacebar> to invoke it. This will load the correct 921-MCB and 672-amplifier settings. The CASASII Main Menu screen reappears.
- Press **F1** – *LOG Initialization*. A 16-field initialization screen appears, which contains a default profile of values for the passive neutron set up. The LOG program will prompt an Y/N response to edit entries. Enter yes (Y) and edit the fields as necessary, include a new File Header name. <Return↲.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F1** - *Log Initialization,* indicating the data was successfully completed.

Option:

- Press **F9** – *Save Initialization Defaults.* Save this edited initialization file if this set up profile is going to be used again in the future. A prompt box appears for a new file name and automatically adds the suffix extension <*.INI> <Return↲.

Detector Pre Calibration and System Warm Up:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The Calibration Screen appears with a graphical area for displaying spectral data in units of channels. Across the bottom, the screen has twelve function keys to input values, expand scale, and move two cursor pointers.
- Press **F2** – *Live Time* and enter **100** seconds in the Acquire request. <Return↲.

- Press **F5** – *Start/Stop*. Begin acquiring a spectrum. A single peak will appear on or about channel **255**.
- Start the **30-minute** warm up period. After 15 minutes, proceed with the fine-gain adjustment.

The passive neutron detector (optional instrumentation) is operationally verified by the Electronics Engineer in the geophysics laboratory prior to deployment for a project. The detector electronics records activity in counts per second and is not calibrated for varying environmental conditions or specific isotope concentrations.

Zero-Depth Reference and Setting the Initial Depth:

The zero-depth reference is identified on the sonde housing. The zero-depth reference for a borehole is usually the top of the casing, but the ground surface or other reference is acceptable.

- Note the borehole's zero-depth reference on the Log Data Sheet.
- Place the sonde in the borehole.
- Release the hoist brake on the OC.
- Use the joystick and align the zero-depth references for both the sonde and borehole.
- Reset the depth counter on the OC to 0.00 ft.

Depth Control:

From the CASASII Main Menu:

- Press **F3** – *Depth Control.* The Depth Control screen appears with four commands labeled F1-F4.
- Press **F2** – *Enter.* Enter values for borehole and sonde depth. <Return↵.
- A Y/N prompt box appears - move the detector to a new depth? A yes (Y) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value between 1-30 ft/min, <Return↵. The LOG program automatically starts moving the sonde to the new depth. A no (N) answer will return to the CASASII Main Menu.
- As the sonde moves, the Depth Control screen and OC both display current depth.
- When starting depth is reached, use the joystick, move the sonde to the nearest 0.5 ft, and record the starting depth on the Log Data Sheet.
- Press <ESC> to return to the CASASII Main Menu.
- A check mark (✓) will appear to the right of **F3** – *Depth Control,* indicating the data was successfully completed.

Acquire Spectra and Begin Logging:

From the CASASII Main Menu:

- Press **F4** – *Acquire Spectra.* The Acquire Screen appears. This command may only be invoked if data were successfully completed for *Log Initialization* (F1), *Detector*

Calibration (F2), and *Depth Control* (F3), which are indicated by a check mark (✓) to the right of each title. Proceed with data acquisition parameters.

- Press **F1** – *Continuous.* A velocity and sample interval must be specified. Those inputs are usually 1-ft per minute and a 0.25-ft sample interval. Enter a stop depth.
- Press <Return↵. The software controlled log run starts. The LOG program automatically adds the file suffix <*.CHN> and sequentially numbers the data files.

From the Instrument Cabin Monitor the Following Operations During Logging:

- Spectrum collection
- Adjust fine gain as required and record those adjustments on the Log Data Sheet.
- Make entries as necessary on the Log Data Sheet and logbook.
- Strain pressure
- Hydraulic fluid pressure
- Hydra-Gen® power output
- HV1 remains ON (subject to change)
- UPS power output
- Engine tachometer
- Engine gauges
- Hoist operation
- Crane position

Ending a Log Run and Moving the Sonde:

From the Acquire Spectra window: When the sonde reaches the stop depth, the LOG program automatically terminates the data acquisition process. The **F4** - *Acquire Spectra* window remains open, waiting on stand-by.

- Record on the Log Data Sheet the last file number recorded, depth achieved, and approximate time. All this information is found on the final spectra file.
- Press <ESC> to open to the CASASII Main Menu.
- If a Repeat Log Run is required, proceed to that section now, if not continue.
- Press **F3** – *Depth Control.* The depth control screen appears.
- Press **F5** - *Move*. A prompt box appears - move the detector to a new depth? A Y (yes) answer will request a depth be entered; <Return↵; followed by a second prompt - what speed should the hoist should move the sonde? Enter a value (1-30 ft/min), <Return↵. The LOG program automatically starts moving the sonde to the new depth.
- Press <ESC> to open to the CASASII Main Menu.

Check the Zero-Depth Reference:

- After the sonde has returned to 00.0 ft, record on the Log Data Sheet the discrepancy between the original and return zero-depth references.

Option 1:

- Logging will continue with a new log run, a Repeat Log Run, or changing locations. Change file name as appropriate, move to new depth, and acquire data.

Option 2:

- Logging is finished for the day; proceed with collecting a post calibration.

Detector Post Calibration Spectrum:

From the CASASII Main Menu:

- Press **F2** – *Detector Calibration*. The calibration screen appears.
- Press **F2** – *Live Time* and enter **100** seconds. <Return↵>.
- Press **F5** – *Start/Stop* to begin acquiring a spectrum.
- Do not make fine gain adjustments - acquire a spectrum until time elapses.
- Press **F7** – *Precal/Postcal/Prebak/Postbak* and toggle to **Postcal**.
- Press **F6 –** *Save.* Saves the calibration spectra to the default data directory. The LOG program automatically adds the file name extension <*CAA.CHN>
- On the calibration screen, the LOG program prompts "Saved Data, Hit Any Key."
- Press <ESC> to return to the CASASII Main Menu.

Transfer Data files and Shut Down the Logging Computer:

- Copy a set of spectra files from the logging computer to a mass storage device. This data is transferred to the Stoller office for storage and analysis.
- Complete and sign the Log Data Sheet(s).
- Press <CTRL+ESC> on the Windows 95 desktop to display the Start Menu.
- Use the <Arrow Keys> and move to "Shut Down . . ." <Return↵>.
- Wait for Windows to shut down.
- Turn OFF the power switch for the logging computer.
- Turn OFF the HV1 toggle switch and the NIM Bin power switch.

Equipment Rig Down:

- Remove the sonde from the cable head.
- Remove the centralizer.
- Stow the detector in the appropriate storage.
- Remove the sheave wheel from the crane and stow the logging cable.
- Drop the hoist compartment drape and secure.
- Break down the crane, fold the boom into traveling position and secure.
- Lift the outriggers and stow the pads.
- Stow portable stairs and secure.
- Close the Hydra-Gen® compartment door and secure.

Perform the Power Up, Power Down Sequence (Appendix C) to finish.

Safety: Walk around the vehicle and make a final equipment check before leaving the borehole.

Appendix J
Neutron Source Logging Procedure

Neutron Source Handling and Operation

J1.0 Purpose

This procedure governs the use of the source for the neutron capture sonde.

J2.0 Scope

The requirements of this procedure address personnel qualifications and responsibilities, facilities, dosimetry, equipment, equipment operation, documentation, and emergency response to be implemented during the use of the neutron capture measurement probe source.

J3.0 Responsibility

The probe source operator has the primary responsibility for ensuring the well logging is performed in a safe manner in accordance with this procedure. The probe source operator shall supervise all neutron well logging operations for open installations (field use) and specifically ensuring that before probe source operation:

- RADCON and facility operations conduct a pre-job safety briefing identifying plant alarm systems, RWP requirements, location of radiation boundaries (if any), and all adjacent areas where personnel could be affected by the probe source operation.

- All personnel within the 5 mrem/h boundary wear proper dosimetry, as identified on the RWP.

- The applicable RWP, and safe operation and emergency procedures are available at the job site.

- The well logging area is properly posted.

- Personnel exposures are kept as low as reasonably achievable (ALARA)

The probe source operator shall verify or have RADCON verify that boundaries are correctly or conservatively located, and that the neutron source and its production is properly shielded and secure following each operation. A neutron detection instrument such as a "Snoopy" shall be used for these verifications. The probe source operator shall ensure:

- That radiation postings are removed, the area cleaned up, and the proper facility notifications are made at the completion of the job.

- The proper handling, transportation, and storage procedures for the probe source are implemented.

J4.0 Administrative Control

J4.1 Radiation Work Permit

The facility Radiological Control organization section shall generate an RWP for approval and use of the radioactive source(s) used with the neutron capture measurement. All personnel involved with use of this device shall read and understand all provisions of the RWP associated with the use of neutron sources. Each individual must sign the RWP Acknowledgement sheet, indicating they have read and understand the applicable RWP. The RWP will specify the radiological controls required for all personnel involved with the use of the neutron source.

J4.2 Safe Operation and Emergency Procedures

A current copy of the main body of this procedure shall be located at all locations where the neutron capture devices are in use and where the neutron sources are stored.

J4.3 Dosimetry Requirements

Dosimetry requirements will be identified on the RWP.

J5.0 Inspection and Maintenance of the Neutron Source(s)

The source custodian or his alternate shall visually check for defects in the outer source encapsulation before its use on any day. Defective or suspected defective equipment or source encapsulation shall not be used and shall be tagged out of service. If, during the use of the source, personnel have reason to believe that the outer encapsulation may have been breached, all personnel in the immediate area will be notified and RADCON will be notified to verify the integrity of the capsulation. In the event of a source-handling drop, an integrity test would be obtained from RADCON prior to further use.

J6.0 Operations Log

An operations log shall be maintained at each location where the neutron source is used. The beginning and ending times that the source(s) is in use will be recorded in this log. A source checkout log is required if an individual is using the source. The following information is required on a source checkout log:

- Source custodian's name
- Source identification number
- Source isotope
- Source activity (Ci)
- Signature and payroll number of individual authorizing use
- Signature and payroll number of responsible source user
- Date and time source is removed from storage
- Destination for source use
- Date and time source is returned to storage
- Signature and payroll number of individual receiving source for storage

J7.0 Instrumentation

Instrumentation for monitoring radiological conditions will be determined and operated by the RADCON personnel assigned to the project.

J8.0 Use of Isotopic Neutron Source for Borehole Logging

This section establishes the requirements for the safe use of radioactive neutron sources associated with the development, testing, calibration, and operation of well logging neutron probes at well sites.

J8.1 Personnel Requirements

The RWP will state the requirements for RCT coverage. The RWP will also specify the radiological worker training required for all personnel who enter the radiation area established for use of the source. All personnel will exercise the principles of ALARA during use of radioactive sources and probe sources.

J8.2 Source Handling and Associated Probe Equipment

The neutron sources to be used are encapsulated isotopic or chemical radioactive sources. These sources continually produce neutrons of several MeV average energy. Gamma-ray and neutron detectors are used with the source to make a neutron capture detecting probe. The probe (source and detector) is used in calibration wells to test, evaluate, and calibrate its operation or to provide measurements in boreholes. A logging hoist will be used to deploy the neutron capture probe device in the boreholes. A 7/8-in. logging cable or an equivalent logging armored cable capable of supporting the weight of the probe will suspend the neutron capture probe. Data collection and processing electronics will be used with the logging truck to acquire and interpret the down hole measurements and to provide and store processed data.

The source capsules will routinely be used from within a removable source holder that attaches to the probe housings. This source holder connects to the logging tool housing by a threaded connection and will be installed or removed from the housing using a tool that allows the user to maintain a minimum 28-in. separation of extremities from the source capsule. The acceptable tool is a socket driver with a minimum 28-in. extension. The neutron source materials will be stored within the source holder in the shielded cask when not in use. The dose rate at the surface of any shipping cask will not exceed 200 mrem/h. Storing the source within a source holder will eliminate the need to insert and remove the source capsule from the holder for each use.

J8.3 Site Requirements

The encapsulated neutron source is authorized to be removed from the shielding/storage container to be used with the neutron and gamma ray detectors per the signed and approved procedure, when the requirements of the RWP are met. The sources will be stored in shielded shipping casks at the site approved by the RADCON organization. The shipping cask must either be secured in a locked enclosure or secured to a permanent and not easily movable structure to prevent unauthorized movement or theft.

J8.4 Usage Requirements

ALARA principles will be followed in the use of the neutron source.

When personnel are handling the source (such as when the source is being attached to the neutron capture probe), the shortest interval of time possible should be used. Sources whose on-contact total dose rate exceeds 50 mrem/h will be handled using remote implements that provide for a minimum 28-in. separation between the capsule and extremities. Handling of the sources will meet all requirements of the job-specific RWP. For the neutron capture probe, the source should be left deployed within the calibration wells between measurements to take advantage of the shielding provided by the sediments surrounding the well or materials in the calibration models. Personnel will maintain a safe distance, as directed by the RCT, between themselves and the source when their proximity to the source is not required. These time, distance, and shielding precautions will minimize personnel exposures. Because the expected personnel dose rates are negligible when the source is deployed in a borehole, no special precautions need to be taken during data acquisition.

When the source is being used to perform measurements not in a borehole, a temporary radiation area may need to be established and posted, as required by RADCON and the RWP. RCT coverage will be determined by the RWP requirements.

J9.0 Emergency Response

This section establishes the response to emergency situations incurred during well logging operations.

J9.1 General Requirements

The probe source operator has the necessary training and experience to handle emergency situations, and it is the operator's primary responsibility to assure the safety of all personnel during all operations. It is also very important that the operators recognize that an emergency situation exists before any overexposures occur.

Because it is impossible to foresee all potential accident scenarios, it is imperative, that if an emergency situation arises, that not only this document is followed but that common sense and good judgment be exercised.

J9.2 Emergency Situation

- In an emergency situation, remain calm, think clearly, and (if it can be safely performed) determine the extent of the problem by using a survey meter and/or by a visual examination. Remember to employ the concepts of time, distance and shielding to minimize exposures.

- Do not try to recover from the event by yourself as you may make the situation worse. With the area under surveillance, notify the project lead of the situation and the RADCON area supervisor and determine what should be done next. A recovery plan will be developed.

- If necessary, communicate the possible dangers to emergency response personnel.

- As soon as practical, document in detail the events of the emergency and any actions taken at the scene.

J9.3 Personnel Overexposure

Notify the manager of the probe source and RADCON immediately if you suspect that you or someone else has been overexposed.

J9.4 Unauthorized Entry into a Radiologically-Controlled Area

Unauthorized entry into a radiation-controlled area is a serious offense. The probe source operator shall record the individual's name and payroll number and report it to the Manager of the probe source and RADCON. The operator shall try to establish and document where the individual went and how long they were within the radiation area.

EMERGENCY NOTIFICATION LIST

Manager of the probe source	TBD

Designees

Probe Source Custodian	TBD
Probe Source Operator	TBD

RADCON Supervision

Applicable RADCON organization as identified on the RWP regulating the worksite.

Appendix K
Transferring Liquid Nitrogen
To Truck-Mounted Dewar

Transferring Liquid Nitrogen to Truck Mounted Dewar

General

Caution: Liquid Nitrogen can cause severe frostbite and can cause asphyxiation by displacing oxygen in a confined area. Handlers of this material must familiarize themselves with the Material Safety Data Sheet and the handling procedure found in the Truck Operations and Procedures Manual. All personnel should have proper training and instructions for the specific cryogenic liquid and equipment involved.

Personal Protective Equipment (PPE):

Handlers of liquid nitrogen must use the appropriate PPE, including the following: insulated leather gloves, raincoat, long-sleeve shirt or jacket, long pants, and closed top leather shoes.

Dewar Identification:

The permanently mounted dewars in the logging trucks will be referred to as "receivers" for this procedure. The freestanding dewars that are equipped with the pressure building feature are referred to a "supply" dewars.

Valve Identification:

The valves that are used in the following procedure have been given an alphabetical description designation that refers to Figure G-1.

Ball Valve Operation:

The valves on the liquid nitrogen system are configured to be closed when the valve handle is perpendicular to the piping and the direction of nitrogen flow through the valve body. They are configured to be open when the valve handle is parallel to the piping and the direction of nitrogen flow through the valve body.

Contamination Control Procedures:

This procedure must be performed in accordance with *Hanford Radiological Control Manual* (DOE 2001b). The flexible cryogenic transfer hose will be kept outside the controlled area fence. A plastic sleeve must be on the hose prior to the nitrogen transfer. Pass the hose through the fence and attach it to the receiver dewar. The hose must be surveyed by a HPT before withdrawing through the fence.

Figure G-1. Liquid Nitrogen Storage and Distribution System

Pressure Building Feature:

The supply dewars are equipped with a coil that encircles the dewar between the inner and outer stainless steel jacket. The function of the coil is to circulate a small amount of liquid nitrogen through a warmer surface, causing it to vaporize, and then reintroducing the gas into the dewar. The purpose of this feature is to increase the head pressure of the supply dewar to improve the efficiency of the liquid transfer process. This is accomplished by opening the pressure building (PB) valve A on the supply dewar.

Dewar Filling Procedure:

1. The truck tarp must remain up and the truck dewar's service door must remain open during this procedure to ensure adequate ventilation.

2. Close all ball valves on the receiver and supply dewars.

3. Check the sonde's auto fill electrical switch is OFF. Turn OFF if necessary.

4. Remove the protective end caps from the transfer hose and connect it to the liquid lines on the two dewars. The attachment point for the receiver dewar is located on the outside of the truck below the receiver dewar's service door. This fitting is protected with a brass cap. The attachment point for the supply dewar is located on the main liquid valve (F). Tighten the hose fittings with a wrench. Ensure the drain valve (G), located on the transfer hose, is closed.

5. Open the pressure building valve (A) on the supply dewar. Given time, the supply pressure can build to 200 psi.

6. Set the position of the four valves at the top of the receiving dewar:
   - Open the main liquid valve (B) to receive flow.
   - Open the liquid valve (C) to the copper fill line leading to the hose connection to receive flow.
   - Leave valve (D) to the sonde's auto fill system closed.
   - Open the vent valve (E). The receiving dewar is now actively expelling nitrogen gas from the dewar. Stay out of the winch compartment during the fill operation.

7. Open the main liquid valve (F) on the supply dewar slowly to prevent thermal shock to the piping and container, and possible excessive pressure build up within the system. The supply dewar is now actively transferring liquid nitrogen to the receiver dewar. Monitor the supply dewar's pressure gauge. As the transfer progresses the pressure steadily drops. Adequate transfer pressure is above 40 psi.

8. Monitor the receiver dewar and shut off the liquid nitrogen flow according to Step 10. The receiver dewar is full when the sight indicator glass reads full, when liquid nitrogen spits from the receiver dewar's vent, or when the pressure from the supply dewar drops below 40 psi.

9. If necessary, artificially build the receiver dewar's pressure to 15 psi or greater before disconnecting the transfer hose. This is accomplished by closing the receiving dewar's vent valve after it is full. Some residual pressure in the supply dewar will transfer to the receiver dewar boosting its head pressure. If 15 psi cannot be attained, reconnect the transfer hose to a second supply dewar and repeat the above steps. Pressure over 22 psi is automatically vented through the receiver dewar's safety relief valve. Immediately after a transfer, low head pressure lacks enough energy to push liquid nitrogen through the auto fill system. It may take up to 24 hours for the liquid nitrogen to build adequate head pressure to maintain operating levels. Inadequate head pressure could result in a warm tool.

10. When the transfer is complete, close all valves in the following order:
    - Vent valve (E) on receiver dewar.
    - Main liquid valve (F) on supply dewar after adequate pressure is built in the receiver dewar.
    - Liquid valves (B and C) at the top of the receiver dewar.
    - Pressure builder valve (A) on the supply dewar.

11. Open the pressure bleed valve (G) and allow the back pressure to escape before disconnecting the transfer hose. Avoid contact with any liquid draining from the valve.

12. Disconnect the transfer hose. Take care to avoid contact with any liquid remaining in the hose. Have an HPT perform the radiological survey before removing the hose from the fence. Place the end caps on the hose for storage. Store the hose, wrench, and PPE together for reuse.