**Plutonium Isotopic Analysis System for Plutonium
Samples Enriched in ^{238}Pu in EP 60/61 Containers
Volume 2
Hardware Manual**

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June 1, 1990

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Volume 2 Hardware Manual

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Prepared under the auspices of Westinghouse Savannah River Company.

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PREFACE

This hardware manual is addressed to Savannah River Site supervisors and to authorized mechanical and electrical maintenance and service personnel. Each chapter begins with a table of contents that lists the section titles, illustrations, and tabular data presented in that chapter.

The first chapter in this manual is an introduction to the Pu-238 isotopic analysis system. Chapter 2 lists major components of the system and includes electronic block and wiring diagrams. Commercial nuclear instrument modules and their required settings are described in Chapter 3. Chapter 4 contains service and preventive maintenance procedures, as well as a troubleshooting log. In Chapter 5 is a list of spare parts and all relevant mechanical drawings for the system. Chapter 6 contains reference articles.

In addition to this manual, two other manuals complete the description of the Pu-238 isotopic analysis system. The Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923 Vol. 1) explains how to calibrate and operate the system. The Pu-238 Isotopic Analysis Software Manual (UCRL-CR-103923 Vol. 3) is presented in two parts. Part 1 describes the computer codes that control the instrument, analyze the spectral data, and determine the relative plutonium abundances. Part 2 contains the software listings of the instrument control and data analysis.

All commercial items mentioned in this manual are assumed to be functioning correctly for the purposes of system operation. Users are referred to individual equipment manufacturers' manuals for details of operation, troubleshooting, and maintenance of this commercial equipment.

This manual contains warnings, cautions, and notes set apart from the text by starred, solid, or dashed lines, respectively. A WARNING precedes an operation in which incorrect performance may endanger personnel. A CAUTION precedes an operation in which the equipment is at risk. A NOTE provides important supplementary information to the reader.

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Chapter 1

OVERALL SYSTEM DESCRIPTION

This chapter describes the Pu-238 isotopic analysis system. Its purpose is to provide a means to measure and, in concert with calorimetry data, determine the gram quantities of selected isotopes of plutonium in shipments of plutonium oxide materials enriched in Pu-238 to the Savannah River Site. For complete descriptions of the individual system components, see Chapter 2 of this manual and manuals prepared by individual equipment manufacturers. 4

1.1 SYSTEM DESCRIPTION

Lawrence Livermore National Laboratory's Pu-238 isotopic analysis system (Fig. 1-1) consists of two major parts: a germanium detector measurement system and electronic and computer support equipment. The germanium-detector spectrometer system records the gamma-ray spectrum emitted by a sample in a calorimeter canister. By using the measured relative intensities of selected gamma rays in each spectrum, the data analysis code determines the relative percentages of three isotopes of plutonium (Pu-238, -239, and -241) and americium-241. The relative abundances of the minor isotopes, plutonium-240 and plutonium-242, are not determined but are entered as constants or in the case of Pu-240 calculated by using an isotopic correlation. Once the relative isotopics are known, the analysis code prints out the specific heat in watts per gram with an error that is established by how well the relative isotopics have been measured. Calorimetry results yield watts; hence, a ratio of calorimetry to gamma-spectroscopy results yields the grams of plutonium in the sample.

Some of the gamma rays emitted by the sample enter the high-purity germanium detector and deposit energy (are detected) therein. The detector is an ORTEC coaxial n-type (COAX) detector. The gamma rays that interact with the detector deposit a small charge that can be collected at the detector anode by using an applied bias voltage. A charge-sensitive preamplifier senses the change in bias level within the detector, amplifies it, and routes it to the main amplifier.

The main amplifier properly shapes and conditions the pulses and then routes them to an analog-to-digital converter (ADC). Here, different pulse heights, corresponding to different gamma-ray energy depositions within the detector, are decoded into digital bits (larger pulses have more bits). Each detector event is stored in a pulse-height analyzer (PHA), which is connected to the ADC. Thus, as events are detected, they are sorted and stored according to their energy, or pulse height, in the PHA.

Fig. 1-1. (Top) Photograph of the Pu-238 isotopic analysis system and the rack-mounted electronic components. (Bottom) Photograph is a top view of the inside of the sample cave, and to the right side, the Lucite guide (shown removed) for guiding the sample onto the sample turntable.

When the spectral data accumulation is completed, the spectrum is stored in the computer's disk memory. Then the data-analysis software code processes the data to determine the relative percentages of plutonium isotopes in the sample's gamma-ray spectra. Once processed (about 1 min), the results are printed out on the operator's terminal. Results are stored in a circular file on a disk in the MicroVAX II minicomputer. The file holds 99 spectra; once a spectrum gets to position 99, the next spectrum stored will cause record number 99 to be lost.

1.2 SAMPLE CAVE

Figure 1-1 shows the Pu-238 isotopic system (top right) and the inside of the sample cave and lid (bottom right). From left to right (top right) are the central shielded cave, where the sample analysis is performed, and the COAX detector, above which can be seen the main control panel. Use of the control panel and the loading/unloading of samples are discussed in more detail in paragraph 1.3.

Lucite Guide. The bottom right photograph is a top view of the inside of the sample cave, and to the right side, the Lucite guide (shown removed). The Lucite guide usually remains inside the cave, its conical opening serving to position the calorimeter can containing the sample onto the circular sample turntable. Note the two small black arrows, pointing in opposite directions, on the Lucite guide. When the guide is properly aligned, they should point to the two black arrows on the cave top.

1.3 CONTROL PANEL USAGE: SAMPLE LOADING/UNLOADING AND DETECTOR POSITIONING

A control panel on the right side of the sample cave above the COAX detector, shown in Fig. 1-1 (top right), provides control for loading and unloading samples and a count-rate meter for monitoring the detector count rate. Spring-loaded pushbuttons are used to initiate selected actions, each indicating the status of the system by means of lights. As a safety feature, to initiate any action, two buttons must be pushed simultaneously--one with each hand. This ensures that both hands of the operator are out of the way while parts of the assembly are moving. The control panel also contains a color-coded count-rate meter for monitoring the detector count rate while positioning it.

Loading Samples. Place the sample in the cave, using the Lucite guide to help position the calorimeter canister near the center of the turntable (exact centering is not necessary). Press and hold both the LOAD pushbuttons (see Fig. 1-2), causing the sample turntable to descend. When the sample clears the top of the cave, the sample begins to rotate, the lid shuts, and the LOAD buttons are lit green. Rotation and scanning of the sample are required for the system to perform an accurate sample analysis. If the sample does not rotate or move up and down, a problem exists (see paragraph 4.9).

Count-Rate Meter. The count-rate meter scale is divided into three regions: yellow, green, and red. Count rates in the yellow region are considered too low, and rates in the red are too high; count rates in the central green region are considered optimum. If the detector shows a count rate in the red, manually move the detector away from the sample (see below). If the count rate is in the yellow, move the detector closer if possible. If the count rate is still too low, the analysis must be performed with a count rate that is less than ideal. A longer counting time may be required. (Note that as the sample is being scanned its count rate may fluctuate cyclically.) If the detector is as far back from the sample as possible and the count rate remains too high, the analysis will have to be performed at a count rate that is less than ideal.

Positioning Detector. The detector can be moved in or out manually. After releasing the brake on the detector table, push gently with a horizontal motion in the direction required. As the detector moves, its count rate changes. Watch the count-rate meter while moving the detector and stop when the needle is in the central green region or the detector reaches its inner or outer physical limit.

Starting Sample Analysis. After the detector is positioned and its count rate optimally adjusted, initiate an assay using the terminal (see Pu-238 Isotopic Analysis Users Manual, UCRL-CR-103923, Vol. 1, Chapter 4). The first 60 seconds of each analysis measures only the count rate of the detector. At the end of the first 60 seconds (preliminary check), the operator is given the option of counting for the preset default clock time or for the time calculated to achieve approximately 1% precision on the specific power result. After a count begins, the lid motor is disabled and is not enabled until the sample analysis is completed or a proper supervisory interrupt message is processed. A count-in-progress is indicated by the IN USE indicator in the center of the control box being illuminated. All lights but the LOAD lights go off at the end of an analysis.

Fig. 1-2. Photographs of the control panel located above the detector in the Pu-238 isotopic analysis system.

Unloading Samples. To unload a sample, press and hold the buttons labeled UNLOAD. The sample-cave lid opens; when fully opened, the sample is elevated about 9 inches above the cave top. The UNLOAD pushbuttons are lit, signaling that the sample is ready to be removed from the turntable. Depending on the position of the sample, when the count stops, the sample may go down first before being elevated to the top. This allows the elevator electronic control to locate the position of the sample in the cave.

Safety Overrides. All Pu-238 isotopic analysis system assembly mechanisms driven by the stepper motor or linear actuator are load- and limit-switch protected. The stepper motor/actuator are equipped with slip clutches, which become operative at the limits if the limit sensors or associated logic circuitry should fail.

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Fig. 2-1. Block diagram of the Pu-238 isotopic analysis system.

Chapter 2

SYSTEM COMPONENTS

This chapter describes the components of the Pu-238 isotopic analysis system. Service and maintenance procedures for each commercial component can be found in the appropriate vendor manuals.

2.1 COMPONENTS LIST

Supplier	Model No.	Description	Location
LLNL	LEA 90-1402	Control panel	NDA Lab
ORTEC	GMX-151853-PS	High-purity coaxial (COAX) detector and preamplifier	NDA Lab
DEC	Letterwriter 100	Printing terminal	NDA Lab
Tektronix	2225	Oscilloscope	NDA Lab rack
Canberra	2020	Spectroscopy amplifier	NDA Lab NIM bin
Canberra	8075	Analog-to-digital converter	NDA Lab NIM bin
Canberra	8232	Gain/zero stabilizer	NDA Lab NIM bin
ORTEC	729A	Liquid nitrogen monitor	NDA Lab NIM bin
ORTEC	459	Detector high-voltage module	NDA Lab NIM bin
Canberra	90	Pulse-height analyzer	NDA Lab rack
DEC	MicroVAX II	32-bit minicomputer	NDA Lab rack

Fig. 2-2. Photograph of the Pu-238 isotopic analysis system's rack-mounted electronic components and computer.

2.2 COMMERCIAL COMPONENTS: DESCRIPTION AND SPECIFICATIONS

Figure 2-2 shows the rack used to hold the system's electronic components and DEC MicroVAX II computer. See paragraph 2.2.7 for more about this rack.

2.2.1 ORTEC Components

ORTEC COAX Detector Reorder Specification. The high-purity germanium detector is an EG&G ORTEC GMX series 15185-P-S. This coaxial detector is ORTEC's GAMMA-X n-type detector with an ion-implanted front detector contact (entrance window). It has a warranted 15% relative efficiency at 1.33 MeV and a warranted energy resolution of 1.85 keV for the full width at half maximum (FWHM). The original order specified the detector crystal diameter to be 50 ± 1 mm and the length to be 50 ± 1 mm. The -P nomenclature identifies it as being in a POPTOP capsule configuration. The -S identifies it as being in a side-looking configuration.

The preamplifier is integrated into the cylindrical housing immediately at the rear of the detector housing. It has an automatic high-voltage shutoff that functions if all the liquid nitrogen evaporates, and a low-level liquid nitrogen alarm that is connected to the ORTEC 729A electronic module.

The cryostat specification is CFG-PS30, i.e., a POPTOP side-looking cryostat. The dewar configuration is a model DWR-30S, 30-liter side-port dewar.

ORTEC 729A Liquid Nitrogen NIM Module. This is a modified unit. The modifications are shown in the vendor manual. When the low-level liquid nitrogen thermistor warms up, the 729A buzzes continually, and a +5-V logical signal triggers the computer to print a WARNING message on the system printer. For details, see the ORTEC 729A manual.

ORTEC 459 Detector High-Voltage NIM Module. This is a standard unit. See the appropriate ORTEC manual for specific details.

Fig. 2-3. Canberra 90 multichannel pulse-height analyzer (Model 9103).

2.2.2 Canberra Components

Canberra 90 Multichannel Pulse-Height Analyzer (PHA). The Canberra Industries pulse-height analyzer (Model 9103) shown in Fig. 2-3 was ordered with 8K channels. A single input collect interfaces (Model 9131), a high-speed intelligence input/output (I/O) board (Model 9173), and a Q-bus interface card (Model 8673V) are used.

Canberra Analog-to-Digital Converter (ADC). The most important matching electronic module is the Canberra ADC (Model 8075). This converter has a 100-mHz digitization rate for 8K channels. The ADC has a flat cable that connects to the single input collect interface card inside the Canberra 90.

Canberra Amplifiers and Stabilizers. Two other electronic NIM bin modules are used with the Canberra pulse-height analyzers--a Canberra 2020 amplifier and a Canberra 8232 gain and zero stabilizer unit.

See the appropriate Canberra manual for specific details.

Fig. 2-4. Digital Equipment Corporation (DEC) Micro-VAX II computer.

2.2.3 Digital Equipment Corporation MicroVAX II Computer

The computer used to support the LLNL-designed Pu-238 isotopic analysis system for the Savannah River Site's H-Canyon Facility is the rack-mounted version of the Digital Equipment Corporation (DEC) MicroVAX II. The operating system is VMS. This MicroVAX II computer, shown in Fig. 2-4, includes several features:

Micro-VAX module with bootstrap read-only memory (ROM) and diagnostics.

5 Megabyte (Mb) parity MOS memory.

One 71-megabyte, 5-1/4-in. Winchester disk (RD-53) for use as the system device.

A 5 1/4-in. dual floppy disk drive (RX50).

A 95-Mb cartridge tape drive (TK50).

One controller each for the Winchester disk and tape drives.

Two serial line asynchronous EIA/CCITT interfaces--one for the console terminal and one for expansion.

A 4-port serial-interface card with -4 lines.

An Ethernet interface card and port.

A VMS 2-user license.

See Digital Equipment Corporation manuals for specific details.

M7606-BT	
M7608-BE	
M3106 DZQ11	EMPTY
M7516 DELQA	M7546 TQK-50BA
8673V Canberra hi-speed interface	
M7555 RQDX3	ADAC 1616 CCI
EMPTY	ADAC 1616 HCO

Fig. 2-5. Backplane configuration for the Micro-VAX II computer.

Figure 2-5 shows the backplane configuration for the MicroVAX II computer and identification data about the devices attached to it. The function of each device is as follows.

Slot 1--The quad-height M7606-BT control processing unit (CPU) module occupies the first slot in the backplane. It consists of a CPU, line-frequency clock, bootstrap and diagnostic ROM, two serial-line units, 1 megabyte of RAM memory, and a memory management unit (MMU).

Slot 2--The quad-height M7608-BE board contains 4 megabytes of memory.

Slot 3AB--The double-height DZQ11 board (M3106) connects the Q22 bus to (up to) four asynchronous serial lines. It conforms to the RS-232-C and RS-423-A interface standards.

Slot 3CD--Empty

Slot 4AB--The double-height DELQA Ethernet board (M7516) provides for DECNET communications, if desired. DECNET is not installed on the system.

Slot 4CD--The double-height TQK-50BA (M7546) is a controller module and signal cable that is an essential part of the TK50 tape-drive subsystem.

Slot 5--The quad-height 8673V Canberra high-speed communications module in slot 5 is a buffered computer interface designed to translate serial bit data to parallel character data for the Micro-VAX II computer.

Slot 6AB--The dual-height RQDX3 controller (M7555) module in slot 6 is a disk controller that interfaces the RD53 (hard) disk drive to the MicroVAX II bus. The RQDX3 is a DMA controller and conforms to DEC's mass storage control protocol (MSP).

Slot 6CD--The ADAC Model 1616 CCI board detects contact closure on any or all of 16 discrete input lines. This board is a double-height module that plugs directly into the MicroVAX II backplane. The status of the individual lines is stored in a register and interfaced directly to the MicroVAX II bus.

Slot 7CD--The double-height ADAC 1616 HCO module contains 16 discrete latched output registers with high-current drive capability. The module plugs directly into the MicroVAX II backplane. Each line is capable of sinking up to 300 mA from a load returned to voltages as high as +32 V. ADAC documentation manuals have been supplied.

Fig. 2-6. Wiring diagram of ADAC terminal strips.

2.2.4 ADAC HCO and CCI Boards

Two interface boards are plugged into the MicroVAX II computer and connected to the 1300 HCO and 1300 CCI terminal strips as shown in Fig. 2-6 (also see Fig. 2-9). The HCO is a high-current output board; the CCI is a contact closure board. These boards provide communication interfaces between the position sensors and the computer, and between the computer and the solenoids. For more information, see the vendor manuals.

ADAC Model 1616 HCO board contains 16 discrete latched outputs with high-current drive capability. It also contains bus transceivers, a 16-bit status register, and a flexible address scheme that allows them to operate as addressable memory. The HCO series is mounted on half-quad-size 8-1/2- X 5-in. printed-circuit boards and plugs directly into the backplane of the MicroVAX II. A 16-bit word from the bus is strobed into one of two 16-bit registers. Each line of the registers drives a power driver capable of sinking up to 300 mA from a load returned to a voltage as high as +32V.

1616 HCO & 1632 HCO

The ADAC Model 1616 CCI board detects contact closure on any or all of 16 discrete input lines. The contact closure system is mounted on a half-quad-size 8-1/2 X 5-in. printed-circuit board that plugs directly into the backplane of the Micro-VAX II. The status of the individual lines is stored in a register and interfaced directly to the bus of the Micro-VAX II. Each of the 16 input lines is filtered and sets a flip-flop when contact closure to ground occurs. A common reset line for all flip-flops is provided to reset the register when data are read into the bus. The unit interfaces with the Micro-VAX II in either program control or interrupt mode. Bit assignments for the ADAC CCI and HCO board addresses for the solids actinide analysis system can be found in the Pu-238 Isotopic Analysis Software Manual (UCRL-ID-103923 Vol. 3, Chapter 1).

1616 CCI

Fig. 2-7. ADAC Model 1616 and 1632 HCO boards (a) and Model 1616 CCI board (b).

2.2.5 Tektronix Oscilloscope

The Tektronix 2225 oscilloscope, mounted in the rack with the optional rack-mount kit as shown in Fig. 2-8, receives input from the detector and is normally used during initial setup of the system to inspect the system electronics for excessive noise and ground loops and to verify that the incoming pulses have the proper shaping. For more information, see the manufacturer's manual.

Fig. 2-8. Tektronix 2225 oscilloscope in the rack-mounted configuration.

2.2.6 Digital Equipment Corporation (DEC) Letterwriter 100 Printer/Terminal

A Digital Equipment Corporation terminal (Model Letterwriter 100) is connected to the Pu-238 isotopic analysis spectrometer system.

This terminal is an operator unit. That is, operators can use it to initiate an assay on the Pu-238 isotopic analysis system. For instructions on the use of this terminal, consult the Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923 Vol. 1).

The power switch for the terminal is on the rear of the unit in the lower right-hand corner. The POWER/FAULT LED goes on when power is turned on. There are two important switch settings on the terminal. The terminal should be set to UPPER CASE by pressing the CAPS LOCK key. Input to the instrument control program is expected in upper case. The terminal must also be set to ON LINE, i.e., the LINE LED indicator should be on. Press the LINE/LOCAL key to switch to the ON LINE mode. Switching the terminal offline will block any communication to or from the computer.

The terminal provided by the Canberra 90 multichannel analyzer serves as the VMS operating system terminal for the Pu-238 isotopic analysis instrument. The keyboard for this terminal is located on the front of the rack and will rarely, if ever, be used by the system operators. Consult the Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923, Vol. 1) for more information on this terminal.

Fig. 2-9. Back view of electronics rack (top).

2.2.7 Equipment Rack

Equipment Rack All electronic support equipment for the Pu-238 isotopic analysis system is mounted in a rack purchased from Canberra (Floor Cabinet Model 5000). It includes a 425 cubic feet/min. cooling and air filtering system and a power distribution plug strip (see Figs. 2-9 and 2-10).

Fig. 2-10. Back view of electronics rack (bottom).

2.3 SYSTEM WIRING DIAGRAMS

2.3.1 AC Power Distribution

Figure 2-11 is a schematic diagram of the ac power distribution to the Pu-238 isotopic analysis system.

Fig. 2-11. Distribution of ac power for the Pu-238 isotopic analysis system.

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2.3.2 Detector Wiring List and Diagram (Fig. 2-12)

From Level 1 ^a	Cable type	To Level 2	Connectors
1. ICR 2020 amplifier	RG 59 A/U	Count-rate meter (in control panel)	BNC
2. 2020 amplifier	Belden 8723	Detector preamp power	9-pin minia- ture D (male)
3. 2020 amplifier	RG 59 A/U	Signal-out detector	BNC
4. HV supply	RG 59 A/U	Detector bias shutdown	BNC
5. HV supply	RG 62 B/U	Detector HV	King's SHV
6. ORTEC LN monitor	RG 59 A/U	LN dewar	BNC
7. DEC Letterwriter 100	Belden 8723	Micro-VAX II computer	25-pin minia- ture D (male)
8. Spare ^b	RG 59 A/U	Spare	None

^aAll wiring/connections:

Level 1 = Internal to electronics rack.

Level 2 = To/from instrument rack to instrument control panel/detector.

^bNot shown on wiring diagram in Fig. 2-12.

Fig. 2-13. Photograph of the control panel for the Pu-238 isotopic analysis system.

2.4 SAMPLE CONTROL PANEL, TURNTABLE, ELEVATOR, AND LID CONTROL (Figs. 2-13 through 2-16)

The control panel on the Pu-238 isotopic analysis system enables an operator to load or unload a sample. The count-rate meter atop the panel aids the operator in manually positioning the detector for optimum counting. It also provides control for the sample cave lid, for the sample turntable position (loading and unloading samples), and for turntable rotation during sample counting. It also sends control signals between both detectors and the MicroVAX II computer and provides system status signals (lighted switches) between the control panel and the MicroVAX II computer. To service or replace the control panel, see Chapter 4.

Parts listings for the control panel, sample elevator and rotation mechanisms, lid actuator, sensors, and switches are given on the following three pages. This is followed by a component layout of the PAL board.

LAWRENCE LIVERMORE LABORATORY		ELECTRONIC ENGINEERING		UNIVERSITY OF CALIFORNIA		LEA90-140203P0		REV
PARTS LIST CONT.		LIVERMORE, CALIFORNIA		FILE		SHEET 1 OF 3		

COMMERCIAL PARTS & MATERIALS

COMPONENT DESIGNATION	QTY REQD	DESCRIPTION	
DESCRIPTION			

VENDOR : FIRE DEVICES (818)968-5597
 SWITCH | 2 | STRIP SWITCH (#101-B 2ft.) | 101-B

VENDOR : RAMCO ELECTRIC (515)225-6933
 SENSOR | 1 | BEAM SENSOR (EX-M2) | EX-M2
 SENSOR | 1 | SENSOR (EX-D200E) | EX-D200E

VENDOR : WESTERN TECH. MARKETING (415)968-6200
 LIN. ACT. | 1 | LIN. ACTUATOR (D155B-14-MS4-MT1-01) |
 IFX | 1 | IFX INDEXER CARD |
 IFX-MB | 1 | IFX MOTHER BOARD |
 COMPONENT | 1 | DC MOTOR CONTROLLER (D2302) | -D2302
 LE-DRIVE | 1 | LE-DRIVE W/MOTOR (LE-5783) | LE-7583

PAL BOARD PARTS

D1	1	1N4148 DIODE	5910-53273
D2	1	1N4148 DIODE	5910-53273
U5, U11	2	QUAD TRANSISTOR ARRAY, MHQ2222	5961-59323
U	15	OPTICAL ISOLATOR, 4N25	5961-59181
U8	1	74LS123, DUAL ONE-SHOT	5961-70479
U14	1	G20V8 P.A.L.	5961-70651
U17	1	75451 DUAL PERIF.DRIVER, NAND	5961-58402
U22	1	75452 DUAL PERIF.DRIVER, AND	5961-62969

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LAWRENCE LIVERMORE LABORATORY		LIVERMORE, CALIFORNIA		FILE	SHEET 2 OF 3
PARTS LIST CONT.					
COMMERCIAL PARTS & MATERIALS					
COMPONENT DESIGNATION	QTY REQD	DESCRIPTION			STOCK NO.
PAL BOARD					
PAL BOARD	1	CUSTOM CONTROL CIRCUIT			-XXXXX
ALL RESISTORS ARE 1/4 WATT, CARBON					
R1	1	1K			5905-16489
R2	1	500			-16482
R3	1	200K			-16544
R4	1	100K			-16537
R5	1	51K			-16530
R6	1	1K			-16489
R7	1	1K			-16489
R8	1	330			-16477
R9	1	10K			-16513
R10	1	330			-16477
R11	1	1K			-16489
R12	1	1K			-16489
R13	1	1K			-16489
R14	1	680			-16485
R15	1	680			-16485
R16	1	680			-16485
R17	1	680			-16485
R18	1	680			-16485
R19	1	1K			-16489
R20	1	1K			-16489
R21	1	330			-16477
C1	1	330 uFD, 6V			5910-52611
C2	1	330 uFD, 6V			5910-52611
C3	1	.15 uFD, CERAMIC			5910-57967
C4	1	.15 uFD, CERAMIC			5910-57967
RNET1	1	10K RES NETWORK, 15 RESISTORS			5905-60979
RNET2	1	330 RES NETWORK, 8 RESISTORS			5905-60929
RNET3	1	10K RES NETWORK, 15 RESISTORS			5905-60979

Fig. 2-14. Control panel PAL logic board layout.

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Fig. 2-15. Control panel internal wiring diagram.

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Fig. 2-16. Control panel PAL Logic board schematic.

2.5 CONTROL PANEL PAL LOGIC BOARD PROGRAM LISTINGS.

=====

THE FOLLOWING IS A LISTING OF THE PROGRAM USED FOR CONTROLLING
THE STEPPER MOTOR WHICH DRIVES THE SAMPLE UP AND DOWN. THE
PROGRAM IS STORED IN NON-VOLITAL MEMORY, BUT CAN BE CHANGED, IF
NEEDED, BY CONNECTING A TERMINAL TO THE PROGRAM PORT ON THE
SAMPLE CONTROL UNIT.

=====

IFX PROGRAM LISTING FOR SRP SYSTEM IFX CARD

=====

SEQ#4 RAISE THE SAMPLE

LD0 MN A100 V100 L D-1000000 G N

SEQ#6 COUNT SEQUENCE

LD0 MN A100 V100 GH100 V10 A50 L D1000000 G T1 D-1000000 G T1 N

SEQ#7 LOWER THE SAMPLE

LD0 OSH1 MN A100 V100 GH100

=====

```

Name      SRP_V9  ;
Partno    G20V8;
Date      03/05/90;
Revision  01;
Designer  Ken DeWitt;
Company    LLNL;
Assembly  S.R.P. H-CANYON Pu ASSAY SYSTEM SAMPLE CONTROL UNIT ;
Location   XXXXX;
Device     G20V8;

```

```

/*****
/*This device is a motor control circuit used to drive a COMPUMOTOR */
/*circuit for controlling the lid and sample height actuators in the */
/*Pu Assay System at the S. R. P. Plant */
/*****
/* Allowable Target Device Types:          G20V8 */
/*****

```

/** Inputs **/

```

Pin 2      = CW_LIMIT_SWITCH           ;
Pin 3      = CCW_LIMIT_SWITCH          ;
Pin 4      = !LOAD_SWITCH              ;
Pin 5      = !UNLOAD_SWITCH            ;
Pin 6      = !COUNTING                ;
Pin 7      = !STRIP_SENSOR             ;
Pin 8      = !LID_OPEN                 ;
Pin 9      = !LID_CLOSED               ;
Pin 10     = !HOME_SWITCH              ;
Pin 11     = !IR_CRUSH_SENSOR          ;

```

/** Outputs **/

```

Pin 15     = !CW_LIMIT                 ;
Pin 16     = !CCW_LIMIT                ;
Pin 17     = OPEN_LID                  ;
Pin 18     = CLOSE_LID                 ;
Pin 20     = COUNT_CYCLE_SEQ_2         ;
Pin 22     = ENABLE_SAMPLE_ROTATION    ;
Pin 19     = LOWER_SAMPLE_SEQ_1        ;
Pin 21     = RAISE_SAMPLE_SEQ_3        ;

```

```

/** Declarations and Intermediate Variable Definitions **/
F = !LID_OPEN & !LID_CLOSED ;
B = !COUNTING ;
    & !LOAD_SWITCH ;
    & !UNLOAD_SWITCH ;
D = !LID_OPEN ;
E = !COUNTING ;
    & UNLOAD_SWITCH ;
/** Logic Equations **/

CW_LIMIT      = IR_CRUSH_SENSOR
               # CW_LIMIT_SWITCH
               # B ;

CCW_LIMIT      = CCW_LIMIT_SWITCH
               # B ;

OPEN_LID       = D & E ;
CLOSE_LID      = !LOWER_SAMPLE_SEQ_1
               & !LID_CLOSED
               & LOAD_SWITCH
               & !COUNTING
               & !STRIP_SENSOR ;

COUNT_CYCLE_SEQ_2 = LID_CLOSED
                   & COUNTING ;

ENABLE_SAMPLE_ROTATION = COUNT_CYCLE_SEQ_2
                       # F ;

LOWER_SAMPLE_SEQ_1 = !HOME_SWITCH
                   & LOAD_SWITCH
                   & !COUNTING ;

RAISE_SAMPLE_SEQ_3 = LID_OPEN
                   & E ;

```

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				FILE	SHEET 3 OF 3	0
LIVERMORE, CALIFORNIA						

COMMERCIAL PARTS & MATERIALS

COMPONENT DESIGNATION	QTY REQD	DESCRIPTION	LLNL STK.#
--------------------------	-------------	-------------	------------

SAMPLE CONTROL UNIT

CHASSIS	1	BUCKEYE ENCLOSURE 5 1/4 X 11 11/32 X 13	5975-59710
---------	---	---	------------

PS1	1	POWER SUPPLY, PC MODULAR, 5V/3.0A	6130-70804
PS2	1	POWER SUPPLY, MODULAR PC, 24V/0.37A	6130-69662
SSR	1	SOLID STATE RELAY, 3-32VDC CONT, 25A	5945-66892
SW1	1	SWITCH, PUSH, LIGHTED, ALT, DPDT	5930-70797
SW2-SW6	5	SWITCH, PUSH, LIGHTED, 2PDT 90EA1C2	5930-48898
METER	1	PANEL METER, DC, 0 TO 100uA, RES. 2.28K	6625-18532
SW1 LAMP	1	120V, S.C. MIDGET FLANGE, #NE2FH	6240-46644
SW2-6 LAMP	10	6.3V, S.C. MID. FLANGE, #349	6240-61372
F1	1	3.2A, S.B., 3AG, W/FUSE HOLDER #342004A	5920-32238

CONNECTORS

J-1	1	25 PIN SUB-MIN 'D', (SOCKETS)	5935-67277
J-2	1	25 PIN SUB-MIN 'D', (PINS)	-67276
J-3, J-9	2	CIRCULAR, MS, 6 PIN #20, SOCKETS	-48886
J-4, 6, 7, 8	4	CIRCULAR, MS, 4 PIN #20, SOCKETS	-48884
J-5, 15	2	CIRCULAR, MS, 2 PIN #20, SOCKETS	-48882
J-10, 11, 12	3	CIRCULAR, MS, 3PIN #16, SOCKETS	-57384
J-13	1	ISOLATED BNC	-45319
J-14	1	A/C POWER PLUG, MALE, EAC-302	-70191

PAL BOARD COMPONENT LAYOUT

CHAPTER 3

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Chapter 3

INITIAL SYSTEM SETTINGS

This chapter provides the initial settings for most components used in the Pu-238 isotopic analysis system. The reader should be aware that actual settings on the various electronic modules for the detector system may vary from those specified when they were first installed in 1990 at the Savannah River Site. Contact the Laboratories Department supervisor or see the Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923 Vol. 1) before making any changes.

Refer to manufacturers' manuals for further details and for specific service information on system components.

Fig. 3-1. Rack-mounted-oscilloscope front-panel controls and indicators.

3.1 TEKTRONIX OSCILLOSCOPE

The front panel controls and indicators of the Tektronix oscilloscope Model 2225 are shown in Fig. 3-1. Set the controls as follows:

1. Activate the panel by pressing the POWER ON/OFF pushbutton to the lower right of the oscilloscope screen. Observe that the green POWER LED is on.
2. Set the TRIGGER SOURCE switch to VERT Mode, and the TRIGGER MODE switch to NORM.
3. Set the COUPLING switch to DC.
4. Set the SLOPE switch in the top position.
5. Set the TIME BASE SEC/DIV rotary switch to 2 microseconds.
6. Set CH 1 VOLTS/DIV rotary switch for 1X PROBE to 2 (which also sets the 10X PROBE to 20).
7. Set CH 1 AC/GND/DC switch to DC.

NOTE: The oscilloscope is now ready for operation. Other controls are not needed. The system operates in either CHOP or ALT mode.

Fig. 3-2. Nuclear instrument module (NIM) bin.

3.2 NUCLEAR INSTRUMENT MODULE (NIM) BIN

As shown in Fig. 3-2, the five rack-mounted NIM bin modules for the detector system are the amplifier, analog-digital converter (ADC), gain-zero stabilizer, liquid-nitrogen monitor, and high-voltage supply, respectively. Verify the presence of connections between UNIPOLAR OUTPUT (amplifier) and ADC IN (analog-digital converter), as shown in the photograph, before readying the NIM bin modules for system operation.

Fig. 3-3. Amplifier front-panel controls and indicators.

3.3 CANBERRA 2020 AMPLIFIER

3.3.1 Setting Up Amplifier

The Canberra 2020 amplifier receives analog signals from the "coaxial" detector, whose volume should be $\geq 100 \text{ cm}^3$ and whose FWHM resolution at 122 keV should be $< 1 \text{ keV}$. No external adjustments can be made to this detector; if it is out of tolerance, it should be replaced in accordance with paragraph 4.2. For more details on the detector, see the ORTEC solid-state photon detector operator manual on the GMX series coaxial photon detector systems.

For proper operation, the amplifier gain should be set to give 0.25 keV/channel. The initial settings given below assume correct pole-zero and pileup rejector adjustments, both of which are important to good high-count-rate energy resolution. Perform initial or subsequent pole-zero and pileup rejector adjustments, as needed, according to paragraphs 3.3.2 and 3.3.3.

The front panel controls and indicators of the Canberra 2020 amplifier are shown in Fig. 3-3. Set the controls as follows:

1. Set the COARSE GAIN rotary switch to 100.
2. Set the FINE GAIN potentiometer to approximately 490.

NOTE: Amplifier fine gain should be set such that the plutonium-238 152.7-keV peak is at channel 612 and the plutonium-238 766.4-keV peak is at channel 3063. First, set the analyzer cursors to the correct channels. Adjust the fine gain so that the two peaks are about as far apart as the cursors. Move both cursors such that the lower-energy cursor is at the position of the lower-energy peak. Check the spacing between peaks relative to the spacing between the cursors. Continue to adjust the fine gain until the correct spacing is obtained. Exact positioning of the peaks is accomplished with the ZERO adjustment on the analog-digital converter.

3. Set the INPUT POLARITY toggle switch to - (negative).
4. Set the SHAPING MULTIPLIER switch to X1.
5. Set the SHAPING TIME μSEC rotary switch to 1.0 μs .
6. Set the RESTORER RATE toggle switch to AUTO.
7. Set the RESTORER MODE toggle switch to ASYM.
8. Set the THRESHOLD toggle switch to AUTO.
9. Set the PUR (pileup rejector) toggle switch to ON. Observe that the red PUR LED is on.

3.3.2 Adjusting Pole Zero

Pole-zero adjustment is accomplished by rotating the screw potentiometer directly under the P/Z placard on the front panel of the amplifier. This procedure requires the use of a source with a count rate between 2000 and 10,000 counts/s (cps). Perform pole-zero adjustment as follows:

1. Install the appropriate radiation source.
2. Verify that amplifier gain is properly set at 0.25 keV/channel.

NOTE: Pole-zero adjustment may change the amplifier gain slightly.

3. On the amplifier panel, set the RESTORER RATE toggle switch to AUTO.

(a) Overshoot

(b) Undershoot

(c) Correct

(d) As Installed

Fig. 3-4. Amplifier pole-zero adjustment unipolar pulses showing (a) overshoot, (b) undershoot, and (c) correct potentiometer setting for preamplifier decay.

4. Set the RESTORER MODE toggle switch to ASYM.
5. Set the THRESHOLD toggle switch to AUTO.
6. On the rack-mounted oscilloscope (Fig. 3-1), verify that the scope is set to CH 1 and perform the following:
 - a. Set the VOLTS/DIV rotary switches for the 10X PROBE to 20.
 - b. Set the TIME BASE SEC/DIV rotary switch to 50 microseconds.
7. On the amplifier panel, observing unipolar output, adjust the polezero potentiometer so that the trailing edge of the unipolar pulse returns to baseline with no strong evidence of overshoot or undershoot.

NOTE: Figure 3-4 compares the correct unipolar pulse (c) with too much overshoot (a) and too much undershoot (b) for the preamplifier decay-time constant. Small-amplitude signals with long decay times are due to charge trapping in the detector and cannot be corrected for by adjusting the pole-zero potentiometer.

8. Restore the system to initial condition as follows:
 - a. Remove the radiation source.
 - b. On the rack-mounted oscilloscope, set the TIME BASE SEC/DIV rotary switch to 20 microseconds.
 - c. On the amplifier panel, set RESTORER MODE toggle switch to ASYM.

For additional information, see the Canberra 2020 vendor manual, Section 5.3.2, pp. 5-3 through 5-6.

3.3.3 Adjusting Pileup Rejector

All count-rate activity must be stopped before the pileup rejector (PUR) can be adjusted. Hence, all radioactivity must be removed from the sample cave and its lid closed. Perform the adjustment as follows:

1. On the amplifier, set the PUR toggle switch to ON.
2. Adjust the screwdriver potentiometer counterclockwise (CCW) until the red LED light comes on steady.
3. Turn the screwdriver potentiometer clockwise (CW) one full turn until the LED light rarely blinks on.

For additional information, see the Canberra 2020 vendor manual, Section 5.4.2, p. 5-10.

Fig. 3-5. Analog-digital converter (ADC) front-panel controls and indicators.

3.4 CANBERRA 8075 ANALOG-DIGITAL CONVERTER

System setup of the Canberra 8075 analog-digital converter (ADC) requires adjustment of a ZERO potentiometer on the front panel.

Front panel controls and indicators of the Canberra 8075 analog-to-digital converter are shown in Fig. 3-5. Set the controls as follows:

1. Set the inner GAIN rotary switch to 4K.
2. Set the outer RANGE rotary switch to 4K.
3. Set all six OFFSET toggle switches to down position.
4. Set the LLD (low-level discriminator) potentiometer to about 0.10.
5. Adjust the ZERO potentiometer as follows:
 - a. Verify that amplifier gain is set to give 0.25 keV/channel. If necessary, adjust amplifier gain in accordance with paragraph 3.3.1, step 2.
 - b. Adjust the ZERO potentiometer so that channel zero is near zero energy, i.e., such that the plutonium-238 152.7-keV peak is at channel 612 and the plutonium-238 766.4-keV peak is at channel 3063.
6. Set the PEAK DETECT toggle switch to AUTO.
7. Set the PHA/SVA toggle switch to PHA.
8. Set the COINC/ANTI toggle switch to ANTI.

Fig. 3-6. Gain/zero-stabilizer front-panel controls and indicators.

3.5 CANBERRA 8232 GAIN/ZERO STABILIZER

The SET and INCR pushbuttons on the Canberra 8232 gain/zero stabilizer are used to enter the values for gain/zero stabilization of the detector.

The peak at channel 612 is used for zero stabilization of the detector (see paragraph 3.3.1 to set the coarse and fine amplifier gain to position the plutonium-238 766.4-keV peak at channel 3063). Controls and indicators of the Canberra 8232 gain/zero stabilizer are shown in Fig. 3-6. Enter values and set controls as follows:

1. Set the ZERO/GAIN toggle switch to ZERO, then enter the ZERO PEAK value (612) as follows:
 - a. Press the INCR pushbutton until the PEAK LED is illuminated.
 - b. Press the SET pushbutton. The first digit in display should flash.
 - c. Press the INCR pushbutton until the proper digit is displayed, then press the SET pushbutton.
 - d. Continue until all digits of ZERO PEAK value are correctly set.
2. Set the ZERO/GAIN toggle switch to GAIN, then repeat steps 1a.-1d. to enter the GAIN PEAK value (3063).
3. Reset the ZERO/GAIN toggle switch to ZERO, then enter the ZERO WINDOW value (13) as follows:
 - a. Press the INCR pushbutton until the WINDOW LED is illuminated.
 - b. Press the SET pushbutton. The first digit in display should flash.
 - c. Press the INCR pushbutton until the proper digit is displayed; then press the SET pushbutton.
 - d. Continue until all digits of ZERO WINDOW value are correctly set.
4. Set the ZERO/GAIN toggle switch to GAIN, then repeat steps 3a.-3d. to enter the GAIN WINDOW value (21).
5. Reset the ZERO/GAIN toggle switch to ZERO, then enter the ZERO ANALOG RNG. value (0.125) as follows:
 - a. Press the INCR pushbutton until the ANALOG RNG. LED is illuminated.
 - b. Press the SET pushbutton. The first digit in display should flash.
 - c. Press the INCR pushbutton until the proper value (0.125) is displayed; then press the SET pushbutton. (ANALOG RNG. values are automatically changed by pressing the INCR pushbutton.)
6. Set the ZERO/GAIN toggle switch to GAIN, then repeat steps 5a.-5c. to enter the GAIN ANALOG RNG. value (0.125).
7. Set the STABILIZATION ZERO ON/HOLD/OFF and STABILIZATION GAIN ON/HOLD/OFF toggle switches to ON after both spectral peaks are properly positioned (see NOTE in paragraph 3.3.1).
8. Set the REMOTE/MANUAL toggle switch to MANUAL.

Fig. 3-7. Liquid-nitrogen-monitor front-panel controls and indicators.

3.6 ORTEC 729A LIQUID-NITROGEN MONITOR (MODIFIED)

The modified ORTEC 729A liquid-nitrogen monitor module sounds an audible alarm if the liquid nitrogen in the dewar drops below a certain minimum level. The monitor also has been modified by ORTEC to output a TTL logic signal that causes an alarm message to be printed out on the Pu-238 isotopic analysis system operator's terminal:

!!!WARNING!!!

!!! Liquid nitrogen level low in detector dewar!!!

Press RETURN to continue.

Refilling the dewar with liquid nitrogen (see paragraph 4.1) silences the alarm. Ignoring the alarm eventually results in automatic shutdown of the detector's high voltage once the liquid nitrogen level is too low, signaled by a flashing light (ALARM HV DISABLED) on the upper front panel of the monitor.

-C A U T I O N-

During system operation, do not ignore liquid-nitrogen monitor low-nitrogen alarm. Detector high voltage should be shut down automatically, but the detector will be damaged if this does not happen, resulting in expensive repairs.

The alarm (buzzer) also sounds if the NIM bin's power is shut off or the sensor is broken or disconnected. It sounds when the monitor module is inserted into or removed from the NIM bin. Silencing the alarm in this case requires reversing the position of a USE/SHIP switch located in the middle of the left side of the monitor, which is accessible only when the monitor is removed from the NIM bin. As appropriate, remove and reinstall the monitor in accordance with paragraph 4.7.

The monitor normally operates on NIM bin power, but an internal battery provides for fail-safe operation even in the event of power failure.

Front-panel controls and indicators of the liquid-nitrogen monitor are shown in Fig. 3-7. The only control is the TEST/NORM OPER/HV DISABLED toggle switch, which, when set to TEST, sounds the alarm. For normal operation this switch must be set to NORM OPER, which is verified by observing that the HV ENABLE light is on.

For additional details, see the ORTEC 729A service manual, pp. 1-4, and circuit diagrams for modifications.

Fig. 3-8. High-voltage-supply front-panel controls and indicators.

3.7 ORTEC 459 HIGH-VOLTAGE SUPPLY

The ORTEC 459 high-voltage (bias) supply for the detector must have negative polarity and be set to the correct voltage. Wrong polarity or excessive voltage will damage system components. For this reason, to guard against mistakes, the voltage should always be set to zero before shutting off the high-voltage supply.

Front panel controls and indicators of the high-voltage supply are shown in Fig. 3-8. Set the controls as follows:

-C A U T I O N-

Setting the incorrect high-voltage polarity--positive in this case--may blow out the input field effect transistor (FET) in the cooled internal preamplifier.

1. Be absolutely sure that the NEG (negative polarity) light is on.

NOTE: To change polarity, consult the ORTEC 459 manufacturer's manual, p. 2.

-C A U T I O N-

Excessive voltage may damage or destroy the germanium detector. Excessive voltage will surely blow out the input FET in the preamplifier.

2. Set the HIGH-VOLTAGE ON/OFF toggle switch to ON. Observe that the power indicator is illuminated.

3. Slowly turn the OUTPUT VOLTAGE potentiometer to 3.00 on the dial, which corresponds to 3000 V. (LLNL recommends that the voltage be brought up slowly, i.e., at about 100 V/s.)

3.8 CANBERRA SERIES 90 MULTICHANNEL ANALYZER

Data-collection parameters for the Pu-238 isotopic analysis system are set by the computer program. Once the system modules are readied for operation and the Canberra Series 90 multichannel analyzer (MCA) setup configuration is verified, no user interaction is required except to ensure that the CONTROL/STATUS key switch is set to ON LINE (to enable computer control).

If a power failure occurs, the MCA is supposed to remember all its settings. See Paragraph 3.8.2 for the setup procedure if memory is lost. Set up soft keys and user-assigned fields, if desired, in accordance with paragraphs 3.8.3 and 3.8.4. Implement x-axis display calibration, if desired, in accordance with paragraph 3.8.5. Consult Canberra Series 90 Operator's Manuals, Extended User Section, pp. 1-26, if a new MCA must be installed.

3.8.1 Setting Up Multichannel Analyzer (Existing Unit)

The multichannel analyzer setup configuration assigns one extended user (User No. 1) to the host computer. Group No. 1 is assigned to Unit (ADC) No. 1, with a memory of 4K. Front panel controls and indicators of the MCA are shown in Fig. 3-9. Verify setup configuration as follows:

Fig. 3-9. Multichannel-analyzer front-panel controls and indicators.

1. Assuming normal display on the touch screen, set the CONTROL/STATUS key switch to SUPERVISOR and proceed as follows:

a. At the upper right of the display, touch MENU to obtain the executive menu.

b. Touch SUPERVISOR to get the next line in menu.

c. Touch USER SUMMRY and observe the following:

<u>USER</u>	<u>TYPE</u>	<u>GROUP</u>	<u>MEMORY</u>	<u>INPUTS</u>	<u>PASSWD</u>
H 1 *	EXTENDED	1	4K		0000
		2	4K		
					<u>RETURN</u>

d. Verify presence of asterisk, denoting that Series 90 can communicate with the computer. If asterisk is not displayed, do the following:

(1) Touch MENU.

(2) Touch CURRNT USER, and observe that box labeled HOST ASSIGN is set to [YES]. If not, touch HOST ASSIGN to set it from [NO] to [YES].

e. Touch RETURN or MENU EXIT to return to main display.

2. Verify group unit by setting the CONTROL/STATUS key switch to any position and proceeding by either of the following two methods (a or b):

a. GROUP SUMMRY method:

(1) Touch MENU to obtain the executive menu.

(2) Touch CURRNT USER to get the next line in menu.

(3) Touch CONFIG GROUPS to get the next line in menu.

(4) Touch GROUP SUMMRY and observe the following:

<u>GROUP</u>	<u>SIZE</u>	<u>ACQ. UNIT</u>	<u>PRESET</u>
1	4K	1 PHA+	T(True) = XX.X
2	4K	--	

(5) Touch MENU EXIT to return to display.

b. ACQ. SUMMRY method:

(1) Touch MENU to obtain the executive menu.

(2) Touch SYSTEM to get the next line in menu.

(3) Touch ACQ. SUMMRY and observe the following:

<u>UNIT #</u>	<u>DESCRIPTION</u>	<u>USER</u>	<u>GROUP</u>
1	Single-input C.I. Bd #1	1	1

(4) Touch MENU EXIT to return to the display.

3. Set the CONTROL/STATUS key switch to ON LINE and observe that the ON LINE LED is on. The system is now ready for operation under computer control.

3.8.2 Setting Up Multichannel Analyzer (New Unit Only)

When a multichannel analyzer from the factory is powered up, it starts in a factory default status. This gives users a standard acquisition configuration by which to begin operation, but the touch screen does not display the usual fields. Before proceeding, become familiar with the Canberra Series 90 manufacturer's manual, possibly starting with the tutorial section. Set up the multichannel analyzer from factory default status as follows:

1. Assuming the multichannel analyzer is turned on and normal display is on screen (see Fig. 3-9), set the CONTROL/STATUS key switch to SUPERVISOR.

2. Calibrate touch screen and obtain factory default summary as follows:
 - a. At upper right on the display, touch MENU for the executive menu.
 - b. Touch SUPERVISOR to get the next line in menu.
 - c. Touch FACTRY DFAULT and observe that the CNFIRM box appears under asterisks. Touch the CNFIRM box to continue.
 - d. Touch the blinking dots as directed to calibrate the touch screen.
 - e. Touch USER SUMMRY to obtain the factory default summary:

1 Extended User (User #1)
 User #1 assigned to host computer
 Group #1 assigned to Unit (ADC) #1

Each group has 4 K memory

3. Change the time and date as follows:
 - a. Assuming the system still displays the executive menu (from step 2, above), touch TIME/DATE and observe that the following boxes are displayed:

YEAR MONTH DAY HOUR MINUTE

- b. Touch the appropriate box and enter new value as follows:
 - (1) Using the numeric keypad on the console, type the new number.
 - (2) Press the STORE key adjacent to the keypad.
 - (3) Repeat as necessary to enter correct values in all boxes.
 - c. Touch MENU EXIT to return to display.

4. Set the CONTROL/STATUS key switch to ON LINE and observe that the ON LINE LED is on. The system is now ready for operation under computer control.

3.8.3 Setting Up Soft Keys

The soft keys have not yet been assigned. Consulting Canberra Series 90 Operator's Manuals, Extended User Section 3.0-3.2, set up soft keys as follows:

1. Touch MENU at upper right on display to obtain the executive menu.
2. Touch CURRNT USER to get the next line in menu.
3. Touch ASSIGN SOFKEY to assign key functions. The following arrangement has been found useful:

<u>Useful soft key</u>		<u>Useful soft key</u>	
<u>Soft No.</u>	<u>assignments</u>	<u>Soft. No.</u>	<u>assignments</u>
1	X-AXIS CALIB.	5	NORMALIZE
2	XFER	6	SMOOTH (3-pt)
3	PEAK SEARCH	7	STRIP
4	SORT ROI	8	DIFFER

4. Touch MENU EXIT to return to the display.
5. Continue by setting up user-assigned fields (paragraph 3.9.4), or return system to operating readiness by setting the CONTROL/STATUS key switch to ON LINE and observing that the ON LINE LED is on.

3.8.4 Setting Up User-Assigned Fields

User-assigned fields may also be assigned at this time. Consult the Canberra Series 90 Operator's Manuals, Extended User Sections 2.0 and 3.0, as necessary, and set up user-assigned fields as follows:

1. Assuming the system still displays the executive menu (paragraph 3.8.3), touch ASSIGN FIELDS to get the next line in menu.

2. Touch OPTION FIELDS and then the appropriate key to define the function of that key. The following arrangement has been found useful:

<u>Field No.</u>	<u>Option</u>	<u>Fixed places format</u>
1	AREA	1
2	% ERROR	3
3	PEAK CENTER	3
4	FWHM	3
5	PRESET TIME	1
6	TRUE TIME	1
7	% DEADTIME	2
8	CPS INTEG	3

3. Touch MENU EXIT to return to display.

4. Set the CONTROL/STATUS key switch to ON LINE and observe that the ON LINE LED is on. The system is now ready for operation under computer control.

3.8.5 Calibrating X-Axis Display

If the soft keys have been assigned (paragraph 3.8.3) and x-axis (energy) calibration has been chosen as one of the soft keys, this feature may be used to calibrate the display. Implement x-axis calibration as follows:

1. Assuming normal display on the touch screen, select two peaks in the spectrum as calibration peaks.

NOTE: For this system the usual choices are the plutonium-238 peak at 152.7 keV and the plutonium-238 peak at 766.4 keV.

2. Place selected peaks in the regions of interest (ROI) by positioning the cursor window on the peak and pressing the ENTER ROI key on the console.

3. Touch the X-AXIS CALIB. soft key to obtain several options displayed at the bottom of the screen.

4. Touch COMPUTE COEFFS to get the next set of options.

5. Enter the energy value for the first calibration peak as follows:

a. Press the INDEX RIGHT key on the console until the cursors are on the first calibration peak.

b. Touch PEAK option on the display. Observe that the display shows the channel position of the peak and asks for its energy.

c. Type the energy value, using the numeric keypad on the right side of the console.

d. Press the STORE key adjacent to the keypad.

e. If the value is correct, touch the ACCEPT option on the display.

6. In the same way, enter the energy value for the second calibration peak, and observe that gain and zero values are displayed.

7. If the gain and zero values appear to be correct, touch the END option, completing energy calibration of the display.

Fig. 3-10. Micro-VAX II computer front panel controls and indicators.

3.9 DIGITAL EQUIPMENT CORPORATION MICROVAX II COMPUTER

Front panel controls and indicators of the Digital Equipment Corporation (DEC) MicroVAX II computer are shown in Fig. 3-10. Proceed as follows:

1. Set the ON/OFF switch to ON, observing that the DC OK green LED is on and that the green LED in Ready pushbutton is also on, denoting that the fixed Winchester disk is ready to be accessed.

2. Verify that the green LED in Write Protect is not on.

Consult the Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923 Vol. 1) for further information on boot-up and operation.

Table 3-1 lists device addresses and vectors for the interface boards in the Micro-VAX II computer.

Table 3-1. MicroVAX II computer interface board device addresses and vectors.

Device	Address	Vector	Interface board	Comments
System console	777560	60	MicroVAX II CPU	Port A0 ^a
Series 90 MCA	776100	370	Canberra 8673V	
User terminal	760100	300	DZQ11	Ch 0 ^a
Free port	760100	300	DZQ11	Ch 3 ^a
LN monitor and CCI interface	764010	270	ADAC 1616 CCI	Note b
HCO interface	764000	--	ADAC 1616 HCO	Note b
RD54	772150	--	RQDX3	Hard disk
TK50	774440	--	TQK50	Tape drive

^aBaud rate = software settable.

^bSee Pu-238 Isotopic Analysis Software Manual (UCRL-CR-103923 Vol. 3, Ch. 1).

3.10 Digital Equipment Corporation Letterwriter 100 terminal/printer.

Front panel controls and indicators of the Digital Equipment Corporation (DEC) Letterwriter 100 terminal/printer are shown in Fig. 3-11. Prepare equipment for system operation as follows:

1. Verify that the supply and feed of printer paper at the terminal/printer are adequate. (Red-bordered paper means the supply is running out.)

2. Set the terminal/printer ON/OFF switch (found on the rear of the unit) to ON, verifying that the POWER/FAULT LED and LINE LED are on.

Consult the Pu-238 Isotopic Analysis Users Manual (UCRL-CR-103923, Vol. 1) for further information.

CHAPTER 4

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DO NOT MICROFILM
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Chapter 4

SERVICE AND MAINTENANCE PROCEDURES

This chapter discusses periodic service and/or maintenance that must be performed on the Pu-238 isotopic analysis system. Before performing any service, it is advisable to first read, discuss (if necessary), and understand the complete description of the item/part/component to be serviced and then to follow these procedures in performing the service.

Fig. 4-1. Transferring liquid nitrogen from the supply dewar to the detector dewar.

4.1 ADDING LIQUID NITROGEN TO THE DETECTOR DEWAR

To operate properly, a germanium detector must be kept at liquid nitrogen temperature ($77\text{ K} = -196^{\circ}\text{C}$). A liquid-nitrogen sensor monitors the level of liquid nitrogen in the dewar. If the liquid-nitrogen level falls below the internal-temperature limit of the sensor, a warning message appears on the operator terminal, and the liquid-nitrogen monitor emits an audible alarm signaling that the dewar should be refilled. If this alarm is ignored, the bias voltage will shut off automatically when the liquid nitrogen falls further (in about 24 hours) to prevent damage to the detector.

-C A U T I O N-

Do not exceed pressures of 20 psi in the pressurized fill line. See the EG&G ORTEC Solid-State Photon Detector Operations Manual for specific instructions and precautions.

When it is full, the typical dewar holds 30 L of liquid nitrogen. This supply will last from 14 to 30 days, depending on ambient temperature, humidity, and altitude above sea level. To ensure that the nitrogen supply does not drop below the proper level, you should refill the dewar weekly and keep a public record to document the filling.

Figure 4-1 shows the preferred method for transferring liquid nitrogen from the supply dewar to the detector dewar.

4.2 REMOVING THE ORTEC DETECTOR

(Refer to assembly drawing AAA 88-114841-OF; Detector Housing and Shielding)

If the detector must be returned to EG&G ORTEC for service or repair, remove the detector as follows:

-CAUTION-

To avoid arcing, shut off high-voltage power before attempting to remove the detector. Arcing can severely damage the detector.

1. Shut off high-voltage power to the detector.
2. Manually move the detector back from the sample cave as far as possible.
3. Disconnect the five detector cables (preamp power, signal output, liquid-nitrogen monitor, high voltage, and HV shutdown) from the cables to the rack.
4. Remove the lid-detector housing (part 17) by removing screws (parts 24) that hold the two half-end caps to the barrel.
5. Remove the two screws holding the dewar-plate tab (part 74 on assembly drawing 88-114840-OE) on the rear of the table so that the detector may be slid back off the detector stand table.

-CAUTION-

Handle equipment gently to avoid damage. If you are inexperienced, seek help from someone who has removed similar detectors.

6. Standing behind the detector and dewar, pull the detector slowly toward you until the end of the detector is exposed from the detector shield.

NOTE: Once a new detector is received or the old one serviced, confirm with the Analytical Laboratories supervisor that the replacement detector is operating properly before reassembling the system.

8. Reverse steps 1 through 6 to reinstall the detector, noting that a new or replacement detector may have a different high-voltage setting than that cited in paragraph 3.7.

4.3 SERVICING THE COUNT-RATE METER

The count-rate meter is driven by the ICR (input count rate) output of the Canberra 2020 amplifier; the connections are made through a BNC coaxial cable from the ICR connection on the back of the amplifier to the back of the control box. The count-rate meter has a three-color (yellow, green, and red) meter scale, the yellow (left) portion of which indicates that count rates are too low and the red (right) portion indicates that count rates are too high for optimum counting conditions. The green (center) portion indicates the preferred region in which all counts should be recorded.

The indicated count rate is controlled by the distance of the detector from the sample. See the Pu-238 Isotopic Analysis Users Manual, UCRL-CR-103923 Vol. 1, for details on counting a sample.

-CAUTION-

Do not change the ZERO adjustment beneath the count-rate meter
without a valid reason. Otherwise it will not read properly.

Normally the count-rate meter needle should be at the beginning of the red region when the Canberra MCA dead time is 40%. If a minor adjustment seems to be required, the slightly recessed ZERO adjustment beneath the meter may be used. To correct the ZERO adjustment on the meter, remove the BNC coaxial cable and gently slide the metal bar located beneath the clear portion of the meter until the needle is positioned over the ZERO on the scale.

If the meter does NOT show any count rate when a sample of known activity is used and the detector is as close as possible, proceed as follows:

1. Remove the coaxial BNC cable from the meter and connect the cable to an oscilloscope to verify the presence of pulses on the cable.
2. If necessary, remove two screws from the top rear of the box and slide the top cover off the back of the count-rate meter.
3. Request a trained electronics technician to inspect and troubleshoot the meter's internal circuitry (refer to Fig. 2-15).

4.4 SERVICING THE SAMPLE ROTATION DRIVE MECHANISM (Refer to assembly drawing AAA 89-114840-0E)

Sample rotation is effected by a Bodine motor (part 29) controlled by a solid-state relay, which is controlled by internal logic and signals from the MicroVAX II computer. Coupled to the motor is the calorimeter can base (part 12), which has alternating black/shiny sectors. A diffuse/reflective optical sensor (part 62) is positioned on the side of the can base; thus the beam, reflected from the shiny sectors on the calorimeter can base as it rotates, is chopped into alternating voltage signals, which are amplified and used to trigger a one-shot multivibrator. If rotation stops, the one-shot multivibrator times out. It is connected to the ADAC terminal strip (see paragraph 2.2.4 and circuit diagram Fig. 2-6).

On rare occasions, the Pu-238 isotopic analysis system operator's terminal may print the warning, "Sample not rotating." In this case, open the sample cave and raise the sample canister completely. Note the orientation of the handle of the sample canister, recalling that the sample turntable is supposed to begin rotating as soon as the lid starts to close. Depress the LOAD pushbutton and verify that the canister is turning as it descends, after the lid begins to close. If it has not rotated after several tries of LOAD and UNLOAD, the sample rotation drive mechanism or associated hardware may be malfunctioning. Proceed as follows:

1. Check that the calorimeter can base turntable gear mechanism is properly coupled with the ball thrust bearing (part 22). If it appears to be, then remove the turntable and check whether the rotation motor shaft turns. If it does not, proceed with the next step.

2. Raise the sample elevator to its uppermost travel to inspect the sample rotation mechanism more closely.

3. Verify nonrotation by examining the drive mechanism for motor (part 29) rotation and finally shaft (part 36) rotation.

* * * * *

-W A R N I N G-

To avoid electrical shock, remove all electrical power to the motor before servicing the system. Always follow Westinghouse Lock, Tag, and Try procedures when performing the following.

* * * * *

4. If the motor shaft is not turning, refer to paragraph 4.7.

5. If all components are turning but the sample rotation alarm is still present, the rotation sensor (part 62) may be out of adjustment or alignment.

Fig. 4-2. Nuclear instrument module (NIM) bin and modules

4.5 SERVICING/REPLACING NIM BIN MODULES

Occasionally, one or more of the nuclear instrument modules (NIM) in the Canberra NIM bin rack will have to be serviced or replaced (see Fig. 4-2). Although the rack that holds these modules can be pulled out, doing so is difficult. Because the rack also contains processor circuit boards for the Canberra 90 (which make it heavy and unwieldy), two technicians should participate in the following procedure:

1. With the second technician at the front of the rack, open the back of the NIM bin rack.
2. Ensure that all cables routed to the NIM bin are free to move forward (about 8 in.).
3. Have the technician in front of the NIM rack pull it slowly forward; it will slide about halfway out.
4. If necessary, disconnect the cables from the rear of adjoining modules to service/replace the malfunctioning module.

NOTE: Before disconnecting any NIM bin module, see the appropriate paragraph in Chapter 3 (initial system settings) for all applicable precautions. ORTEC 729A liquid nitrogen modules have internal alarms that sound if the NIM bin power is shut off or the sensor is disconnected (see paragraph 3.6). Removing the ORTEC high-voltage NIM bin module shuts off high voltage to the detector (see paragraph 3.7 for CAUTIONS relating to the high-voltage modules). Also consult the manufacturers' manuals as necessary.

5. When servicing is complete, reconnect the cables (which are properly labeled) to the appropriate BNC connectors.
6. Push the bin in slowly, being sure to clear cables from its path.
7. Close the back of the rack.

4.6 SERVICING/REPLACING CANBERRA 90 PROCESSOR BOARDS

Should replacement of one of the Canberra 90 processor boards at the rear of the NIM bin be necessary, follow the procedure in paragraph 4.5. Then refer to the Canberra 90 service manual or contact a Savannah River Site CSWE group specialist who has attended Canberra 90 service school.

4.7 REPLACING THE SAMPLE ROTATION MOTOR

(Refer to assembly drawing AAA 89-114840-OE and chamber assembly drawing AAA 89-114869-OO.)

Replace the sample rotation motor as follows:

* * * * *

-W A R N I N G-

To avoid electrical shock, remove all electrical power to the control panel before servicing the system. Always follow Westinghouse Lock, Tag, and Try procedures when performing the following.

* * * * *

1. Disconnect the cable labeled Rotation Motor Power (Bodine motor) at the rear of the control panel before proceeding.
2. It may be possible to remove the motor by raising the sample elevator mechanism to its upper most travel. If not, remove the front shield (part 1) from the lower front of the cave by first removing the four button-head cap screws (part 20 in drawing AAA 88-114869-OO). The shield weighs 200 pounds, and we advise the use of slings and a lift or hoist in lifting it out.
3. Disconnect the power cable from the Bodine rotation motor.
4. Remove the four bolts that hold the rotation motor mounting bracket (part 47 in assembly drawing AAA 89-114840-OE) to the rail table using a 3/16 inch hex wrench. The motor and bracket assembly can now be removed from the cave.
5. Remove the two bolts that hold the motor to the bracket and loosen the flexible coupling (part 36 in assembly drawing AAA 89-114840-OE) from the Bodine motor shaft.
6. To install a new motor, reverse steps 1 through 6.

4.8 REPLACING THE ELEVATOR RAIL TABLE AND STEPPER MOTOR
(Refer to assembly drawings AAA 88-114840-OE and AAA 88-114869-00.)

Replace the rail table as follows:

* * * * *

-W A R N I N G-

To avoid electrical shock, remove all electrical power to the control panel before servicing the system. Always follow Westinghouse Lock, Tag, and Try procedures when performing the following.

* * * * *

1. Before beginning mechanical disassembly, disconnect the two cables labeled Elevator Power and Switches at the rear of the control box. Also remove can guide (part 10).
2. Remove the two bolts (parts 19 in drawing AAA 88-114869-00) near the top of the rail table. The nuts for these bolts are on the outside left-wall of the cave. A 3/16-in. hex wrench is required for the screw heads.
3. Loosen the set screw in the rail-table capture tray (part 59 in assembly drawing AAA 88-114840-OE) at the bottom of the sample cave. Raise the rail table straight up until it clears the rail table capture tray and then remove it from the cave.
4. Remove the rotation motor assembly from the rail table and install it on the replacement rail table by following the procedure described in paragraph 4.7.
5. Place the position sensors on the replacement rail table in the same locations as on the rail table being replaced.
6. Reverse the order of steps 1 through 4 to install a new elevator rail table.

4.9 REPLACING THE SAMPLE CAVE LID LINEAR ACTUATOR (Refer to assembly drawing AAA 88-114840-OE)

Replace the linear actuator with the lid open or closed as follows:

* * * * *

-W A R N I N G-

To avoid electrical shock, remove all electrical power to the control panel before servicing the system. Always follow Westinghouse Lock, Tag, and Try procedures when performing the following.

* * * * *

1. Before beginning mechanical disassembly, disconnect the two cables labeled "SW-1 Retract Limit" and "SW-2 Extend Limit" at the Electric Cylinder Control box. These cables are connected to the magnetic reed switches (position sensors) on the linear actuator.
2. Remove the nut at the end of the actuator (part 25) where the actuator shaft connects to the sample cave lid.
3. Remove actuator cover (part 17) by removing the two socket-head cap screws (parts 49).
4. Remove the yellow power cable from the actuator (part 25).
5. Remove the two socket head cap screws (parts 49) at the other end of the actuator, while supporting the unit. When these two screws are removed, the unit is free.
6. Position the position sensors on the replacement linear actuator in the same locations as those on the actuator being replaced.
7. Reverse the order of steps 1-5 to install a new lid actuator. Do not tighten the screws until assembly is complete.

4.10 MAINTENANCE/REPLACEMENT CHECKLIST

Frequency	Procedure	Reference paragraph
<u>Daily</u>		
<u>Weekly</u>	1. Refill liquid nitrogen dewar; document filling.	4.1--Adding Liquid Nitrogen to the detector dewar
<u>Annually</u>	1. Change filter in rack-mounted fan	2.2.7--Equipment Rack, Rack-Fans, . . .

This section should be used to describe problems that occur in the Pu-238 isotopic analysis system, the dates they occur, the fixes used to solve them, and the names of the individuals who perform the fixes. If kept faithfully, this log may aid in future problem-solving.

Instructions: Indicate when the problem occurred, briefly describe the problem and fix, and enter the name of the person who performed the fix.

Date	Problem/Fix	Serviced By

Instructions: Indicate when the problem occurred, briefly describe the problem and and fix, and enter the name of the person who performed the fix.

[illegible]

CHAPTER 5

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Chapter 5

MECHANICAL COMPONENTS/DRAWINGS

This chapter contains a list of spare parts and recommended spare parts, a list of mechanical components used in building the Pu-238 isotopic analysis system, and one set of mechanical print drawings. The assembly drawing (AAA 88-114840-OE) and certain others are contained in plastic pages. Because lost drawings are hard to replace, users are urged to remove the drawings only when needed and to replace them, in numerical order, when done.

All parts associated with the system are potentially replaceable. The following list includes only those items that may fail due to normal wear and tear. Specific addresses of manufacturers are included wherever the item may be sufficiently unique. Part numbers are those on LLNL assembly drawing AAA 88-114840-OE.

5.1 SPARE PARTS AND RECOMMENDED SPARE PARTS

Part no. on LLNL assy dwg	Part name	Manufacturer	Model no.	No. needed per system	Approx price
22	Andrews ball thrust bearing	King Bearing Co. 37 Wyoming St. Pleasanton, CA 94566 (415) 484-2040	B-24	1 ea.	\$28.40/ea.
24	Rail table with 18 inch travel and Stepper motor with indexer	Daedal Parker both avilable from Western Technology 375 Castro Street Mountain View, CA 94041 (415) 968-6200	506181S-LH A57-83	1 ea. 1 ea.	\$1,600. \$3,536.
25	Linear actuator 14 inch travel (MOD) AC including controller	Industrial Devices Bay Pneumatic, Inc. 440 Convention Way Redwood City, CA 94063	D155B-14- MS4-MT1-01 D2302	1 ea.	\$3,100.
26	Ball bushings	Thomson Linear Motion Co. King Bearing	SUPER-12	4 ea.	\$18.75/ea.

5.1 SPARE PARTS AND RECOMMENDED SPARE PARTS (CONTINUED)

Part no. on LLNL assy dwg	Part name	Manufacturer	Model no.	No. needed per system	Approx price
32	Pillow block	Thomson Linear Motion Co. King Bearing	#SPB-12-OPN	4 ea.	\$65.38/ea.
31	Shaft assy	Thomson Linear Motion Co. King Bearing	#SA12-30-E2	2 ea.	\$195.20/ea.
29	Gear Motor AC, 2 RPM	Bodine Electric King N\Bearing	No. 766 Frame No. KYC-2275	1 ea.	\$145.15/ea.
30	PopTOP Detector	ORTEC	GMX 15185-P-S	1 ea.	\$13,000.
33	Leveling pad	Reid's Tool Supply Bay City Screw 601 Industrial Rd. San Carlos, CA 94070 (415) 592-3211	#TL-2	4 ea.	\$28./ea.
34	Swivel caster 4-inch dia.	PJ Company 1-800-421-2880	MH420PH64-R	2 ea.	\$10./ea.
35	Rigid caster 4-inch dia.	PJ Company	MH420PH64-S	2 ea.	\$13.30/ea.
36	Flexible coupling	Stock Drive Products King Bearing	SDP 5T2-0608	1 ea.	\$6./ea.
39	Shaft collar	McMaster-Carr King Bearing	6436K36	4 ea.	\$5.50/ea.
62	Diffuse Reflective sensor	Sunix So. Coast Controls 584 S. State College Blvd. Fullerton, CA 92631	EX-D200E	1 ea.	\$77.78/ea.
63	Thru-beam Sensor Projector	Sunix	EX-M2P	1 ea.	\$80./ea.
64	Thru-beam Sensor Detector	Sunix	EX-M2D	1 ea.	\$80./ea.
72	Optiswitch	Optek LLNL Stock	KT851C	1 ea.	\$1.50/ea.

5.2 LIST OF MECHANICAL DRAWINGS

The following mechanical drawings detail the design of LLNL's two-detector actinide analysis system. Including the assembly drawing (AAA 88-114840-OE), there are 60 drawings whose first version is -OO and subsequent versions are -OA, -OB, -OC, etc. The two digits following "AAA" denote the year in which the drawing was first made. This manual incorporates the most recent drawings although the text may in some instances refer to earlier versions.

AAA 88-114840-OE (assembly drawing)

AAA 88-114839-OO	Lid Assembly	AAA 89-100219-OO	Door shielding
AAA 88-114841-OF	Detector Housing and shielding	AAA 89-100220-OO	Front shielding
AAA 88-114842-OO	Collimator cap	AAA 89-100221-OA	Back shielding
AAA 88-114844-OO	Shield	AAA 89-100222-OB	Left-side shielding
AAA 88-114845-OB	Capsule sleeve	AAA 89-100223-OA	Right-side shielding
AAA 88-114847-OA	Lid-detector housing	AAA 90-100227-OB	Outer housing
AAA 88-114848-OA	Filter disc	AAA 90-100228-OA	Outer shielding cover
AAA 88-114849-OC	Filter, split disc	AAA 90-100229-OB	Outer shielding No.1
AAA 88-114850-OB	Shield, split disc	AAA 90-100230-OA	Outer shielding No.2
AAA 88-114851-OA	Collimator	AAA 89-100236-OO	Door liner
AAA 88-114852-OC	Chamber	AAA 89-100237-OO	Front liner
AAA 88-114853-OO	Can guide	AAA 89-100238-OO	Back liner
AAA 88-114854-OO	Brace, dewar stand	AAA 89-100239-OA	Left-side liner
AAA 88-114855-OO	Left actuator bracket	AAA 89-100240-OA	Right-side liner
AAA 88-114856-OO	Right actuator bracket	AAA 89-100243-OO	Skirt
AAA 88-114857-OO	Calorimeter can base	AAA 89-102653-OO	Back lid shielding
AAA 88-114858-OO	Positioning ring	AAA 89-102654-OO	Front lid shielding
AAA 88-114859-OO	Rail table capture tray	AAA 89-102655-OO	Top lid shielding
AAA 88-114860-OO	Bushing block	AAA 89-102656-OB	Lid liner
AAA 88-114861-OO	Dewar base pad	AAA 89-102659-OO	Door assembly
AAA 88-114862-OA	Dewar side pad	AAA 90-100222-OO	Support Angle
AAA 88-114863-OC	Dewar plate	AAA 90-100249-OO	Detector housing
AAA 88-114864-OO	Lid rail, left		
AAA 88-114865-OO	Count rate meter bracket	AAA 90-103602-OO	Rotation disc mount, base
AAA 88-114866-OO	Lid rail, right	AAA 90-103603-OO	Rotation disc mount, top
AAA 88-114867-OA	Rotation motor mount	AAA 90-103606-OB	Count rate meter mount
AAA 88-114868-OB	Dewar stand	AAA 90-103607-OB	Disc sensor bracket
AAA 88-114869-OO	Chamber assembly	AAA 90-103630-OB	Dewar plate tab
AAA 89-100205-OO	Lid casing	AAA 89-100209-OO	Right lid shielding
AAA 89-100208-OO	Actuator cover		
AAA 89-100210-OO	Base plate	AAA 90-105214-OO	Mounting plate
AAA 89-100211-OO	Shaft support	AAA 90-105246-OO	Outer shielding sleeve
AAA 89-100218-OA	Front door	AAA 90-105247-OO	Dewar travel stop
		AAA 90-105248-OO	Lid shaft cover
		AAA 90-105249-OO	Lid shaft support

5.3 MECHANICAL DRAWING PRINTS