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Flexible Receiver Radiation Detection System (FRRDS) Users Manual

GL Troyer

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Abstract: The Flexible Receiver Radiation Detection System (FRRDS) comprises a control computer, a remote data acquisition subsystem, and three hyperpure germanium gamma radiation detectors. The scope of this document is the description of various steps for the orderly start-up, use, and shutdown of the FRRDS. Only those items necessary for these operations are included. This document is a companion to WHC-SD-W151-UM-002, "Operating Instructions For the 42" Inch Flexible Receiver," WHC-SD-W151-UM-003, "Operating Instructions For the 4"-6" Inch Flexible Receiver," and the vendor supplied system users guide (Ref. 6).

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Flexible Receiver Radiation Detection System (FRRDS)
Users Manual

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Flexible Receiver Radiation Detection System (FRRDS) Users Manual

1 Introduction

The Flexible Receiver Radiation Detection System (FRRDS) comprises a control computer, a remote data acquisition subsystem, and three hyperpure germanium gamma radiation detectors. The control computer is located in the instrumentation trailer for the Flexible Receiver. The remote data acquisition subsystem is located within a few meters of the Flexible Receiver at the well head. The gamma detectors are mounted on the Flexible Receiver itself. An orderly process is required for proper start-up and shutdown.

2 Scope

The scope of this document is the description of various steps for the orderly start-up, use, and shutdown of the FRRDS. Only those items necessary for these operations are included. This document is a companion to WHC-SD-W151-UM-002, "Operating Instructions For the 42" Inch Flexible Receiver," WHC-SD-W151-UM-003, "Operating Instructions For the 4"-6" Inch Flexible Receiver," and the vendor supplied system users guide (Ref. 6).

3 Purpose

The purpose of this document is to identify requirements and steps for the orderly start-up, use and shutdown of the FRRDS.

4 Glossary and Definitions

bias voltage	An electrical potential used to condition electronic devices for certain operations. The bias voltage for germanium gamma detectors ranges from 2000 to 4000 V DC at a few 100 micro-amps.
pulse	A rapidly changing electrical voltage. Usually associated with detection of a gamma radiation event in this context. Usually less than 10 volts and of a few micro-seconds in duration.
cryostat	A thermos like container used to maintain materials at very cold temperatures. Typically a vacuum type thermos bottle used to hold

	liquified gases such as nitrogen or oxygen at their boiling point. Typically has an open mouth or loose fitting ambient pressure cap.
cool-down	Process by which gamma detectors are cooled with liquid nitrogen to operating temperature, 77°K.
Dewar	See cryostat
detector	A device for sensing a physical event or change, ie. radiation or temperature detector.
endcap	The front end of the detector housing. Typically, a high purity germanium detector is housed in a cylindrical vacuum body attached to a cryostat. The end of the tube away from the cryostat is the endcap. The endcap may be of thinner material than the body of the vacuum tube. The thin material minimizes shielding of gamma rays penetrating into the detector immediately inside the endcap.
FRRDS	Flexible Receiver Radiation Detector System: the gamma radiation monitoring system for the flexible receiver.
LN2	Liquified nitrogen gas, a cryogenic fluid at atmospheric pressure, 77°K.
top-off	Process of adding liquid to a container until full or at overflow.

5 Procedures

The following procedures identify general system operations per the flow chart identified in Figure 1.

5.1 Detector Cool-down

Prior to operation, the FRRDS gamma detectors must be filled with liquid nitrogen (LN2) and allowed to cool for a minimum of 5 hours. For practical scheduling, it is recommended that the detector cooling start a day prior to required operation. Once cooled, the detector cryostats are designed to hold

Figure 1 General System Operation Sequence

temperature for 4 days between filling. Daily checks of LN2 levels is required. It is recommend that the detectors be 'topped off' with LN2 at start of operable days. Otherwise, re-filling the detectors with LN2 for continuous operation can be accomplished safely on Fridays and Mondays.

Caution: Cycling the temperature of the detectors due to complete loss of LN2 can cause damage to or failure of the detectors.

Caution: Liquid nitrogen temperature level must be maintained on detectors when detector bias voltage is applied or system is energized and detectors are connected. Detector failure is likely should temperature control fail while voltage is applied.

5.1.1 Materials and Equipment

- 1) Liquid nitrogen (LN2) in dispensing cryostat (Dewar, thermos) containers. At least 20 liters of LN2 are required for initial cooldown and next day 'top off' of all detectors.
- 2) Metal funnel
- 3) Graduated wooden dowel or ruler at least 18 inches long to fit in detector cryostat mouth.
- 4) Leather gloves (standard work gloves).
- 5) Face shield.
- 6) Liquid nitrogen usage log (Appendix A).

5.1.2 Precautions

- 1) Liquid nitrogen is a very cold (cryogenic) liquid that rapidly cools (freezes) anything in prolonged contact such as clothing and skin.
- 2) Avoid contact and spatter by using personal protective equipment.
- 3) Momentary contact of droplets may be unavoidable but of low risk; use reasonable prudence in dispensing LN2.
- 4) Liquid nitrogen is typically delivered in 20 liter Dewars that are somewhat awkward as a primary dispenser. A single person can perform the lifting and dispensing, but two people are recommended.

5.1.3 Steps

Note: If detectors are known to be empty of LN2, skip to step 5.1.3.4.

Note: If detectors contain LN2, proceed with step 5.1.3.1.

5.1.3.1 Measure the liquid nitrogen level in detector cryostats by slowly inserting measuring stick into cryostat until reaching bottom.

5.1.3.2 After 5 to 10 seconds, withdraw the stick and wave in air until frost accumulates from the air humidity. Note or record frost line value. A suggested record form is shown in Appendix A.

5.1.3.3 Repeat steps 5.1.3.1 and 5.1.3.2 for each detector. Note whether all detectors have similar levels.

Note: Excessive use of LN2 is an indication of cryostat failure. Notify supervision if excessive use is observed.

5.1.3.4 To fill detector cryostat, remove insulated cryostat cap and insert metal funnel in mouth of cryostat. Use a small piece of rope, rubber or plastic tubing or tightly folded paper as a wedge between the funnel and the cryostat for vapor venting. Avoid allowing the 'wedge' to fall into the cryostat. Alternatively, an outside rib on the funnel at contact with cryostat mouth will allow sufficient venting.

5.1.3.5 Slowly dispense (pour) LN2 from the stock cryostat into the funnel. Rapid venting of nitrogen gas will occur when the LN2 contacts any warm surfaces. Venting will diminish as contacted materials are cooled. Continue slowly filling until LN2 begins to overflow cryostat mouth.

5.1.3.6 Replace cryostat caps and store supply cryostats.

5.2 Detector Placement and Electrical Connection

The detectors are used on fixed locations on the FRRDS. They are connected to a remote electronics cabinet by a cable set of wires providing power, control signals and detector pulse data. The detectors must be connected and placed after 'cool down'

5.2.1 Materials and Equipment

- 1) FRRDS Gamma Detectors (cooled, 4 ea.)
- 2) Interconnecting Electronic Cables (3 sets)
- 3) Remote electronics cabinet
- 4) Ethernet cable
- 5) Plastic sheeting for contamination protection
- 6) Power cable

5.2.2 Precautions

- 1) Do not energize system until all components are properly cabled in order to avoid open and active connector leads.
- 2) Do not energize detectors until proper cooldown is completed (section 5.1).
- 3) Use of plastic sheeting to protect equipment from radiation contamination is recommended. However, care should be taken to not cover air or ventilation ports on the electronics cabinet.

5.2.3 Steps

Note: Cables and connection points are identified with number labels. Refer to drawings H-2-79190 and EG&G 446926 for detail cable interconnection guidance.

Note: Nucleonics chassis must be placed sufficiently near Flexible Receiver to allow final cabled detector placement.

5.2.3.1 Remove storage end caps from detectors and ensure that barrel tape is not damaged or missing. If missing, cover any exposed areas with the same tape material.

5.2.3.2 Select the corresponding cable set for each detector and connect the individual cables to the detector per matching numbers on the cables and the detector pigtails.

For FRRDS-1: The cables are number as xy where x is the detector number (1-3) and y is the cable number (1-6).

For FRRDS-2: The cable sets resolve to 1, 2, and 3. Each set is a high voltage cable and a multiconductor cable.

- 5.2.3.3 Apply plastic sheeting to detector cryostat and electronic cable connections for protection from contamination and inclement weather conditions. Observe procedure precautions (section 5.2.2)
- 5.2.3.4 At the rear of the remote electronics module, connect the bundled cable sets to the receptacles on the chassis per the matching cable numbers.
- 5.2.3.5 Connect the EtherNet communications cable from the instrument trailer to the remote instrument module rear chassis connector labeled 'E'.
- 5.2.3.6 Connect line power to the rear of the remote instrument module rear chassis.

Note: General configuration and switch settings of modules is shown in Appendix D.

- 5.2.3.7 Open the front panel of the remote instrument module and insure that the High Voltage modules are switched off and set to zero volts on the 10-turn potentiometers.
- 5.2.3.8 Turn on the main power to the remote electronic chassis. Turn on the main chassis power at the rear of the remote instrument module.
- 5.2.3.9 At the front of the instrument module, switch on the High Voltage modules and slowly (100 volts per second or 500 volts per 5 seconds) adjust each voltage to the operating value written on the corresponding detectors.
- 5.2.3.10 Close the front panel to the remote instrument module.
- 5.2.3.11 Place each detector at its designated location on the FRRDS. A non-conducting centering pad is matched to the bottom of each detector cryostat. The barrel of the detector is carefully inserted into the shield receiver such that at final position it does not touch the shield housing.

5.3 Computer Start-up

Once the detectors and remote instrument module are ready, the control computer may be started. This startup order is required to obtain proper communications between all the equipment.

5.3.1 Materials and Equipment

- 1) MicroVAX computer and required associated peripherals
- 2) Special issue VAXGAP computer software package for the 3 detector system
- 3) Prepared and energized remote detector system (section 5.2)

5.3.2 Steps

Note: A generalized configuration diagram of the discussed components is shown in Figure 2.

5.3.2.1 Insure that computer system is in shutdown and power off mode. (See shutdown procedure if not.)

5.3.2.2 If not on, turn on laser printer. (Support cabinet power may need to be turned on; laser power switch is at rear of printer.)

5.3.2.3 Insure that uninterruptible power supply is on and functional per status lights.

5.3.2.4 Turn on computer power strip switch. (Power strip is resting at side of computer display unit.)

5.3.2.5 Allow automatic power up sequence to proceed. When complete the display will show the bootstrap request as shown in Figure 3

Figure 2 Orientation of System Components and Power Switches

Note: In certain situations, automatic boot may be stalled as shown in Figure 3. In this case, proceed to step 5.3.2.6. If bootstrap continues, skip step 5.3.2.6.

```
KA48-A V1.2-32B-V4.0
08-00-2B-8E
9MB
>>>
```

Figure 3 Startup Messages

5.3.2.6 Enter the bootstrap command as:

b Return

5.3.2.7 Perform login procedure, section 5.4.

5.4 Computer Login

Once the computer has been started, the user is required to log onto the system. User names and valid passwords for normal operations are recorded in the system log book. It should be noted that the computer system does not have a record of the current plain text passwords. Passwords entered by the user are stored in an encrypted form. Thus, either the user must remember the password, or the passwords must be kept in a controlled record. An example of the login screen is shown in Figure 4.

5.5 System Startup Verification

After Login and prior to routine operations, the system operability may be determined by starting an acquisition. This may be with or without radiation sources. Site conditions may be sufficient to provide ample signal to confirm readiness. Alternatively, a check source may be placed near the endcaps of the detectors and a short acquisition started as noted here.

5.5.1 Materials and Equipment

1) Configured and operational
FRRDS

Figure 4 Example of System Login Display

5.5.2 Steps

- 5.5.2.1 At the system prompt, start the Gamma Collection (GC) program by entering the command:

GC

- 5.5.2.2 After the GC program has started and the status display is presented, enter the following start acquisition command:

S;A1-A3,60

Note: The example command initiates detectors A1, A2, and A3 for a 60 second count time.

Note: The program will begin updating the status display showing data acquisition time and time remaining. Time is displayed in seconds.

- 5.5.2.3 At the end of the acquisition (time remaining is zero), enter the calculation and reporting commands:

DA;A1

DA;A2

DA;A3

Note: This step causes the program to automatically process the acquired data and to generate a report for each detector on the laser printer.

- 5.5.2.4 Log the operation and store the generated reports in operations data notebook. Review reports to determine operability of system.

5.6 Process Data Acquisition

Once the system has been configured and started, the user may control the data acquisition. For routine operations other than calibration, daily source checks, and background update, the automatic data acquisition and reporting sequence is used as follows. Appropriate other procedures may be found in the system users manual (Ref. 6).

5.6.1 Materials and Equipment

1) Configured and operational FRRDS

5.6.2 Steps

- 5.6.2.1 At the system prompt and just prior to begin of equipment retrieval, start the Gamma Collection (GC) program by entering the command:

GC **Return**

- 5.6.2.2 After the GC program has started and the status display is presented, enter the following automatic background scan command

BS;60 **Return**

- 5.6.2.3 At the end of a retrieval, enter the completion command:

ENDBS **Return**

- 5.6.2.4 Enter appropriate parameter and descriptive data into the system log book. Review reports. Perform any additional post retrieval data processes as directed.

5.7 System Shutdown

An orderly system shutdown is required to properly stop operations. In general, this is the reverse of the startup procedure except for the computer programs.

5.7.1 Equipment and Materials

1) Operational FRRDS

5.7.2 Steps

- 5.7.2.1 Exit the GC program by typing the combination keys:

CTRL **C**

- 5.7.2.2 Start the shutdown sequence by typing the command:

FRRDSDOWN **Return**

- 5.7.2.3 Power off computer system at power strip. Power off UPS at rear of unit.

Note: UPS may discharge to a non-recoverable state if not turned off and line power is interrupted (off) longer than rated capacity.

- 5.7.2.4 At remote instrument module, open the front panel and slowly lower the high voltage to each detector. Turn off high voltage modules when voltage has been brought to zero. Close front panel.
- 5.7.2.5 Turn off the remote instrument module at the rear chassis.
- 5.7.2.6 Unless more near term work is anticipated at current location, disconnect and store all signal cables. Place detectors in storage box.

Note: Maintenance of LN2 in detectors is recommended if operations are expected within at least two normal refill periods. Detectors may be moved while containing LN2 for normal operational support. Observe normal precautions as noted in section 5.1.2.

6 **References**

- 1 WHC-SD-W151-UM-002, "Operating Instructions For the 42" Inch Flexible Receiver".
- 2 WHC-SD-W151-UM-003, "Operating Instructions For the 4"-6" Inch Flexible Receiver".
- 3 Drawing 446929, "Hanford Computer Diagram and Wiring Interconnect," EG&G Idaho, Inc, September 1994, sheets 1 of 1.
- 4 Drawing 446926, "Hanford Gamma Ray Spectrometer System Rack, Wiring, Module, and Connection Diagram," EG&G Idaho, Inc, September 1994, sheets 1, 3, and 4 of 5.
- 5 Drawing H-2-79190, "LLCE Equipment Drawing Arrangement," Westinghouse Hanford Co., 1995.
- 6 Goodwin, S. G., J. K. Hartwell, L. O. Johnson, E. W. Killian, "Hanford #2 Spectrometer System Operator's and Service Guide," EG&G Idaho, Inc., ERA-NRE-94-103, September 1994.

Appendix B. Background Collection

The FRRDS system provides semi-quantitative gamma isotopic results based on calibration and background corrections. A background of ambient activity is maintained by the system and may be updated as operations warrant. Update would typically be at the start of new operations or a judged need to update due to process knowledge. A similar version of this procedure may be found in the systems user guide (Ref. 6).

- C.1 Start a spectral acquisition for five minutes (300 seconds) by entering the following command:

S;A1-A3,300 Return

- C.2 At completion, store the acquired backgrounds for new spectral acquisitions by entering the following command:

BKG;A1-A3 Return

Appendix C. System Calibration

System calibration is dependent on source to detector geometry and any interposed shielding. For FRRDS, geometry is the distance from the center of the retriever to the endcap of the detectors. Shielding is the Flexible Receiver housing and any lead at the detectors designed to control detector count rates. Not included in typical calibrations for FRRDS is self shielding of the source such as radioactivity inside of a pump housing being processed by the Flexible Receiver. Existing calibrations must be modified through manual computations to reflect process knowledge about the degree of self shielding from source to source.

Requirements:

- 1) A traceable source of ^{228}Th of approximately one microCurie.
- 2) Operational FRRDS positioned on a flexible receiver.

- C.1 Suspend the source in the center of the Flexible Receiver at the height of the FRRDS detector view ports.

Note: Shielding, source geometry, and source activity govern the amount of time required to obtain a valid calibration spectrum. This measurement may require as much as six hours of counting.

- C.2 Acquire calibration spectra sufficient for statistical validity (minimum 15 minutes) by entering the following command:

S;A1-A3,900 Return

- C.3 Start the calibration by entering the following command as described in section 2.8 of Ref. 6:

CB;A1 Return
 CB;A2 Return
 CB;A3 Return

- C.4 Record status of operations in system log book.

Appendix D. Nominal Electronics Settings

8713 ADC

Gain: 8K
 Coarse: 8K
 Offset Switches: All down
 Peak Detect/Auto: Up
 PHA: Up
 Anticoincidence: Down
 Gate in connected to Amp Unipolar Out.

2022 Amp

Coarse: 10
 Fine (detector dependent, nominal values):
 Set 1 978
 Set 2 965
 Set 3 940
 Shaping: 2
 Polarity (+): Up
 Unipolar out connected to ADC Gate in.

Figure 5 FRRDS-2 detector electronics position identification.