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MANUAL**

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ARIES

Segmented Gamma-Ray Scanner

User Manual

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April 16, 1998

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April 17, 1998

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Win_SGS Segmented Gamma-Ray Scanner User Manual

ABSTRACT

The segmented gamma-ray scanner (SGS) designated as *Win_SGS* at the Los Alamos Plutonium Facility has been installed and is intended for use in quantifying the radioisotope content of DOE-STD-3013-96 equivalent containers. The SGS features new software written in C and a new user interface that runs under Microsoft Windows™.

CHAPTER 1

WELCOME TO THE ARIES SEGMENTED GAMMA-RAY SCANNER

In this chapter, you will learn about

- This manual
- Measurement principles
- Win_SGS Menu

1.0 INTRODUCTION

The operation of the Aries Segmented Gamma-ray Scanner (SGS) is documented in this manual. It covers user instructions as well as hardware and software details. Additional information is found in the documentation for the commercially available components and modules that compose the SGS.

1.1 Audience

This manual is intended for three different types of user: the operators who routinely use the SGS, the supervisors who oversee the operators' work, and the technical supervisor, who is the local user assigned to be the resident expert.

- Chapters 1 and 2 are directed to operators. They provide an introduction to the SGS, an overview of its features, and a discussion of the options in the Operator Menu.
- Chapter 3 is intended for the NDA Lab supervisor. It contains explanations of the options available only in the Supervisor Menu. NDA Lab supervisors should also familiarize themselves with Chapters 1 and 2.
- Chapters 4 and 5 are intended for the technical supervisor. Chapter 4 contains explanations of the options available only in the Full Menu. Chapter 5 provides instructions for starting up the SGS for the first time. The technical supervisor should be acquainted with the entire contents of this manual.
- Appendix A is a mini-reference for the system software, *ARIES*. It contains explanations of code terminology and basic instructions for interacting with the program. It is useful for any novice user.
- Appendix B describes SGS software-controlled functions that are common to the execution of many of the menu options. These functions are referenced only by descriptive name elsewhere in this manual.
- Appendix C describes SGS analysis equations that are used in the determination of the final assay results.

1.2 Technique

The SGS is a rugged, versatile nondestructive assay instrument used to measure the distinctive gamma-ray emission from sealed containers bearing waste that may be contaminated with special nuclear materials (SNM) or other radioisotopes. The SGS combines physical motion and active radiation detection in the assay. Segments of the sample are scanned by an external transmission source as the sample is raised incrementally by an elevator and turned about a vertical axis by a rotator. Gamma radiation from the sample and the source is detected with a collimated germanium detector. Combining the results from each segment yields the assayed isotope mass in the sample.

1.3 SGS Safety Features

Several safety features have been engineered into *Win-SGS* design:

- In addition to the radiation from the sample on the turntable, there are ^{75}Se and ^{137}Cs sources used for transmission measurements in *ARIES*. The transmission sources are housed inside a thick tungsten shield. The sources can be accessed using a stepping motor to align a selected source with a collimator aperture. The single aperture is blocked by a moveable tungsten shutter. **Stay out of the beam when the shutter is open.** The shutter is fail-safe. When its solenoid is not energized during a transmission measurement, the shutter safely blocks the transmission source beam. When a transmission measurement is being performed, the solenoid attached to the shutter is energized, lifting it vertically from in front of the transmission source collimator.

1.4 Host Control

The *ARIES* SGS will operate under Host Control in order to incorporate the coordination of instrument measurements. The SGS will perform measurements instructed by the Host without operator intervention. A menu option is provided to switch between the host control or manual mode where the operator is then expected to perform the measurements. The host control is a master/slave relationship where the SGS when it is in Host Control listens for commands from the Host to perform the measurements.

1.5 Measurement Principles

The SGS measures gamma radiation arising from natural radioactive decay. Correction factors and refinements are then applied to the measurement to improve its accuracy. These enhancements fall into three categories: gamma-ray attenuation and absorption corrections, sample rotation and vertical scanning, and rate-loss corrections.

Gamma-ray attenuation and absorption corrections compensate for absorption by the components of the sample. The SGS measures how much the assay item attenuates its own gamma rays by determining the attenuation of gamma rays by the sample from an external radioactive source. A correction that is a function of this measured attenuation is applied to compensate for gamma rays produced within the sample that are absorbed before they escape.

Sample rotation and vertical scanning allow a more uniform response from radioactive material in the assay item. The SGS rotates the sample during measurement to reduce the bias from radial heterogeneity. It also incrementally elevates the sample to scan horizontal segments to account for segment-to-segment attenuation differences. The total SNM content of the sample is obtained by summing the assay results from the individual segments.

The count rate from samples with higher SNM concentrations may be high enough that losses occur during pulse processing due to pile-up. Rate-loss corrections are made for count-rate-related losses in the electronics of the gamma-ray spectroscopy system. The relative rate of a small radioactive source fixed to the detector provides a basis for this correction.

For generic SNM gamma-ray spectra, the recommended reference source for rate-loss correction is ^{109}Cd . This isotope emits a prominent gamma ray at 88.03 keV. While it is straightforward to configure the SGS software to accommodate a different rate-loss reference source, the examples in all subsequent discussions in this manual assume that rate-loss correction is based on the 88.03-keV gamma ray from ^{109}Cd .

The preceding corrections make the SGS method applicable to a wide range of low-density SNM-bearing materials such as paper, plastics, ash, sand, and liquids. Calibration is usually accomplished with samples consisting of dilute mixtures of SNM in oxide form mixed with sand or graphite. This technique provides the important advantage of *not* requiring the calibration standard to be a chemical, physical, or geometric match with the unknown.

1.6 Gamma-Ray Spectrum Analysis Mechanics

A computer-controlled multichannel analyzer is used to determine the count rates in three energy regions of interest (ROIs) for each assay, transmission, and reference peak that is specified for a given measurement. One ROI encompasses the peak itself, and the others are set on segments of the Compton continuum immediately above and below the peak ROI. The continuum ROIs are used to approximate the area and uncertainty of the continuum underlying the full-energy peak in the peak ROI. Then the full-energy peak area and its uncertainty are computed. For further information on the continuum-subtraction algorithm that is used, see Section 5.3 of Passive Nondestructive Assay of Nuclear Materials (NUREG/CR-5550), edited by Doug Reilly, Norbert Ensslin, Hastings Smith, Jr., and Sarah Kreiner.

Net count rates are determined by dividing each full-energy peak area by the real (elapsed clock) time for which the data were acquired. Then the net count rates at the assay and transmission energies are multiplied by a rate-loss correction factor. This correction factor is the ratio of the net count rate of the reference peak obtained during the most recent background run to the net count rate of the reference peak from the sample run. For further information on rate-related losses and corrections, see Section 5.4 of Passive Nondestructive Assay of Nuclear Materials. Finally, the room-background count rate for each energy region is subtracted. This gives the full-energy interaction rates at the assay and transmission energies.

The quality of the gamma-ray spectra are checked regularly by assuring that the centroid and width of the reference peak are within specified tolerances. The centroid is determined using the five-channel method outlined in Section 5.1.7 of Passive Nondestructive Assay of Nuclear Materials. Section 5.2.4 of the same volume gives the method used to estimate the peak's full-width at half-maximum (FWHM).

1.7 Overview of ARIES SGS Operations

Before routine use of *Win_SGS* begins, it is necessary to perform an energy calibration of the spectrometry system (see *Set Up Detector*, in Chapter 5). Energy calibration coefficients (offset in keV, slope in keV/channel) are entered into the parameter database. Then a background run must be made with no sources in the detector's view, other than the reference source. This run is used to determine the room background net count rates in the assay regions of the spectrum and also to measure the rate from the reference source for rate-loss corrections.

Next, the unattenuated transmission source intensity must be characterized. This is accomplished by acquiring a spectrum from the transmission source with no intervening sample or container. The transmission peaks are analyzed and compared to control limits in order to assure adequate source strength and transmission spectrum quality. The transmission full-energy interaction rates are saved and used to normalize subsequent transmission measurements through empty containers and samples.

In order to correct for attenuation of assay gamma rays by the container wall, a transmission measurement is made through an empty container. Container correction factors for each assay energy are deduced from a fit to the measured transmission fractions at the transmission energies. These container correction factors are used in the data analysis at each segment of an assay.

Next, repeated measurements must be made on one or more reference standards. The program computes and reports a calibration factor (in counts/s/gram of SNM mass) for each assay peak. These calibration factors must be entered into the parameter database before assays can be performed.

Assays of certain standards must be performed regularly as part of the Measurement Control program. In order to detect and track undesirable trends in measurement bias, an assay is performed and its result is compared with a reference value stored in the parameter file. The difference between the assay result and the reference value (normalized to the historical standard deviation of past assays) is compared with warning and action limits. To detect and track undesirable trends in measurement precision, a series of consecutive assays on the same reference standard must be performed regularly. A chi-squared test compares the ratio of the observed measurement variance from the repeated runs to that expected from propagated counting statistics. The value of this ratio is tested against limits from the chi-squared distribution.

After the preliminaries have been completed, the SGS is ready to measure an unknown sample. For each segment, the full-energy interaction rates at the assay energies are determined. Also, a matrix-attenuation correction factor is determined and applied, along with the container correction factor. This gives the corrected count rates for the assay energies in the current segment. After all segments

have been measured, the corrected count rates are summed to get the total corrected rates for the sample. When divided by the calibration factors, estimates of SNM mass are obtained.

1.8 User Interface

Win_SGS uses a conventional Microsoft Windows™ style of user interface. There is one menu displayed with options password protected for different levels of User: operator, NDA Lab supervisor, and technical supervisor. The operator options are discussed in Chapter 2. The additional options available to the NDA Lab supervisor are described in Chapter 3. Only the technical supervisor has access to all of the menu options. These options are described in Chapter 5. Fundamental menu operations, such as data entry and key usage, are described in Appendix A. The menu is:

File	Setup	Options	Diagnostics	Host	Window	Help
Edit Access List	General	Assay	Compumotor	Control	Arrange Icons	About
List Log	Container Type	Straight Through	MCA	Manual	Cascade	
Printer Setup		Background			Tile	
Print Window		Empty Container			Close All Windows	
Exit		Calibrate				
		Bias				
		Precision				

Drop-down menu options can be selected by using the arrow keys and Enter or by positioning on the menu option and clicking the top button of the mouse.

1.9 Definitions

<i>Calibration</i>	Calls out the specific full-energy peaks to be analyzed. The user selects from a pick list a set of calibration parameters.
<i>Conditional Assay</i>	An assay in which the User ignores an advisory that a Calibration, a Straight-Through run, or a Measurement Control Bias or Precision run is out of date. The User is permitted by the program to do this, but a "Conditional Assay" warning is displayed, and all results and printouts are flagged with the "Conditional Assay" label.
<i>Corrected Rate</i>	The container- and matrix-corrected FEIR at a given energy and for a particular segment.
<i>Dialog Box</i>	A screen in which Users may change or fill in data in their individual fields, much as the User would with a pencil and a data form. Fields in the dialog box are selected by using the arrow keys and/or Tab to move forward and Do-Tab to move backward.
<i>FEIR</i>	Full Energy Interaction Rate. This is the Raw Rate corrected for losses due to deadtime and pulse pileup.
<i>MCA</i>	Multichannel analyzer. In this system, the multichannel analyzer is a combination of hardware and software. Analog spectral data are digitized in the analog-to-digital converter (ADC). The results are sent to the AIM module, in which the pulse-height analysis is performed. The spectrum is exhibited and manipulated using a powerful set of programs supplied by the MCA manufacturer. For more information on MCAs, see Chapter 4.8 of <u>Passive Nondestructive Assay of Nuclear Materials</u> .
<i>Measurement Type</i>	A descriptive name for a suite of assay parameters that includes the isotopes to be assayed (thereby implying the transmission source(s) to be used) and the Container Type in which the sample resides. The parameters that describe each entry in the Measurement Type pick list are pre-defined in the database by the technical supervisor. The User can enter no selections other than those on the pick list. Attempts to do so will prompt an error message and an instruction to use the pick lists.
<i>Pick List</i>	A submenu or list of options accessible from a menu item by when the user clicks on the item with the mouse.
<i>Program</i>	The SGS code, including the portions that are down-loaded to the Compumotor 4000.
<i>Raw Rate</i>	The net peak area (peak ROI less Compton continuum) divided by the true time and with the room background count rate subtracted.

<i>ROI</i>	Region Of Interest. This is a selected set of contiguous channels in a multichannel pulse-height rendition of a gamma-ray spectrum. The <i>WinSGS</i> program uses no peak-fitting algorithms. Rather, it relies on the judicious selection of ROIs to determine full-energy peak areas.
<i>Scrollable Form</i>	A list of items that is too long to fit in the screen window. The User may scroll through the list using the arrow keys, and may make changes or selections as appropriate.
<i>Total Corrected Rate</i>	The sum over all segments of the Corrected Rates for a given assay energy.

CHAPTER 2

USING THE OPERATOR MENU

In this chapter, you will learn about :

- Measurements
- List Log
- Printer Setup
- Print Window
- Exiting *Win_SGS*

File	Setup	Options	Diagnostics	Host	Window	Help
Edit Access List	General	Assay	Compumotor	Manual	Arrange Icons	About
List Log	Container Type	Straight Through	MCA	Control	Cascade	
Printer Setup		Background			Tile	
Print Window		Empty Container			Close All Windows	
Exit		Calibrate				
		Bias				
		Precision				

The Main Menu options that are in bold print in the menu displayed above are available without a password entry. Each will be discussed in detail below.

2.0 MEASUREMENT

2.0.1 Assay

Assay is the most heavily used option in the Win_SGS program. Select it to measure the SNM in a drum or box. You may opt to repeat the complete assay a selected number of times in an unattended mode. If this option is exercised, a statistical analysis of some of the assay results is performed and printed out at the end of the series. Assay proceeds as follows:

The operator is instructed to enter the sample information. This information is obtained from the MASS ticket attached to the sample. The item id, operator id, and material type must be entered before the user is permitted to continue with the assay. The user can select the type of printout required for the assay and decide if the spectral data should be written to disk.

Item Information

Item ID:

NMT4-10A

Operator ID:

Jane

Material Type:

83

Enrichment:

81.28

☒ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☒ Short
 ☐ Medium
 ☐ Long

OK

Cancel

To continue with the Assay click on the **OK** button. If the user decides not to continue with the Assay, click on the **Cancel** button and the main menu will be presented so that the user can select another option.

When the sample information has been entered, the user is prompted to select the container type being measured. A list of the available container types is presented. These container types have been assigned by the technical supervisor in the **General** and **Setup Parameters** options prior to the running of the assay. This list is in a picklist form, so the user highlights the selection by moving the pointer to the selection and clicking the mouse button.

Container Types

Select container type:

- 5 gallon garbage pail
- 5 gallon garbage pail
- 5 gallon PLASTIC paint can
- 5 gallon paint can
- Tall can

Comment: Test on user interface

OK **Cancel**

To continue with the Assay click on the **OK** button. If the user decides not to continue with the Assay, click on the **Cancel** button. The Item Information screen is displayed and the user can make a change on this screen or click **OK** and select another container type from the Container Types screen.

The **Win_SGS** program then verifies that the container has a current Straight Through measurement and a valid Calibration measurement. If either or both of these elapsed times exceed the limits set in the parameter file, the program will display the appropriate message(s):

<p style="text-align: center;">Win_SGS >>>ATTENTION<<< CALIBRATION UPDATE IS NEEDED DAYS SINCE LAST CALIBRATION: XX CONTROL LIMITS (DAYS): YY</p> <p style="text-align: center;">Proceed with Assay Return to Main Menu</p>

If the user selects **Proceed with Assay** , the program sets a CONDITIONAL ASSAY flag to be TRUE and continues. If **Return to Main Menu** is selected, the user is returned to the main menu.

The program computes the number of days since the last Straight-Through run and compares it with the limit set in the parameter file. If the limit is exceeded, the program displays this message:

<p style="text-align: center;">Win_SGS <<<ATTENTION>>> STRAIGHT -THROUGH RUN IS NEEDED DAYS SINCE LAST STRAIGHT-THROUGH: XX CONTROL LIMIT (DAYS): YY</p> <p style="text-align: center;">Proceed with Assay Return to Main Menu</p>
--

If the user has selected to continue, the program presents the following information box to verify that the user has selected the container type that is going to be measured. If any of the information displayed is not correct, the user is given the option to return to the screen that allows another selection of a container type.

Item ID:	NMT4-10A	Operator ID:
Container Type:	55 gallon drum	
Number Assay Cycles:	1	Container Height: 2.0
Material Type:	83	
Enrichment:	81.28	
Trans. Source(s) 75 SE Position 1		
Open Time	40.00	Close Time 30.00 Primary Peak: 400.646
Transmission Peaks (keV): 136.000, 279.528, 400.646		
Assay Peaks (keV): 129.294, 203.537, 345.014, 413.712		
Segment Correction is: OFF		
Lump Correction:	ON	
Comment:		
Printout Selected:	Short	
		<input type="button" value="OK"/> <input type="button" value="CANCEL"/>

When the assay is to continue, the sample table is automatically moved to the load position.

The peaks for the container type are read from the database and set in the MCA. The current background file, straight through file, and empty container file are read so that the values calculated during these measurements can be used in the assay analysis. There is a straight through file for each type of transmission source that has been selected and each is read during the assay process.

The Emergency Stop Button is checked at the beginning of the assay and throughout the measurement. If it has been pushed, the program stops with a message to the operator.

The number of segments entered in the parameter entries is used for the container.

If status is OK, the program starts the ROTATE TABLE procedure. After successfully completing an OPEN SHUTTER procedure, the program sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA ACQUIRE, and accumulates a transmission spectrum while the sample is exposed to the transmission source. The program displays the following screen informing the operator of the current status of the SGS during passive and transmission data collection.

Measurement in Progress

Measurement in progress, click on PAUSE button to suspend assay. Click on CANCEL to terminate assay.

Segment 1 out of 30

Progress bar for number of segments executed

Progress bar for how much time is left in count

Spectral display

Pause Cancel...

While the transmission spectrum is being collected, the program analyzes the preceding passive spectrum for the net intensities of the rate-loss peak and assay peaks and computes the FEIRs at the assay energies. Note that for the first segment, no passive spectrum has yet been acquired.

When the transmission spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent passive run and sets the digital stabilizer to "gain stabilization hold" and "zero stabilization hold." If the save spectral data flag is set, the program writes the transmission and passive spectral data to a file on disk. Note: If several assays are written to disk, the hard disk can begin to fill quickly.

After successfully completing a CLOSE SHUTTER procedure, the program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a passive spectrum.

While the passive spectrum is being collected, the program analyzes the transmission spectrum to obtain the net intensities of the rate-loss peak and transmission peak(s), and computes FEIRs at the transmission energies.

When the passive spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent transmission run.

If the medium or long printout check box has been selected, the **Win_SGS** program will write to the screen the printout for the selection and will automatically print the screen. Otherwise the short format will be presented at the end of the assay after all segments have been completed.

The program performs the following diagnostic tests:

- **Opacity**

The program computes the transmission of the prime gamma ray from the transmission source and compares it to the **OPACITY** control limit. If *NN* segments (set in the Parameter File) are blacker than the control limit (usually 0.01, set in the Parameter File), then the program terminates the assay by:

- ☒ Executing the **TERMINATE RUN** procedure.
- ☒ Displaying the following message:

Win_SGS
>>>>ATTENTION<<<<
XXX.X keV TRANSMISSION TOO LOW
ON NN SEGMENTS.
Transmission = .YYY. Limit = *OPACITY*

Container requires repacking prior to SGS assay!

OK

- **Spectrum Quality**

The program performs a **SPECTRUM QUALITY CHECK** on the reference (rate-loss source) peak.

The program invokes the procedure to index the sample height by the prescribed segment thickness.

To the **FEIRs** of the assay peaks, the program applies an Attenuation Correction and a Container Correction. Results are summed with the results of all other segments in the current cycle to yield Total Corrected Rates.

The program repeats segment data collection until the **LAST_SEGMENT** has been assayed.

The program divides the Total Corrected Rates by the calibration factors to get assays (in grams of SNM) at each energy for each isotope.

If Assay is running in the autocycle mode, the program repeats single assays for each of the specified number of assay cycles.

The Cycle # message is displayed on the printout form, short, medium, or long.

After the LAST_SEGMENT of the final Assay cycle, the program writes the data to a file formatted such that it can be read into a spreadsheet. This file is **Win_SGS.dat** and is written every time the user selects the write data to file option. An example of the file output is located in Appendix A. It also writes the data to a local database for viewing in the **List Log** option.

If (and only if) Assay is running in the autocycle mode, the program displays the mean assay (grams of SNM), along with standard deviation.

The program then positions the elevator to the beginning position and turns off the rotation table so that the operator can unload the sample.

The program returns the Main Menu to the display.

2.0.2 Background

The Background option facilitates the measurement and updating of gamma radiation from the NDA room environment. Background data should be recent enough to accurately characterize contributions to the spectra from the room during measurements using other options. Room background is subtracted during the process of calculating FEIRs for assay and transmission peaks. Background proceeds as follows:

The program displays the following screen:

Straight Through/Background

Operator ID:

Comment:

☐ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☐ Short

☐ Medium

☐ Long

OK **Cancel**

The program displays the information screen to validate the peaks and count time that is going to be used in the background measurement. If the user selects the **OK** button the Background measurement option will display the information screen. If **Cancel** is selected the main menu will be displayed.

G05 SGS	
Option:	Background
Background time (secs):	1800.00
Trans Peaks (keV):	136.000 279.528 400.646 661.638
Assay Peaks (keV):	129.294 203.357 345.014 413.712 163.363 185.720 766.350
Comment:	
Printout Selected:	Short
<div style="text-align: center;"><input type="button" value="OK"/> <input type="button" value="Cancel"/></div>	

A response is required in this dialog box. Either select OK or Cancel. If Cancel is selected the previous **Straight Through/Background** dialog box is returned and the user can either change an entry or return from the dialog box to the main menu. (Note: This example is from the G05 SGS but the information is the same for the ARIES SGS except for the title.)

The program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a spectrum. The spectral data screen is displayed during the measurement.

When the Background spectrum times out, the program analyzes the spectrum to obtain the net intensities of the rate-loss peak and of transmission and assay peak ROIs, and computes the FEIRs.

FEIRs, along with date and time, are written to a background file, **BKGDATA.BKG** for reference during subsequent measurement runs. The results of the background measurement are also written to the result log database.

The program returns the Main Menu to the display.

2.0.3 Straight-Through

Two operations are accomplished during a Straight-Through measurement. First, with the shutter closed, a brief spectrum is acquired. The primary assay peaks in this spectrum are analyzed and compared with control limits in order to detect contamination in the SGS. Then, the unattenuated transmission source intensity is measured. Transmission peaks are analyzed and compared to control limits in order to assure adequate source strength and transmission spectrum quality. Straight-Through proceeds as follows:

When the Straight Through option is selected the program displays the same dialog box as in background.

Straight Through/Background

Operator ID:

Comment:

☐ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☐ Short

☐ Medium

☐ Long

OK **Cancel**

After the user enters the information and selects OK, the information screen is displayed. The user has the same choices as in Background of returning to the dialog screen or continuing with the Straight Through measurement. If **Cancel** is selected the main menu will be displayed.

G05 SGS	
Option:	Straight Through
Turntable Ht(cm):	24.50
Trans. Src	75SE Position 3
Open Time	300.00 Close Time 100.00
Primary Trans. Peak (keV):	400.646
Trans. Src	137CS Position 2
Open Time	300.00 Close Time 100.00
Primary Trans. Peak (keV):	661.638
Trans Peaks (keV):	136.000 279.528 400.646 661.638
Assay Peaks (keV):	129.294 203.357 345.014 413.712 163.363 185.720 766.350
Comment:	
Printout Selected:	Short
<div>OK Cancel</div>	

The program first positions the source wheel to the "home" position and then positions it to the first source selected in the parameter setup. The program invokes the RAISE/LOWER ELEVATOR procedure to raise the turntable to the height specified in the parameter file. This places the turntable surface just below the bottom of the detector collimator so that surface contamination (if present) is in the detector's field of view.

If no elevator status fault is sensed, the program starts the ROTATE TABLE procedure, then makes the appropriate MCA acquire time preset.

The program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a Straight-Through background spectrum.

When the background spectrum times out, the program analyzes the spectrum to obtain net intensities of the rate-loss peak and assay peak(s) and computes FEIRs at the assay energies.

The FEIR of the rate-loss gamma ray is decay-corrected to the date at which the historical rate-loss gamma-ray FEIR (Reference Source Rate in the parameter file) was measured. The corrected rate is then compared to the historical value. If it is not within the specified range (Reference Source Range in the parameter file), then the program saves no results, flags the Straight-Through run as BAD, displays the following message.

The program compares the FEIR at the primary assay energy with the control limit in the parameter file. If the limit is exceeded, the program saves no results, flags the Straight-Through run as Not Valid, displays the following message:

The program obtains the following information from the most recent Straight-Through run of the selected Measurement Type:

- Date and time
- True time
- FEIR and standard deviation for the reference source peak and transmission peak(s).

The program invokes the RAISE/LOWER ELEVATOR procedure to return the turntable to the load height.

The program initializes the MCA by making the appropriate acquire time preset and setting up the transmission regions of interest specified by the Measurement Type.

The program executes the OPEN SHUTTER procedure, and then sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA ACQUIRE, and accumulates a Straight-Through transmission spectrum.

When the transmission spectrum times out, the program sets the digital stabilizer to "zero stabilization hold" and "gain stabilization hold", analyzes the spectrum to obtain centroids, full-width-half-maxima, and net intensities of the rate-loss peak and the primary transmission source peak. The FEIR is computed at the primary transmission energy.

The FEIR at the primary transmission energy is checked against control limits (in the parameter file) in order to avoid using a transmission source that is too hot or cold. If the FEIR exceeds the hot limit, the program saves no results, flags the Straight-Through run as BAD, exhibits the following message:

Win_SGS
>>>>ATTENTION<<<<
TRANSMISSION SOURCE IS TOO HOT.
USE LESS ACTIVE SOURCE.
Straight-Through transmission is not valid.

OK

If the FEIR is lower than cold limit, the program saves no results, flags the assay as BAD, exhibits the following message:

Win_SGS
>>>>ATTENTION<<<<
TRANSMISSION SOURCE IS TOO WEAK.
REPLACE SOURCE IMMEDIATELY.
Straight-Through transmission is not valid.

OK

A cool limit is set at a supervisor-selected time prior to cold limit. If cool limit has expired (but the cold limit date has not yet been reached), the program exhibits the following message:

Win_SGS
>>>>ATTENTION<<<<
TRANSMISSION SOURCE IS WEAK.
REPLACE AS SOON AS POSSIBLE,
BUT BEFORE MM/DD/YY.

OK

The source replacement deadline, *MM/DD/YY*, is the date at which the cold limit would be reached.

The primary transmission FEIR is divided by the rate-loss and decay-corrected FEIR for the same peak in the most recent Straight-Through run (see 3.10). This ratio should be within a specified (Fractional Source Control Limit in the parameter file) fractional range of one. If it is not, the program saves no results, flags the Straight-Through run as BAD, exhibits the following message:

Win_SGS
>>>>ATTENTION<<<<
TRANSMISSION SOURCE RATE
IS OUTSIDE CONTROL LIMITS.
Normalized Rate = Z.ZZ
Limits = 1 +/- Fractional Limit
CHECK GEOMETRY AND ABSORBERS
Straight Through transmission is not valid.

If the ratio is greater than 1.2, then the program should conclude instead that a hotter transmission source has been installed and display the following message:

Win_SGS
>>>>ATTENTION<<<<
A HOTTER TRANSMISSION SOURCE
HAS BEEN INSTALLED.

Use new transmission source rate?
Yes
No

If you accept the new transmission source rate, then the program

- Saves the primary transmission FEIR and the current date for reference during future Straight-Through runs.
- Calculates the new cool limit and cold limit and saves them for reference during future Straight-Through runs.

If you reject the new transmission source rate, then the program exhibits the following message:

The program performs a SPECTRUM QUALITY CHECK on the primary transmission and the reference (rate-loss source) peaks.

FEIRs, along with date and time, are written to a file for each of the transmission sources selected, so that they can be referenced during subsequent Empty Container and Straight-Through runs. The results of the Straight Through measurements are written to the log database.

The program repeats the Straight Through measurement for each of the transmission sources selected in the parameter setup.

The program returns the Main Menu to the display.

2.0.4 Calibrate

In the Calibrate option, repeated measurements are made on one of the reference standards. Names and specifications of reference standards are entered in advance into the parameter database by the technical supervisor. The program computes and reports a calibration factor (mean of the Total Corrected Rate divided by the known SNM mass) for each assay peak.

The program checks the Emergency stop bit to determine that it is OK to begin operation of the SGS. If the Emergency stop button has been pushed, the program cannot begin a measurement.

The program then checks that the source-too-cold flag has not been set. If it is set during another measurement, the message:

"Source is too cold. Assays are not permitted."

is displayed and the program returns to the main menu. The operator should then call the technical supervisor to replace the source.

The operator is instructed to enter the sample information. This information is obtained from the calibration standard. The item id, operator id, and material type must be entered before the user is permitted to continue with the calibration. The user can select the type of printout required for the calibration assay and decide if the spectral data should be written to disk.

Container Types

Select container type:

- 5 gallon garbage pail
- 5 gallon garbage pail
- 5 gallon PLASTIC paint can
- 5 gallon paint can
- Tall can

Comment: Test on user interface

OK Cancel

When the sample information has been entered, the user is prompted to select the container type being measured. A list of the available container types is presented. These container types have been assigned by the technical supervisor in the **General** and **Setup Parameters** options prior to the running of the assay. This list is in a picklist form, so the user highlights the selection by moving the pointer to the selection and clicking the mouse button. When OK is selected, the program continues and calculates the number of days since the last Straight Through measurement. If Cancel is selected, the user is returned to the main menu.

The program computes the number of days since the last Straight Through run and compares it with the limit set in the parameter file. If the limit is exceeded, the program displays this message:

Win_SGS	
>>>>ATTENTION<<<<	
STRAIGHT-THROUGH RUN IS NEEDED	
DAYS SINCE LAST STRAIGHT-THROUGH: XX	
CONTROL LIMIT (DAYS): YY	
Proceed with Calibration	Return to Main Menu

If the calibration is to proceed, the program presents the following information box to verify that the user has selected the container type that is going to be measured. If any of the information displayed is not correct, the user is given the option to return to the screen that allows another selection of a container type.

Item ID:	NMT4-10A	Operator ID:
Container Type:	55 gallon drum	
Number Assay Cycles:	1	Container Height: 2.0
Material Type:	83	
Enrichment:	81.28	
Trans. Source(s) 75 SE Position 1		
Open Time	40.00	Close Time 30.00 Primary Peak: 400.646
Transmission Peaks (keV): 136.000, 279.528, 400.646		
Assay Peaks (keV): 129.294, 203.537, 345.014, 413.712		
Segment Correction is: OFF		
Lump Correction:	ON	
Comment:		
Printout Selected:	Short	
OK CANCEL		

The user is permitted to modify the number of cycles for the calibration measurement. The number of cycles is set in the calibration parameter setup for the container type that has been selected.

Number of Cycles:

OK Cancel

When the assay is to continue, the sample table is automatically moved to a load position.

The peaks for the container type are read from the database and set in the MCA. The current background file, straight through file, and empty container file are read so that the values calculated during these measurements can be used in the assay analysis. There is a straight through file for each type of transmission source that has been selected and each is read during the assay process.

The Emergency Stop Button is checked at the beginning of the assay and throughout the measurement. If it has been pushed, the program stops with a message to the operator.

The number of segments entered in the parameter entries is used for the container.

If status is OK, the program starts the ROTATE TABLE procedure. After successfully completing an OPEN SHUTTER procedure, the program sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA ACQUIRE, and accumulates a transmission spectrum while the sample is exposed to the transmission source. The program displays the following screen informing the operator of the current status of the SGS during passive and transmission data collection bottom of the detector collimator. The containers rest directly on the turntable surface. This implies that the table height for the first segment depends on the Container Type and should be specified in the parameter database.

While the transmission spectrum is being collected, the program analyzes the preceding passive spectrum for the net intensities of the rate-loss peak and assay peaks and computes the FEIRs at the assay energies. Note that for the first segment, no passive spectrum has yet been acquired.

When the transmission spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent passive run and sets the digital stabilizer to "gain stabilization hold" and "zero stabilization hold." If the save spectral data flag is set, the program writes the transmission and passive spectral data to a file on disk. Note: This can begin to fill the hard disk quickly if several assays are written to disk.

After successfully completing a CLOSE SHUTTER procedure, the program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a passive spectrum.

While the passive spectrum is being collected, the program analyzes the transmission spectrum to obtain the net intensities of the rate-loss peak and transmission peak(s), and computes FEIRs at the transmission energies.

When the passive spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent transmission run.

If the medium or long printout check box has been selected, the Win_SGS program will write to the screen the printout for the selection and will automatically print the screen. Otherwise the short format will be presented at the end of the assay after all segments have been completed.

The program performs the following diagnostic tests:

- **Opacity**

The program computes the transmission of the prime gamma ray from the transmission source and compares it to the OPACITY control limit. If *NN* segments (set in the Parameter File) are blacker than the control limit (usually 0.01, set in the Parameter File), then the program terminates the assay by:

- ☒ Executing the TERMINATE RUN procedure.
- ☒ Displaying the following message:

- **Spectrum Quality**

The program performs a SPECTRUM QUALITY CHECK on the reference (rate-loss source) peak.

The program invokes the procedure to index the sample height by the prescribed segment thickness.

To the FEIRs of the assay peaks, the program applies an Attenuation Correction, an End-Effect Correction (as appropriate), and a Container Correction. Results are summed with the results of all the other segments to obtain the Total Corrected Rates for each assay peak.

The program repeats the assay process until last segment has been assayed. Total Corrected Rates for the assay peaks in the current cycle are retained for subsequent statistical analysis.

The program repeats the assay for each of the specified number of assay cycles.

After the last segment of the final Calibration cycle, the program initiates the UNLOAD procedure.

The program computes the means of the ratios of Total Corrected Rates to SNM mass for each of the assay energies. Standard deviations are also computed.

The program saves the Calibration results and prints them out on a printer attached to the SGS computer.

The program returns the Main Menu to the display.

2.0.5 Empty Container

The Empty Container option facilitates the measurement and updating of empty container transmission values. The transmission of an empty container is used in the data analysis at each segment of an assay. The transmission of the material within the container is obtained by dividing the measured transmission through the container and its contents by the stored value of the transmission through the empty container. Once a container's transmission values have been measured to a high precision (better than 0.2%), they need not be remeasured unless an existing container model is replaced by a new one. If additional transmission source gamma rays are added to the Container Types, then Empty Container runs should be repeated to include all of the gamma rays. Empty container transmission values are stored in parameter files and retained until they are updated by a subsequent Empty Container run.

The program sets the Manual Mode operation to off so that the SGS is under computer control. It then checks the Emergency stop bit to determine that it is OK to begin operation of the SGS. If the Emergency stop button has been pushed, the program cannot begin a measurement.

The program then checks that the source-too-cold flag has not been set. If it is set during another measurement, the message:

"Source is too cold. Assays are not permitted."

is displayed and the program returns to the main menu. The operator should then call the technical supervisor to replace the source.

The user is prompted to enter the operator id and to select a printout mode for the Empty Container measurement.

The image shows a software dialog box titled "Empty Container". It contains the following elements:

- A label "Operator ID:" followed by a rectangular text input field.
- A checkbox labeled "Automatic Short Printout".
- A checkbox labeled "Write spectral data to disk".
- A group box titled "Print Mode" containing three radio button options: "Short", "Medium", and "Long".
- At the bottom, there are two buttons: "OK" and "Cancel".

The user then selects the type of empty container that is going to be measured.

Empty Container

Operator ID: _____

☐ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☐ Short

☐ Medium

☐ Long

OK Cancel

The program computes the number of days since the last Straight-Through run and compares it with the limit set in the parameter file. If the limit is exceeded, the program displays this message:

Win_SGS

>>>>ATTENTION<<<<

STRAIGHT-THROUGH RUN IS NEEDED.

DAYS SINCE LAST STRAIGHT THROUGH: XX

CONTROL LIMIT (DAYS): YY

Proceed with Empty Container Return to Main Menu

The user can return to the main menu and run a straight through measurement or continue with the empty container measurement. The empty container results will not be valid if the straight through run has not completed successfully.

For your information, the next screen displays the selected measurement and analysis parameters. An example follows:

Win_SGS	
Container Type:	55 gallon drum
Trans. Source(s): 75SE	Source #: 1
Open Time:	40.00
Primary Trans. Peak (keV):	400.646
Transmission Peaks (keV):	136.0, 279.5, 400.6
Comment:	
<div>OK</div> <div>Cancel</div>	

A response is required on one of the bottom two lines. If there is a mistake in the parameters, the user may choose the **Return to Item Information Screen** option. The Empty Container dialog box is returned to the screen with the previous responses entered thereon. The user may correct the erroneous field, and continue.

When the assay is to continue, the sample table is automatically moved to a load position.

The peaks for the container type are read from the database and set in the MCA. The current background file, straight through file, and empty container file are read so that the values calculated during these measurements can be used in the assay analysis. There is a straight through file for each type of transmission source that has been selected and each is read during the assay process.

The Emergency Stop Button is checked at the beginning of the assay and throughout the measurement. If it has been pushed, the program stops with a message to the operator.

The number of segments entered in the parameter entries is used for the container. The program invokes the **RAISE/LOWER ELEVATOR** procedure to raise the container to the height specified in the parameter database.

If no elevator status fault is sensed, the program starts the **ROTATE TABLE** procedure, and then initializes the MCA by making the appropriate acquire time preset (from the parameter file) and setting up the regions of interest specified by the Container Type.

The program executes the **OPEN SHUTTER** procedure and then sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA **ACQUIRE**, and accumulates an Empty Container transmission spectrum.

When the Empty Container transmission spectrum times out, the program sets the digital stabilizer to "gain stabilization hold" and "zero stabilization hold," executes the UNLOAD sequence, and analyzes the spectrum to obtain net intensities of the rate-loss peak and the transmission source peak(s).

The program computes the FEIRs. Then it refers to the most recent Straight-Through results and calculates transmissions and Container Correction Factors for each transmission energy.

The program performs a least-squares fit of the Container Correction Factors to their corresponding energies from the transmission peaks. Fit coefficients are stored for reference by other measurement options.

The program returns the Main Menu to the display.

2.0.6 Bias

A Bias run is performed regularly as part of the Measurement Control program. The measurement is an assay of a reference standard or some other stable, reproducible, homogeneous sample. When the run is completed, the assay mass is compared with the reference value stored in the parameter file. The difference between the assay result and the reference value (normalized to the historical standard deviation of past Bias runs, also in the parameter file) is compared with warning and action limits. Subsequent assays are flagged if the tests are not passed.

The operator is instructed to enter the sample information. The item id, operator id, and material type must be entered before the user is permitted to continue with the assay. The user can select the type of printout required for the assay and decide if the spectral data should be written to disk.

Item Information

Item ID: NMT4-10A

Operator ID: Jane

Material Type: 83

Enrichment: 81.28

☒ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☒ Short

☐ Medium

☐ Long

OK Cancel

When the sample information has been entered, the user is prompted to select the container type being measured. A list of the available container types is presented. These container types have been assigned by the technical supervisor in the **General and Setup Parameters**

options prior to the running of the assay. This list is in a picklist form, so the user highlights the selection by moving the pointer to the selection and clicking the mouse button.

Container Types

Select container type:

- 5 gallon garbage pail
- 5 gallon garbage pail
- 5 gallon PLASTIC paint can
- 5 gallon paint can
- Tall can

Comment: Test on user interface

OK Cancel

After the Container Type is selected, the program presents the following information box to verify that the user has selected the container type that is going to be measured. If any of the information displayed is not correct, the user is given the option to return to the screen that allows another selection of a container type.

Item ID:	NMT4-10A	Operator ID:
Container Type:	55 gallon drum	
Number Assay Cycles:	1	Container Height: 2.0
Material Type:	83	
Enrichment:	81.28	
Trans. Source(s) 75 SE Position 1		
Open Time	40.00	Close Time 30.00 Primary Peak: 400.646
Transmission Peaks (keV): 136.000, 279.528, 400.646		
Assay Peaks (keV): 129.294, 203.537, 345.014, 413.712		
Segment Correction is: OFF		
Lump Correction:	ON	
Comment:		
Printout Selected:	Short	
		<input type="button" value="OK"/> <input type="button" value="CANCEL"/>

The **Win_SGS** program then verifies that the container has a current Straight Through measurement and a valid Calibration measurement. If either or both of these elapsed times exceed the limits set in the parameter file, the program will display the appropriate message(s):

Win_SGS	
>>>>ATTENTION<<<<	
CALIBRATION UPDATE IS NEEDED.	
DAYS SINCE LAST CALIBRATION: XX	
CONTROL LIMIT (DAYS): YY	
<input type="button" value="Proceed with Bias"/>	<input type="button" value="Return to Main Menu"/>

A response is required on one of the bottom two lines. The default is Proceed with Bias. Press Enter to continue. If you choose not to proceed, select the bottom option to return to the Main Menu.

The program computes the number of days since the last Straight-Through run and compares it with the limit set in the parameter file. If the limit is exceeded, the program displays this message:

Win_SGS	
>>>>ATTENTION<<<<	
STRAIGHT-THROUGH RUN IS NEEDED.	
DAYS SINCE LAST STRAIGHT-THROUGH: XX	
CONTROL LIMIT (DAYS): YY	
Proceed with Bias	Return to Main Menu

When the bias assay is to continue, the sample table is automatically moved to a load position.

The peaks for the container type are read from the database and set in the MCA. The current background file, straight through file, and empty container file are read so that the values calculated during these measurements can be used in the assay analysis. There is a straight through file for each type of transmission source that has been selected and each is read during the assay process.

The Emergency Stop Button is checked at the beginning of the assay and throughout the measurement. If it has been pushed, the program stops with a message to the operator.

If no elevator status fault is sensed, the program starts the ROTATE TABLE procedure and then initializes the MCA by making the appropriate acquire time preset (from the parameter file) and setting up regions of interest specified by the Measurement Type.

After successfully completing an OPEN SHUTTER procedure, the program sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA ACQUIRE, and accumulates a transmission spectrum while the sample is exposed to the transmission source.

While the transmission spectrum is being collected, the program analyzes the preceding passive spectrum for the net intensities of the rate-loss peak and the assay peaks and computes the FEIRs at the assay energies. The program also performs a SPECTRUM

QUALITY CHECK on the reference (rate-loss) peak. Note that for the first segment, no passive spectrum has yet been acquired.

When the transmission spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent passive run and sets the digital stabilizer to "gain stabilization hold" and "zero stabilization hold."

After successfully completing a CLOSE SHUTTER procedure, the program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a passive spectrum.

While the passive spectrum is being collected, the program analyzes the transmission spectrum to obtain net intensities of the rate-loss peak and transmission peak(s), and computes the FEIR at the transmission energies.

When the passive spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent transmission run.

The program invokes the RAISE/LOWER ELEVATOR procedure to lower the sample the prescribed segment thickness.

To the FEIRs of the assay peaks, the program applies an Attenuation Correction, an End-Effect Correction (as appropriate), and a Container Correction. Results are summed with the results of all other segments to yield Total Corrected Rates.

The program repeats the assay steps until the last segment has been assayed.

After the last segment, the program initiates the UNLOAD procedure.

The program divides the Total Corrected Rates by calibration factors to get assays (in grams of SNM) at each energy.

The Assay result at the primary assay energy is tested against the reference value stored in the parameter database. The difference between the reference value and the current Bias result is divided by the historical standard deviation for Bias assays. This quotient is compared to WARN_LIM and ACTION_LIM, the warning and action limits in the parameter database. If the action limit is exceeded, the Bias run is flagged BAD and the following message is displayed:

The BAD assay flag is reset upon successful completion of a subsequent Bias run. If the warning limit is exceeded, the CONDITIONAL assay flag is set and the following message is displayed:

The CONDITIONAL assay flag is reset upon successful completion of a subsequent Bias run.

The program saves the Bias results to the Measurement Control Log .

The program returns the Main Menu to the display.

2.0.8 Precision

A Precision run is performed regularly as part of the Measurement Control program, employing the same reference standard as used for the Bias run. The measurement consists of autocycled assays (any selected number of cycles). The program performs a chi-squared test to compare the ratio of the observed measurement variance from the repeated runs to that expected from propagated counting statistics. The value of this ratio is tested against limits from the chi-squared distribution. Subsequent assays are flagged if the test is not passed.

The operator is instructed to enter the sample information. This information is obtained from the ticket attached to the sample. The item id, operator id, and material type must be entered before the user is permitted to continue with the assay. The user can select the type of printout required for the assay and decide if the spectral data should be written to disk.

Item Information

Item ID: NMT4-10A

Operator ID: Jane

Material Type: 83

Enrichment: 81.28

☒ Automatic Short Printout

☐ Write spectral data to disk

Print Mode

☒ Short

☐ Medium

☐ Long

OK Cancel

When the sample information has been entered, the user is prompted to select the container type being measured. A list of the available container types is presented. These container types have been assigned by the technical supervisor in the **General** and **Setup Parameters** options prior to the running of the assay. This list is in a picklist form, so the user highlights the selection by moving the pointer to the selection and clicking the mouse button.

Container Types

Select container type:

- 5 gallon garbage pail
- 5 gallon garbage pail
- 5 gallon PLASTIC paint can
- 5 gallon paint can
- Tall can

Comment: Test on user interface

OK Cancel

After the Container Type is selected, the program prompts the user to verify the number of cycles for the Precision measurement. The number of cycles has been set in the parameter file and can be modified at the beginning of the Precision assay. The program then presents the following information box to verify that the user has selected the container type that is going to be measured. If any of the information displayed is not correct, the user is given the option to return to the screen that allows another selection of a container type.

Item ID:	NMT4-10A	Operator ID:
Container Type:	55 gallon drum	
Number Assay Cycles:	1	Container Height: 2.0
Material Type:	83	
Enrichment:	81.28	
Trans. Source(s) 75 SE Position 1		
Open Time	40.00	Close Time 30.00 Primary Peak: 400.646
Transmission Peaks (keV): 136.000, 279.528, 400.646		
Assay Peaks (keV): 129.294, 203.537, 345.014, 413.712		
Segment Correction is: OFF		
Lump Correction:	ON	
Comment:		
Printout Selected:	Short	
		<input type="button" value="OK"/> <input type="button" value="CANCEL"/>

The **Win_SGS** program then verifies that the container has a current Straight Through measurement and a valid Calibration measurement. If either or both of these elapsed times exceed the limits set in the parameter file, the program will display the appropriate message(s):

Win_SGS	
>>>>ATTENTION<<<<	
CALIBRATION UPDATE IS NEEDED.	
DAYS SINCE LAST CALIBRATION: XX	
CONTROL LIMIT (DAYS): YY	
<input type="button" value="Proceed with Precision"/>	<input type="button" value="Return to Main Menu"/>

The peaks for the container type are read from the database and set in the MCA. The current background file, straight through file, and empty container file are read so that the values calculated during these measurements can be used in the assay analysis. There is a straight through file for each type of transmission source that has been selected and each is read during the assay process.

The Emergency Stop Button is checked at the beginning of the assay and throughout the measurement. If it has been pushed, the program stops with a message to the operator.

If no elevator status fault is sensed, the program starts the ROTATE TABLE procedure and then initializes the MCA by making the appropriate acquire time preset (from the parameter file) and setting up regions of interest specified by the Measurement Type.

After successfully completing an OPEN SHUTTER procedure, the program sets the digital stabilizer to "gain stabilization on" and "zero stabilization on," clears the MCA memory, turns on MCA ACQUIRE, and accumulates a transmission spectrum while the sample is exposed to the transmission source.

While the transmission spectrum is being collected, the program analyzes the preceding passive spectrum for the net intensities of the rate-loss peak and the assay peaks and computes the FEIRs at the assay energies. The program also performs a SPECTRUM QUALITY CHECK on the reference (rate-loss) peak. Note that for the first segment, no passive spectrum has yet been acquired.

When the transmission spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent passive run and sets the digital stabilizer to "gain stabilization hold" and "zero stabilization hold."

After successfully completing a CLOSE SHUTTER procedure, the program clears the MCA memory, turns on MCA ACQUIRE, and accumulates a passive spectrum.

While the passive spectrum is being collected, the program analyzes the transmission spectrum to obtain net intensities of the rate-loss peak and transmission peak(s), and computes the FEIR at the transmission energies.

When the passive spectrum acquisition times out, the program temporarily saves the spectral data for analysis during the subsequent transmission run.

The program invokes the RAISE/LOWER ELEVATOR procedure to lower the sample the prescribed segment thickness.

To the FEIRs of the assay peaks, the program applies an Attenuation Correction and a Container Correction. Results are summed with the results of all other segments in the current cycle to yield Total Corrected Rates.

The program repeats the assay steps until the last segment has been assayed.

The program divides the Total Corrected Rates by calibration factors to get assays (in grams of SNM) at each energy. Assay results for the current cycle are retained for subsequent use in a reduced chi-square test.

The program repeats the assay for each of the specified number of assay cycles. The program informs you of the Precision run's progress by exhibiting a message like the following:

After the last segment of the final Precision cycle has been measured, the program initiates the UNLOAD procedure.

The program computes the reduced chi-square for the autocycled assay results and compares this value to the corresponding warning and action range limits in the parameter database. If the action limits are exceeded, the assay is flagged BAD and the following message is displayed:

Win_SGS
>>>>ATTENTION<<<<
MEASUREMENT CONTROL PRECISION FAILED.
ACTION LIMITS WERE EXCEEDED.
Reduced Chi-Square = XY.Z
Action Limits = *Action Limit Low* - *Action Limit High*
Subsequent assays are not valid!

OK

The BAD assay flag is reset upon successful completion of a subsequent Precision run. If the warning limits are exceeded, the CONDITIONAL assay flag is set and the following message is displayed:

The CONDITIONAL assay flag is reset upon successful completion of a subsequent Precision run. The program saves the Precision results to the Measurement Control Log

The program returns the Main Menu to the display.

2.1 FILE

2.1.1 List Log

An open-ended log of all measurements (of all types) is kept on the system disk. The List Log option permits you to review them.

The program presents the following pick list:

The image shows a dialog box titled "Log Options". It contains two sections: "Measurement type to search" and "Search Mode".

Measurement type to search

- ☒ Assay
- ☐ Background
- ☐ Bias
- ☐ Calibrate
- ☐ Empty Container
- ☐ Precision
- ☐ Straight Through
- ☐ Errors
- ☐ All

Search Mode

- ☒ By Date
- ☐ By Number

At the bottom of the dialog box are two buttons: "OK" and "Cancel".

Select an option by clicking on the choice with the mouse. When OK is selected, the user is prompted to enter either the dates to search, or the number of entries to display. If Cancel is selected, the user is returned to the main menu.

Entries by Date

Enter START Date (yy/mm/dd): 00/00/00

Enter START Time (hh:ss): 00:00 AM

Enter END Date (yy/mm/dd): 00/00/00

Enter ENDTIME (hh:ss): 00:00 AM

OK Cancel

Entries

Number of entries to list from log: 0

OK Cancel

The date and time of the measurement, operator, item id, results, and status of the measurement are displayed for the number of selections. The display is left on the screen and the user can print the screen by selecting the Print Window option.

2.1.2 Printer Setup

The user can select or deselect a printer that is connected to the system. By clicking on the **Printer Setup** option the **Win_SGS** program displays the Windows interface for defining a printer in the system. Once the changes are made and the user clicks OK or Cancel on the Printer Setup screen, the **Win_SGS** program regains control.

2.1.3 Print Window

The **Print Window** can be used if there is a display screen on the monitor that the user would like to send to the printer. The option will print only the most current screen.

2.1.4 Exit

The user is returned to the Program Manager screen when **Win_SGS** is exited. A verification prompt is first displayed before the program actually terminates.

If the user decides not to exit **Win_SGS**, the main menu is displayed.

2.2 Host

Win_SGS can be operated in either Host Control or Manual mode. If the Control mode is selected then **Win_SGS** listens for commands from the Host computer and performs measurements. If Manual mode is selected then all of the options described above are operated by the operator.

CHAPTER 3

USING THE SUPERVISOR MENU

In this chapter, you will learn about

- Diagnostics
- SGS Hardware Setup

These options require at least level 1 password entry in order to execute them. They are provided for users who are familiar with the hardware on **Win_SGS** and need to perform diagnostic testing.

3.0 DIAGNOSTICS

3.0.1 Compumotor

The Compumotor option permits you to exercise the electromechanical components of the SGS. You may run the rotator and elevator motor, rotate the source wheel, open and close the shutter by using the menu that appears when the Compumotor option is selected from the Diagnostics menu:

ARIES SGS CompuMotor Test Program

Seek Elev. Home ☒ Define as Zero

Move Elev. To Limit ☐ Down ☐ Up

Move Elevator to: 0.000 Inches

Rotation On ☐ ☐ Shutter Open

Stop Requested Action

☐ Constantly Update Input Sensors Display

Elevator:

☐ Upper Limit

☐ Lower Limit

☐ Home

Miscellaneous:

☐ Shutter Open

☐ Shutter Closed

☐ Rotation Sensor

About...

Exit

On initialization, the Seek Elev. Home button should be exercised. Click on the Define as Zero box so that the Compumotor will position the elevator to a zero position and then set that position as a reference for other movements of the position. If at any time the elevator does not appear to be positioning correctly, using the Seek Elev. Home option to reset the elevator to a zero position will help in positioning the elevator correctly.

The Move Elev. To Limit runs the elevator to the down sensor switch, the height sensor switch, or the up sensor switch. This option diagnoses the operation of the sensor switches.

Move Elevator to: permits the operator to position the table to an absolute position relative to the zero position. It moves in increments of inches.

The operator can turn the rotation table on or off by clicking on the Rotation On box and can also open and close the shutter by clicking on the Shutter Open box. These boxes are toggled to on or off by clicking on them.

If a motion has been started and needs to be stopped, the Stop Requested Action button will stop elevator movements.

The input sensors are displayed with a Green led when they are activated during an operation.

To leave the diagnostics screen, click on the Exit button.

3.0.2 MCA

The operator can also identify if the Ortec MCA is operating correctly by starting a count using the MCA diagnostics option. A count time is entered in the MCA Count Time box. Click on the START button to begin the count. The MCA begins counting and displays the spectral data. The count can be stopped before it is finished by clicking on the STOP button.

CHAPTER 4

USING THE TECHNICAL SUPERVISOR MENU

In this chapter, you will learn about

- Edit Access List
- Parameter Setup

:

These options require a level 2 password entry. They are available to users who are responsible for the setup of Win_SGS.

4.0 Edit Access List

The Access List to the Win_SGS parameters can be modified if the user enters the correct username and password.

A dialog box titled "User Validation" with a standard window border. Inside the box, there are two labels: "Username:" and "Password:". Each label is followed by a rectangular text input field. At the bottom of the dialog, there are two buttons: "OK" and "Cancel".

Edit Password File

Edit User Information

Edit Item...

User Name:

Password:

Level:

Ok **Cancel**

Add User

Add User...

User Name:

Password:

Level:

Ok **Cancel**

Delete User...

OK Changes **Cancel Changes**

A technical supervisor has the capability to edit passwords by adding new users with passwords, deleting users and their passwords or by changing passwords for existing users. Before this screen can be accessed, the user must enter a correct username and password. To edit the information, click on EDIT ITEM or ADD ITEM or DELETE USER buttons. The EDIT ITEM button permits the user to modify existing passwords, the ADD ITEM gives the user the ability to add new users, and the DELETE USER deletes a user from the list.

4.1 SETUP

4.1.1 General

There are general parameters that are used in the operation of the SGS. These parameters are password protected and can be accessed only by a technical supervisor. To access these options, the user clicks on the **General** option under the **Setup** menu option. The password screen is displayed and the user must enter the correct user name and password before the parameters are made available.

A dialog box titled "User Validation" with a standard Windows-style title bar. It contains two text input fields. The first field is preceded by the label "Username:" and the second by "Password:". Below the input fields are two buttons: "OK" and "Cancel".

A dialog box titled "Edit Parameters" with a standard Windows-style title bar. It contains a group box labeled "Parameter Lists" which lists five options, each preceded by a radio button: "Gamma-Ray Peaks", "Container Types", "Reference Source Spectrum Quality", "Regions of Interest", and "Transmission Sources". Below the group box are two buttons: "Edit" and "Main Menu".

Choose any General Parameter list by clicking on the radio button and then click the Edit button. Selections from the General Parameter list are discussed in turn below.

4.1.1.1 Gamma Ray Peaks

If Gamma-Ray Peaks is selected from the General Parameters pick list, a scrollable form like the following is displayed:

Gamma-Ray Peaks	
Isotope	keV
239PU	129.294
239PU	203.357
239PU	345.014
239PU	375.042
239PU	413.712
235U	143.780
235U	163.363
235U	185.720
235U	205.311
75SE	136.000
75SE	279.528
75SE	400.646
109CD	88.036
	0.000

:

You may insert, delete, or print this master list of gamma-ray peaks. Use the arrow keys to select the fields you wish to edit. This scrollable form holds up to 100 peaks. Click on the OK button to save the edited form. Click on CANCEL to exit the screen, but not save entries that have been edited.

NOTE: The Gamma Ray column of the Regions of Interest dialog box is constructed by concatenating the isotope name and the peak energy from the Gamma-Ray Peaks dialog box. This column is not editable in the Regions of Interest dialog box. **Once you have entered the gamma-ray peaks of your choice, it is best to avoid changing their order in this list.** If you do, you will have to edit the region-of-interest limits in the Regions of Interest dialog box.

4.1.1.2 Container Types

If Container Types is selected from the Edit Parameters pick list, a form like the following is displayed:

The screenshot shows a window titled "Container Type List". Inside, on the left, is a list box with three items: "Straight Through" (which is selected and highlighted), "Straight Through", and "drum-55g". To the right of the list box is a panel containing three buttons: "Add Item...", "Edit Item...", and "Delete Item...". Below each of these three buttons are "OK" and "Cancel" buttons. At the bottom of the window, there are three buttons: "OK Changes", "Cancel Changes", and "Print List".

Click on the Add button to enter the names of the Container Types and click on OK to save the entries on the form.

4.1.1.3 Reference Source Spectrum Quality

If Reference Source Spectrum Quality Parameters is selected from the Edit Parameters pick list, a dialog box like the following is displayed:

Edit Reference Source Parameters			
Reference Source:		<input type="text"/>	
Centroid:	<input type="text"/>	Centroid Range:	<input type="text"/>
Peak FWHM:	<input type="text"/>	FWHM Range:	<input type="text"/>
Half Life:	<input type="text"/>	Units:	<input type="text"/>
<input type="button" value="OK"/>		<input type="button" value="Print"/>	<input type="button" value="Cancel"/>

The Reference Source isotope is accessible only in the configuration file that is invoked when the program is started. Centroid is the channel number against which you might wish to test the centroid calculated for the reference source peak during a Spectrum Quality Check. The calculated centroid must be within the range $\text{Centroid} \pm \text{Peak centroid range}$ in order to pass the Spectrum Quality Check. Similarly, the peak full-width at half-maximum (expressed in MCA channels) must be within the range $\text{Peak FWHM} \pm \text{Peak FWHM range}$.

4.1.1.4 Regions of Interest

If Regions of Interest is selected from the Edit Parameters pick list, a scrollable form like the following is displayed:

Gamma Ray Name	Low Energy	Backgnd Energy	Peak Energy	Region Energy	High Energy	Backgnd Energy	
239PU129	126.00	127.00	127.20	131.60	132.00	133.00	
239PU203	200.40	201.30	201.60	205.50	205.60	206.20	
239PU345	338.00	339.20	342.90	347.20	347.50	348.50	
239PU414	409.50	410.50	410.60	416.60	417.00	418.00	
75SE136	132.50	133.50	133.90	138.75	139.25	140.25	
75SE280	275.00	276.00	276.40	283.00	283.50	284.50	
75SE401	397.00	398.00	398.20	403.50	404.00	405.00	
109CD88	83.25	86.00	86.10	90.20	90.40	92.75	
235U144	140.50	142.75	143.00	145.25	145.50	147.75	
235U163	158.50	161.50	162.00	165.00	165.50	168.50	
235U186	180.00	183.50	184.00	187.50	188.00	191.50	
235U205	198.50	201.00	204.25	206.75	207.75	209.75	
	0.00	0.00	0.00	0.00	0.00	0.00	
	0.00	0.00	0.00	0.00	0.00	0.00	

OK Cancel Print

The capacity of this Regions of Interest form is 100 peaks. This is the master list from which the regions of interest are drawn for the ROI Setup during measurement-specific parameter editing. You may insert, delete, or otherwise edit this list of peak ROIs. Use the arrow keys to select the fields you wish to edit. Then enter the correct energy (in keV) for the ROI boundary. Click on the **OK** button to save entries in the table. If the entries are not to be saved, click on the **Cancel** button. The ROIs screen can be printed by clicking on the **Print** button

4.1.1.5 Transmission Sources

Win_SGS software provides the capability to define up to four transmission sources to be used with the SGS. The user enters the source name, source position, half-life and the units of the half-life (days or years) of the transmission source. The Win_SGS software uses the information from this screen to determine how many transmission sources should be accessed during measurement data acquisition.

Source Name	Source Position	Half-Life	Units
75SE	1	120.0000	days
	0	0.0000	
	0	0.0000	
	0	0.0000	

OK Cancel Print

When one of the measurement-specific parameter types (e.g., other than General) is selected from the Parameter Types pick list, the program displays the following pick list:

4.1.2 Parameter Setup

4.1.2.1 Measurement Options

Container Type Parameter Setup

Measurement Options

- ☐ Assay
- ☐ MC Bias
- ☐ MC Precision
- ☐ Straight-Thru
- ☐ Calibration

Container Types: [Blacked out pick list]

Measurement Types Parameters

- ☐ Isotopes
- ☐ ROI Setup
- ☐ Assay and Transmission Peaks
- ☐ Attenuation Calibration Coefficients
- ☐ Energy Calibration Parameters
- ☐ MCA Setup Parameters
- ☐ Empty Container Parameters
- ☐ Measurement Parameters

Edit...

Print

OK

Cancel

You may select any of the five Measurement Options by using the arrow keys to select the radio button of the option. Click on the radio button to select the option. Then select from the Container Type pick list the container that parameters are to be modified. Parameters for isotopes, ROIs, assay and transmission peaks, attenuation calibration coefficients, energy calibration, MCA, empty container and measurement configurations can be edited with these options.

In order to edit the Straight Through parameters, select the Straight Through container type and click on the radio button for Straight-Thru. When the Straight Through container type is selected, other options are grayed out so that only the Straight-Thru measurement option is edited.

Note: If you are performing an initial parameter setup for a new Measurement Type, first edit **Isotopes** and then edit each of the remaining parameter types in the order listed on the pick list. This operation is order-dependent. Parameters in the attenuation calibration coefficients, ROIs, and measurement parameters are dependent on the isotopes selected.

4.1.2.2 Isotopes

The isotopes for the assay and the transmission source are displayed for the container type selected. To select an isotope, move the highlighted cursor with the arrow keys and click on the isotope desired with the mouse. The isotope is automatically selected. To deselect the isotope, move the cursor to the highlighted isotope and click with the mouse. The selection toggles on and off.

The image shows a dialog box titled "Isotope Choices" with a close button (X) in the top right corner. It contains two main sections. The first section, labeled "Container type:", has a text field containing "drum-55g". To the right of this field are two buttons: "OK" and "Cancel". Below the "Container type:" label is a list box labeled "Isotopes:". This list box contains four items: "239PU", "75SE", "109CD", and "235U". The item "239PU" is currently selected, indicated by a dark background. The second section, labeled "Transmission source isotope:", has a list box containing the same four items: "239PU", "75SE", "109CD", and "235U". In this list box, "75SE" is currently selected.

4.1.2.3 ROI Setup

Regions of Interest

Use ROI	Gamma Ray Name	Low Energy	Backgnd Energy	Peak Energy	Region Energy	High Energy	Backgnd Energy	
N	239PU129	126.00	127.00	127.20	131.60	132.00	133.00	
N	239PU203	200.40	201.30	201.60	205.50	205.60	206.20	
N	239PU345	338.00	339.20	342.90	347.20	347.50	348.50	
P	239PU414	409.50	410.50	410.60	416.60	417.00	418.00	
Y	75SE136	132.50	133.50	133.90	138.75	139.25	140.25	
Y	75SE280	275.00	276.00	276.40	283.00	283.50	284.50	
Y	75SE401	397.00	398.00	398.20	403.50	404.00	405.00	
Y	109CD88	83.25	86.00	86.10	90.20	90.40	92.75	
N	235U144	140.50	142.75	143.00	145.25	145.50	147.75	
N	235U163	158.50	161.50	162.00	165.00	165.50	168.50	
N	235U186	180.00	183.50	184.00	187.50	188.00	191.50	
N	235U205	198.50	201.00	204.25	206.75	207.75	209.75	
N		0.00	0.00	0.00	0.00	0.00	0.00	
N		0.00	0.00	0.00	0.00	0.00	0.00	
N		0.00	0.00	0.00	0.00	0.00	0.00	

Enter P for primary peak in Y, N column

OK

Cancel

Print

The Gamma Ray column contains all the peaks listed in the Gamma Ray Peaks data base, expressed as concatenations of the isotope and energy. This column is not editable.

All other fields on the dialog box can be edited by selecting the field using the arrow keys, pressing Enter and then by typing in the desired value.

The Use ROI column allows you to select which Gamma Rays will be used in the measurement by entering Y next to peaks that you want to analyze. Enter P if you want to analyze the peak and also designate it as the primary assay peak for that isotope. Enter N if you do not wish to analyze the peak.

The Energy columns are, from left to right, the lower limit of the low-background region, the upper limit of the low-background region, the lower limit of the peak region, the upper limit of the peak region, the lower limit of the high-background region, and the upper limit of the high-background region.

When you have filled out the Regions of Interest dialog box to your satisfaction, click on the **OK** button to save the choices or the **Cancel** to exit the screen without saving the changes. This screen can be printed by clicking on the **Print** button.

Assay and Transmission Peaks

Assay peaks:

- 129.294
- 203.357
- 345.014
- 413.712**
- 136.000
- 279.528
- 400.646
- 88.038
- 143.780
- 163.363
- 185.720
- 205.311

Transmission peaks:

- 129.294
- 203.357
- 345.014
- 413.712
- 136.000**
- 279.528
- 400.646
- 88.038
- 143.780
- 163.363

OK

Cancel

4.1.2.4 Assay and Transmission Peaks

Select any of the gamma-ray energies from this pick list by using the arrow keys and pressing Enter. **Select only those gamma-ray energies that you designated with a Y or a P on the ROI Setup dialog box and enter them in the same order as they appear on the pick list.** Select Transmission peak energies from a pick list in the same manner.

When the Assay & Transmission Peaks dialog box is filled out to your satisfaction, click on the **OK** button to save the choices and return to the Edit which parameters pick list.

4.1.2.5 Coefficients

Assay Name	C0	C1	C2	C3	C4	Cfat Sigma	Coeff	Uncert
239PU414	1.0149000	-0.0439470	0.0701300	0.0056100	0.0001800	0.01000	21.48870	0.10000
	1.0149000	-0.0439470	0.0701300	0.0056100	0.0001800	0.01000	8.73000	0.10000
	1.0149000	-0.0439470	0.0701300	0.0056100	0.0001800	0.01000	21.96000	0.10000

OK
Cancel
Print

The attenuation correction coefficients (C0 through C4) are ordinarily calculated off-line and inserted in the parameter database manually. Any field can be edited by selecting it using the arrow keys and/or by pressing Tab and then by typing in the desired value.

When the Attenuation & Calibration Coefficients dialog box is filled out to your satisfaction, click on the **OK** to save the choices or the **Cancel** button to exit the screen but not save any of the changes. The screen can be printed by clicking on the **Print** button.

4.1.2.6 Energy Calibration Constants

Energy Calibration Parameters	
Energy Offset Calibration Constant - keV:	<input type="text"/>
Energy Slope Calibration Constant - keV/ch:	<input type="text"/>
<div> <input type="button" value="OK"/> <input type="button" value="Cancel"/> </div>	

Energy Calibration constants are ordinarily calculated off-line and inserted in the parameter database manually. The values given in this manual assume an 8 channels/keV calibration, as described in Chapter 5, *Set Up Detector*. Either field can be edited by using the arrow keys, Enter, and/or by pressing Tab and then by typing in the desired value.

When the Energy Calibration dialog box is filled out to your satisfaction, click on the **OK** to save the choices or the **Cancel** button to exit the screen but not save any of the changes.

4.1.2.7 MCA Setup Parameters

MCA Setup Parameters

Container Type:

MCA Setup

ADC: Gain: Memory

Stabilizer Parameters

	Peak	Window	Analog Range	On/Off
Transmission Gain:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Transmission Zero:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Passive Gain:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Passive Zero:	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

The first line of this dialog box is displayed for information only and is not accessible here. All other fields on the dialog box can be edited by selecting the field using the arrow keys, Enter, and/or Tab and then by typing in the desired value.

ADC should always be 1, unless you switch the ADC ribbon cable to the ADC2 connector on the back of the AIM module. Use 8192 for both the MCA Gain and Memory Size.

The lower half of this dialog box pertains to the Digital Stabilizer. Refer to the Canberra Model 8233 Digital Stabilizer User's Manual for more information.

In the Peak column enter the channel numbers of the peak centroids on which you want the Digital Stabilizer to perform Zero and Gain stabilization during both the passive and the transmission scan intervals.

The **Window** parameter is the number of channels used by the Stabilizer as its sampling range. The Window is centered around the **Peak** channel. Valid settings are 1 to 999 channels in odd-valued increments of 2.

The **Analog Range** parameter is the value of the analog attenuation factor applied to the ± 5 -volt range of the correction voltage from the Stabilizer to the ADC. Valid settings for **Analog Range** are 1.0, 0.5, 0.25, and 0.125. An **Analog Range** of 0.5 or less is recommended.

In the **On/Off** column you may enter the stabilization status that you prefer to use. In the **OFF** mode, stabilization is disabled and the correction voltage is held to zero volts. In the **ON** mode, stabilization is enabled: the Stabilizer will compare the incoming data to the **Peak** setting and the **Window** limits and add or subtract one step from the correction voltage, depending on whether the incoming data was below or above the **Peak** channel. In the **OFF** mode, stabilization is disabled, but the correction voltage is maintained at the output.

When you have filled out the **MCA Setup** dialog box to your satisfaction, click on the **OK** to save the choices or the **Cancel** button to exit the screen but not save any of the changes.

Empty Container Parameters		
ContainerType:	<input type="text"/>	Reference Source: <input type="text"/>
Distance from Load Position:		<input type="text"/>
Transmission Source	Transmission Time	Primary Peak
Source 1	<input type="text"/>	<input type="text"/>
Source 2	<input type="text"/>	<input type="text"/>
Source 3	<input type="text"/>	<input type="text"/>
Source 4	<input type="text"/>	<input type="text"/>
OK		Cancel

4.1.2.8 Empty Container Parameters

The container type and reference source boxes of this dialog box are displayed for information only, and are not accessible here.

The Distance from load position is the height in inches above the load position that the table should be raised in order to assure that the transmission source shines through the vertical center of the empty container. Edit it by selecting the field using the arrow keys, Enter, and/or Tab and then by typing in the desired value.

Enter the preferred Transmission acquire time for the number of sources displayed in the same way. This is the time in seconds that is necessary to achieve better than 0.1% statistics on all of the transmission peaks.

Select the Primary transmission source peak energy from a pick list by clicking on the down arrow to view the selections. Toggle the selection by placing the cursor over the primary source peak value and clicking on the mouse button.

When the Empty Container dialog box is filled out to your satisfaction, click on the **OK** to save the choices or the **Cancel** button to exit the screen but not save any of the changes.

4.1.2.9 Measurement Parameters

For each of the measurement options there is a different version of the Measurement Parameters form. Each is presented below. Features common to all are discussed after the Assay Parameters dialog box. Features specific to a given measurement option are discussed after the pertinent form.

Assay Parameters					
Container Type:		drum-55g		Reference Source:	
				109CD	
Transmission Source					
		Transmission Time	Passive Time		
Source 1	75SE	20.00	20.00	Primary Peak 1	400.646
Source 2		0.00	0.00	Primary Peak 2	136.000
Source 3		0.00	0.00	Primary Peak 3	136.000
Source 4		0.00	0.00	Primary Peak 4	136.000
Number of Segments: 8 Maximum Cycles: 1					
Load First Segment Distance: 26.00		Vertical Increment: 2.00		Segment Correction	
				☐ Default ☐ Query	
Number of Opaque Segments Control Limit: 1.00		Opacity Control Limit: 0.01			
OK		Cancel			

The first two lines of the dialog box are displayed for information only and are not accessible here.

Enter the **Transmission** and **Passive** times which are the preset times (in seconds) for the "shutter open" spectra and the "shutter closed" spectra, respectively for each transmission source that has been selected in the General parameters setup. Also use the primary peak pick list to select which primary transmission source peak is going to be used. **Number of Segments** is the number of segments to be used for the assay. **Load-1st segment distance** is the distance (in inches) from home that you want to move the elevator for the first segment of the measurement. **Vertical increment** is the distance (in inches) between consecutive segments. Note that a negative sign means that the incremental move is downward. **Container Height (inches)** is the actual size of the container that is going to be measured. **Maximum cycles** is the number of times that you will permit the measurement to repeat when Autocycle mode is used.

With the cursor positioned at any of the **Lump correction** or **Correction segment** fields, click on the box to toggle **Yes/No** or **On/Off**, which are the allowed choices. However, this version of **SGS** is not outfitted with the options to correct for **SNM** lumps or inter-segment correlations. Until these correction options are included in **SGS**, the choices are essentially "hardwired" to **N** for the default values, and to **OFF** for the queries.

The **Opacity control limit** is the transmission value below which you will consider a segment too opaque ("black") to get a good measurement. The **Number of Opaque Segments Control Limit** allows you to specify how many black segments will be tolerated before the measurement is to be terminated.

When the **Assay Parameters** dialog box is filled out to your satisfaction, click on the **OK** to save the choices or the **Cancel** button to exit the screen but not save any of the changes.

4.1.2.10 Calibration

Calibration Parameters					
Container Type:			Reference Source:		
Transmission Source					
	Transmission Time		Passive Time		
Source 1				Primary Peak 1	
Source 2				Primary Peak 2	
Source 3				Primary Peak 3	
Source 4				Primary Peak 4	
☐ Height Sensing			Height Sensing Vertical Increment:		
Container Height (inches):		Vertical Increment:		Maximum Cycles:	
Load First Segment Distance:		Interval Between Measurements (days):			
Lump Correction			Segment Correction		
☐ Default ☐ Query			☐ Default ☐ Query		
Opacity Control Limit:		Number Opaque Segments Control Limit:			
Mass (grams):		Known Sigma:			
OK			Cancel		

Enter the calibration reference standard's known isotope mass and its uncertainty in the Mass and Known sigma fields which are positioned at the bottom of the Calibration Parameters screen.

Any number of days may be entered for the Interval between measurements. With this parameter you can stipulate the frequency with which calibrations are to be performed. This parameter is located three-fourths of the way down on the screen positioned between Vertical Increment and Segment correction.

4.1.2.11 Bias Parameters

Bias Parameters																																			
Container Type: <input type="text"/>			Reference Source: <input type="text"/>																																
<table border="1"> <thead> <tr> <th>Transmission Sources</th> <th>Transmission Time</th> <th>Passive Time</th> <th></th> <th></th> <th></th> </tr> </thead> <tbody> <tr> <td>Source 1</td> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> <td>Primary Peak 1</td> <td><input type="text"/> </td> </tr> <tr> <td>Source 2</td> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> <td>Primary Peak 2</td> <td><input type="text"/> </td> </tr> <tr> <td>Source 3</td> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> <td>Primary Peak 3</td> <td><input type="text"/> </td> </tr> <tr> <td>Source 4</td> <td><input type="text"/></td> <td><input type="text"/></td> <td><input type="text"/></td> <td>Primary Peak 4</td> <td><input type="text"/> </td> </tr> </tbody> </table>						Transmission Sources	Transmission Time	Passive Time				Source 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 1	<input type="text"/>	Source 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 2	<input type="text"/>	Source 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 3	<input type="text"/>	Source 4	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 4	<input type="text"/>
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☐ Height Sensing		Height Sensing Vertical Increment: <input type="text"/>																																	
Container Height (inches): <input type="text"/>		Vertical Increment: <input type="text"/>																																	
Load First Segment Distance: <input type="text"/>																																			
☐ Lump Correction ☐ Default ☐ Query		☐ Segment Correction ☐ Default ☐ Query																																	
Opacity Control Limit: <input type="text"/>		Number of Opaque Segments Control Limit: <input type="text"/>																																	
Bias Action Limit: <input type="text"/>		Bias Reference Value: <input type="text"/>																																	
Bias Warning Limit: <input type="text"/>		Bias Hist. Standard Deviation: <input type="text"/>																																	
Interval Between Bias Measurements: <input type="text"/>		<input type="button" value="OK"/> <input type="button" value="Cancel"/>																																	

The parameters specific to the Bias measurement are located at the bottom of the screen. The Bias hist. std. dev. is a characteristic standard deviation (in grams) determined from previous Bias runs using the measurement control standard. The Bias ref value is the certified isotope mass (in grams) for the measurement control standard. Both values are used to calculate for the measurement result a t-value, which is the number of standard deviations from the reference value.

Bias action limit is the t-value above which the Bias run will be declared a failure. When the t-value is between Bias warning limit and Bias action limit, the Bias run is declared

CONDITIONAL. If the t-value is less than Bias warning limit, measurement bias is assumed to be in control.

Any number of days may be entered for the Interval between bias measurements.

4.1.2.12 Precision Parameters

Precision Parameters					
Container Type: <input type="text"/>			Reference Source: <input type="text"/>		
Transmission Sources					
		Transmission Time	Passive Time		
Source 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 1	<input type="text"/>
Source 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 2	<input type="text"/>
Source 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 3	<input type="text"/>
Source 4	<input type="text"/>	<input type="text"/>	<input type="text"/>	Primary Peak 4	<input type="text"/>
☐ Height Sensing		Height Sensing Vertical Increment: <input type="text"/>			
Container Height (inches): <input type="text"/>					
Load First Segment Distance: <input type="text"/>		Vertical Increment <input type="text"/>			
☐ Lump Correction <div> ☐ Default ☐ Query </div>		☐ Segment Correction <div> ☐ Default ☐ Query </div>			
Opacity Control Limit: <input type="text"/>		Opaque Segment Control Limit: <input type="text"/>			
Action Probability Percent: <input type="text"/>		Warning Probability Percent: <input type="text"/>			
Historical Standard Deviation: <input type="text"/>		Maximum Cycles: <input type="text"/>			
Interval between Precision Measurements: <input type="text"/>		<input type="button" value="OK"/>		<input type="button" value="Cancel"/>	

Precision calculates a reduced chi-square statistic by multiplying the ratio of the measured standard deviation to the historical standard deviation (Historical Std. Dev.) by the number of degrees of freedom (one less than the number of cycles). This statistic should have a chi-square distribution with the same number of degrees of freedom. Then Precision calculates the probability that a value from this distribution would be more extreme than chi-square. If

this probability, expressed in percent, exceeds Action probability percent, then the Precision run will be declared a failure. If the calculated probability lies between Warning probability percent and Action probability percent, then the Precision run is declared CONDITIONAL. If the probability is less than Precision warning limit, measurement precision is assumed to be in control.

Parameters specific to precision measurements are located at the bottom of the screen.

Any number of days may be entered for the Interval between precision measurements.

4.1.2.13 Straight Through Parameters

Straight Through Parameters								
Container Type:				Reference Source:				
Distance from Load:				Background Count Time:				
Transmission Source								
	Transmission Time	Passive Time	Date	Rate	Rate Range	Hot(cps:)	Primary Peak	
1								
2								
3								
4								
Peak:			Centroid:		Range:		FWHM: Range:	
Cold(cps:)			Cool Warning (days):					
Fractional Source Control Limit:			Contamination Threshold:					
Assay Interval (days):			Calibration Interval(days):					
Reference Source								
Date:			Rate:			Sigma:		Range
					OK		Cancel	

The energies of the peaks from the transmission source selected for this Measurement Type appear in the Peak fields. In the Centroid fields, enter the corresponding peak channel numbers. The first Range column is the number of channels on either side of the peak

channels and within which the measured peak centroid must reside. The FWHM fields and the other Range fields define the limits for acceptable peak shapes (full-widths-at-half-maximum).

The Hot and Cold fields, expressed in counts per second for the primary transmission peak, define the limits of acceptable transmission source strength. A warning of declining source strength begins to be issued at Cool warning days before the transmission source decays to the Cold limit. The count rate at the primary transmission energy is determined, decay-corrected back to the date of the most recent previous Straight-Through run, and divided by the primary transmission count rate at that time. This normalized count rate must be within the Fractional source rate control limit of unity.

Contamination threshold, located $\frac{3}{4}$ of the way down the screen, is the maximum allowed count rate in the primary assay peaks during the contamination check performed during the Straight-Through run.

Assay interval, at the bottom of the Straight Through Parameters, is the number of days allowed to elapse after a valid Straight-Through run before Assay runs will begin to be declared CONDITIONAL. If a period longer than Assay interval has elapsed, Measurement Control runs are not permitted. If a period longer than Calibration interval has elapsed since the last valid Straight-Through run, a Calibration is not permitted.

Trans Date is the date at which Trans Src Rate, the rate-loss- corrected net count rate at the primary transmission energy, was last determined. Trans Src Rate $\pm$ Trans Src Rate Range defines the range, in counts per second, within which the measured primary transmission rate must fall.

Ref Date is the date at which Ref Rate, the net count rate from the reference source, was last determined. Ref Rate $\pm$ Rate Range defines the range, in counts per second, within which the measured reference-source count rate must fall.

Auxiliary menu options that are available to all users are the Window arranging options and the HELP option.

4.2 WINDOW

4.2.1 Arrange Icons, Cascade, Tile

These options are standard Windows interface and operate in the same manner as they do in other Windows' interfaces.

4.2.2 Close All Windows

This option was added in order to permit the user to close all windows currently displayed on the screen. When the SGS performs multiple assays, numerous screens are stacked onto the screen and can be closed at one time by using this option.

4.3 HELP

4.3.1 About

The **About** menu item informs the user of the name of the program, who it is written by and when the last update was made.

CHAPTER 5

SYSTEM STARTUP

In this chapter, you will learn about

- Cable connections
- Startup of the system

5.0 SYSTEM STARTUP

CAUTION: DO NOT CONNECT ANY OF THE PLUGS TO A LIVE CIRCUIT AT THIS TIME.

This chapter gives detailed instructions on starting up the WinSGS SGS for the first time. It is intended for the technical supervisor.

5.0.1 System Interconnection and Power-Up

Before plugging in the power cords and energizing the SGS electronics for the first time, make the proper power and signal cable connections. The following instructions assume that the following arrangements have already been made:

- The monitor is mounted in the electronics rack;
- The computer is mounted in the electronics rack;
- The oscilloscope is rack-mounted above the monitor;
- The NIMBIN and electronics modules are mounted in the rack.

5.0.2 Power Connections

There are two primary power connections for the Aries SGS. One is for the electronics rack, and the other is for the 20 in. x 24 in. gray electrical utility box mounted on the Aries SGS mechanical assembly. The recommendation is for both of the connections to be made to 120 VAC outlets located on the same power transformer. If a 20 Ampere service is available, then both cords may be plugged into the same circuit or else the connections should be made to separate circuits.

The gray electrical utility box houses the CompuMotor 4000 series indexer and stepping motor drivers with encoder interface support. It also supplies control voltage for sensing and safety circuits, and the electrical brake. Verify that 3-prong AC power cords are properly seated on the following:

Parker CompuMotor 4000 indexer;
Parker CompuMotor stepping motor drivers (2 ea.).

Also verify that 'Emergency Stop' mushroom push-button may be activated and released. At this time, there should be no observable action from operating the push-button, other than a need to twist the button cap slightly to release the button.

The electronics rack houses the following items:

- Computer system unit;
- Computer display monitor;
- Tektronix T922R oscilloscope;
- Ortec NIMBIN with multiple electronics modules;
- Rack ventilation fan.

Verify that a 3-prong AC power cord for each of the previously listed items is properly plugged into the master power strip located in the rear of the rack. The power strip should not be powered at this time. The power cable for an external printer should be connected to the master power strip.

5.0.3 System Interconnection and Power-Up

Before energizing any of the Aries SGS instruments, connect all cables according to Table 1.

CAUTION: Incorrect polarity will cause serious damage to the detector. Verify that the Canberra 3105 HV Bias Supply is set for the correct polarity. The proper bias voltage with polarity is marked on the detector housing. ALSO, to protect the detector from damage due to warm-up under bias, install the bias shutdown cable between the Bias Supply and the detector.

Table 1. Cable Connections

Module LABEL (connector type)	Module LABEL (connector type)
Spectroscopy Amplifier PREAMP POWER (9-pin sub-miniature "D")	Detector Preamplifier POWER (9-pin sub-miniature "D")
H. V. Power Supply H. V. OUTPUT (SHV)	Detector Preamplifier HV IN (SHV)
H. V. Power Supply INHIBIT (BNC)	Detector Preamplifier BIAS SHUTDOWN (BNC)
Spectroscopy Amplifier NORM (BNC)	Detector Preamplifier ENERGY (BNC)
Spectroscopy Amplifier UNI OUTPUT (BNC)	Analog to Digital Converter ADC IN (BNC)
Spectroscopy Amplifier PUR (3-PIN MOLEX)	Analog to Digital Converter PUR (3-PIN MOLEX)
Computer Interface DATA (26 CONDUCTOR RIBBON CABLE)	Analog to Digital Converter DATA (26 CONDUCTOR RIBBON CABLE)
Analog to Digital Converter STAB (26 CONDUCTOR RIBBON CABLE)	Digital Stabilizer ADC (26 CONDUCTOR RIBBON CABLE)

5.1 NIM Instrument Modules

The following is a list of the NIM equipment used for this WinSGS system:

<u>Description</u>	<u>Manufacturer</u>	<u>Model</u>
NIM bin with ± 6 , 12, and 24 v DC supplies	Canberra	2000
Digital Stabilizer	Canberra	8233
ADC	Canberra	8706
Fast Spectroscopy Amplifier	Canberra	2024
High Voltage Power Supply	Canberra	3105
Dual Counter Timer	Canberra	2071
Emergency Stop	LANL	N/A

NIM Instrument Settings Adjust the NIM modules for the recommended settings given in Table 2:

Table 2. NIM Instrument Settings

Digital Stabilizer - Canberra model 8232:

Gain/Zero	GAIN
Stabilization Zero (On/Hold/Off)	ON
Stabilization Gain (On/Hold/Off)	ON
Remote/Manual	REMOTE

Analog to Digital Converter - Canberra Model 8706:

Gain	8K
Range	8K
Offsets	All off
LLD	0.00 Peak Detect
ADC In	PHA
Gate In	Anti-Coincidence

Auto

Fast Spectroscopy Amplifier - Canberra Model 2024:

Fine Gain	9.72
Polarity	-
Coarse Gain - GI	2 μ s.
Coarse Gain - Amp	1 μ s
Restorer	Auto
Restorer	SYM
PUR	ON
PUR	UNI

High Voltage Power Supply- Canberra Model 3105:

Polarity Negative
 Setting 3.0 kV.
 ON/OFF As required

Dual Counter Timer - Canberra Model 2071:

Display A/B A
 0.01s/Preset/0.01m 0.01s.
 Preset 101
 Single/Recycle Recycle
 Start/Off/Stop Off

5.3 Energize System

The Aries SGS mechanical assembly should be energized and tested first. Connect the power cord from the gray utility box to a 115 VAC outlet. The CompuMotor 4000 indexer and both of the CompuMotor motor driver amplifier are equipped with LEDs that indicate power status. Verify that all 3 chassis have illuminated LEDs. Verify that the brake activates when the 'Emergency Stop' is pressed. Pressing the 'Emergency Stop' should stop all motion and activate the electrical brake. The 'Emergency Stop' is released with a slight twist of the knob. Activation of either the button mounted on the WinSGS SGS instrument or on the electronics rack should cause the same action.

The electronics rack can now be energized. Before connecting the power cord, set the power switch on the master power strip to off, and activate the power switch on each individual electrical chassis. Confirm the detector power supply switch is set to off. Connect the power cord from master power strip located in the rear of the rack to a 115 VAC outlet. Turn on the master power strip. Lights and LEDs should indicate on the computer, monitor and the NIMBin.

5.4 Boot Computer

The Compaq PC computer will boot automatically when it is powered up. The boot-up process takes about 1 minute. The system boots automatically to the Windows 3.1 operating system. The Win_SGS program can be accessed by clicking on the LANL Icon with the name WinSGS. To reboot press the CTRL+ALT+DEL keys simultaneously. This will provide the user the option of rebooting the system.

CAUTION: Never turn off or reset the computer when the in-use light for the hard disk is on. The in-use light means that the computer might be opening files; turning off or resetting the

computer at this time can destroy data. Always allow the hard drive to spin down completely before reapplying power.

5.5 Start MCA Display

The Win_SGS program will run without activating a virtual multichannel analyzer (MCA) on the terminal. To use the MCA, or to display spectra at any time, do the following:

- Click on the Maestro icon on the Program Manager screen.

An MCA window will appear. You may use the track-ball to resize it and/or relocate it. You may also use the mouse to start or stop a spectrum acquisition, to rescale the spectral display, or to set regions of interest.

5.6 Set Up Detector

Before starting the Win_SGS control program, an energy calibration spectrum must be acquired. Two energy peaks are required in this spectrum: a lower-energy peak at about $\frac{1}{4}$ of the ADC full scale and a higher-energy peak at about $\frac{3}{4}$ of full scale. If the rate-loss reference source is ^{109}Cd , then its 88.036-keV peak will suffice as the low-energy peak. The 661.636-keV gamma rays from the ^{137}Cs in a standard reference source will provide the high-energy peak.

Set up for energy calibration as follows:

CAUTION: Do not proceed to the next step until you have verified that the Bias Supply is set for the correct polarity, or else serious detector damage will result.

Verify that the correct detector bias polarity is indicated on the front panel of the Canberra Model 3105 Detector Bias Supply. If it is not, consult the manual for the Canberra Model 3105 Detector Bias Supply on setting the proper output polarity.

If it is not already set at 0.0, adjust the Canberra Model 3105 Detector Bias Supply's output setting to 0.0. Toggle the HV ON/OFF switch to ON. Then adjust the output setting to the detector's recommended operating bias.

Using the Canberra operating manual for the Canberra Model 2024 Fast Spectroscopy Amplifier, check and adjust the amplifier pole/zero cancellation circuit for optimum peak shape.

Energy calibration requires a reference gamma-ray spectrum with two peaks: one at the lower end of the operating region and the other at the higher-energy end. For this SGS, the ^{109}Cd rate-loss correction source provides a useful low-energy peak at 88.032 keV. A small ^{137}Cs reference source (available in any set of standard reference sources) provides a useful higher-energy gamma ray at 661.632 keV. Position the latter so that its count rate is comparable to that of the ^{109}Cd source. Set up regions of interest on the MCA screen for the two energy-calibration peaks. In an 8192-channel spectrum, ROIs at channels 680-730 and 5270-5320 suffice nicely for the 88- and 662-keV peaks, respectively.

Click the Clear button on the MCA screen to clear the spectral display. Then click the Acquire On button to start an acquisition.

Adjust the amplifier GAIN and DC pots as required to position the reference peaks in the ROIs.

Observe the Marker Info box in the lower left corner of the MCA screen to determine the centroid of the peak in the marked ROI. You can use the ROI Index button to toggle between the two ROIs. In an 8192-channel spectrum, channels 704.3 and 5293.1 are good centroids for the 88- and 662-keV peaks, respectively.

5.7 Start Program

The Windows Program Manager screen is activated when the computer is started. To execute the Win_SGS software double click with the mouse on the LANL Win_SGS icon (the picture of the bridge). This begins the Win_SGS software program.

5.7.1 Establishing Communications with the Motor Indexer

The program initializes communications with the hardware (Compumotor and MCA) and briefly displays a message indicating that the communications are being established. If the indexer initialization is unsuccessful, this dialog box is presented.

*** COMPUMOTOR ERROR *** Unable to initialize CompuMotor
Run program without CompuMotor Quit

In the event that this box is displayed, do the following:

- Verify that the Compumotor 4000 Indexer is plugged in and turned on.
- Push the STOP button on the front panel of the Compumotor and then push the START button.
- Verify that the serial cable is properly installed between the computer and the indexer.
- If the cable connection appears to be sound and correct and the program in the indexer is running but there is still a communications error, call for assistance from the technical supervisor.

5.7.2 Establishing Communications with the MCA

Next, the computer establishes communications with the MCA. If the MCA initialization is unsuccessful, this dialog box is presented.

*** MCA ERROR *** Unable to initialize MCA
Run program without MCA Quit

In the event that this box is displayed, do the following:

- Verify that the NIM bin is energized and that the ADC interface card is in the computer.
- If the cable connections appear to be sound and correct, call for assistance from the technical supervisor.

5.8 Menu Display

After all communications are established and initializations performed, the *Win_SGS* Menu will be displayed. There is one menu used to operate the SGS with some of the options password protected. All routine Win_SGS options can be exercised from the menus. See Chapter 1, *User Interface*, for additional introductory information on the menus.

APPENDICES

The appendices contain information on

- Routine *Win_SGS* code use
- *Win_SGS.dat* data file
- Common *Win_SGS* procedures
- *Win_SGS* calculation equations

APPENDIX A. SGS CODE MINIREFERENCE

Introduction

The *Win_SGS* code is written in C using the NIS-5 software libraries and style guide for nondestructive assay systems. It features an extensive set of menus from which the user selects the options to exercise. All device I/O and data acquisition and analysis are controlled by *Win_SGS*.

The novice user should become familiar with the key usage and data-entry symbols described below before attempting to use the system.

Terminology

The following terms are used in this appendix and in the main text of the Win_SGS Segmented Gamma-Ray Scanner User Manual:

<i>menu</i>	Displayed when the user starts the <i>Win_SGS</i> code and corrects/accepts the date and time. It presents in a pull-down window format the main options from which the user may choose.
<i>window</i>	A menu or submenu field that the user may select with the arrow keys and the Enter key.
<i>pick list</i>	A submenu or list of options within a window or menu item.
<i>dialog box</i>	A screen in which the user may change or fill in data in individual fields, much as the user would with a pencil and a conventional form.

Key Usage

It is useful to know several keyboard commands that have specific functions in the *Win_SGS* code. They are used for moving between and within menu windows, for changing selected data entries, and for accepting the modified dialog box.

⇔	Move between menu windows.
⇅	Move between pick list items within a window.
Tab	Move cursor to next field in dialog box.

Do-Tab	Move cursor to previous field in dialog box.
Enter	Selects the menu or pick list item that is highlighted.

APPENDIX B. *Win_SGS* COMMON PROCEDURES

Introduction

Numerous programmed procedures are common to the execution of many of the menu options. They are detailed in this section and referenced only by descriptive name elsewhere in this manual.

Emergency Stop Button

This procedure is in effect any time a source is exposed or whenever system mechanical components are in motion. The program monitors the status of the Emergency Stop button switch to assure that SGS has not been manually disabled. If, at any time, the normally closed switch is opened, the program stops the SGS by

- Executing the stop procedure.
- Displaying a message that indicates the button has been pressed and that the program is stopping the SGS.

When the button is released, the program will permit operation of the SGS.

Check Spectrum Quality

Specified peak centroids and full-width-half-maxima are compared to control limits (in the parameter file) in order to assure spectrum quality. If it is untrue that a centroid's measured value is between (CENTROID - Centroid Range) and (CENTROID + Centroid Range), the program terminates the measurement and displays the following:

```
Win_SGS
>>>>ATTENTION<<<<
PRIMARY TRANSMISSION
PEAK CENTROID OUT OF RANGE.
Centroid = YYY
Limits = Centroid +/- Centroid Range
CHECK GAIN STABILIZER.
^ Assay may be bad!
```

OK

A measured peak resolution lying outside the range ($FWHM \pm FWHM_LIM$) results in termination of the measurement and display of the following message:

Win_SGS
>>>>ATTENTION<<<<
PEAK FWHM OUT OF RANGE.
FWHM = *YYY*.
Limits = *FWHM +/- FWHM LIMIT*
CHECK DETECTOR.
Assay may be bad!

OK

The program returns to the main menu.

Interrupt Run

At times, such as when SNM is being moved past the SGS, it is expedient to momentarily suspend a measurement run. In order to do this, the user may click on the PAUSE button. This pauses the execution of the spectral data collection until the user clicks on the RESUME button.

You may use the arrow keys (or type the first letter) and press Enter to select an option. You may select Ignore if depressing the hot key was unintentional, and no change in the run is desired. If you decide to Quit, the UNLOAD procedure is invoked. If you choose to Pause the run, the program executes the following steps:

- Stop the MCA ACQUIRE, but do not clear its memory or reset the preset count time.
- Exhibit the following message:

You must select one of the options in the lower part of the message box in order to proceed. If you decide to Quit, the UNLOAD procedure is invoked. If and when you choose to Resume, the following steps are executed by the program:

- Execute the OPEN SHUTTER procedure, if a transmission run was paused.
- Restart the MCA ACQUIRE to complete interrupted accumulation of the spectrum.

End Run

If an unrecoverable hardware error occurs, if a control limit is exceeded, if you press the Emergency Off switch, or if you deliberately terminate the run, procedures are invoked that call an end run procedure. End run prepares the SGS hardware for safe shutdown as it performs the following tasks:

- Stop the motors.
- Use the ROTATE TABLE and RAISE/LOWER ELEVATOR procedures to return the table to the load position.
- Execute the CLOSE SHUTTER procedure, if a transmission run is in progress.
- Stop the MCA ACQUIRE.

APPENDIX C. *Win_SGS* ANALYSIS EQUATIONS

Introduction

All equations used by *Win_SGS* are found in this appendix and the reference cited herein. The conventions we follow in our equation presentation are

- Background peaks and rates (i.e., due to radiation in the room) are indicated with a *B* subscript.
- The rate-loss peak and rate (i.e., the peak used for rate-loss corrections) are indicated with an *RL* subscript.
- The rate-loss reference rate (i.e., the rate at the energy of the rate-loss peak when no other sources are present) is designated by a *ref* subscript.

Peak Areas

No peak fitting is used in *Win_SGS*. Instead, each full-energy peak area is computed using three regions of interest (ROIs). For details, see Section 5.3 of Reference 1. In this reference, the area *B* of the Compton continuum under the peak is given by equation (5-29). Its variance is $S^2(B)$, given by (5-30). The net peak area *A* is given by (5-46) and its variance $S^2(A)$ is given by (5-47).

Full-Energy Interaction Rates

The full-energy interaction rate *FEIR* is the rate-loss corrected, and room-background-subtracted, net rate in an assay or transmission ROI:

$$FEIR = R \frac{R_{ref}}{R_{RL}} - R_B$$

and

$$\left(\frac{\sigma_{FEIR}}{FEIR} \right)^2 = \left(1 + \frac{R_B}{FEIR} \right)^2 \left[\left(\frac{\sigma_R}{R} \right)^2 + \left(\frac{\sigma_{R_{ref}}}{R_{ref}} \right)^2 + \left(\frac{\sigma_{R_{RL}}}{R_{RL}} \right)^2 \right] + \left(\frac{\sigma_{R_B}}{R_B} \right)^2$$

where

$R = \frac{A}{t}$ is the net rate in an ROI. *A* is the net peak area, *t* is the associated counting time, and

$\sigma_R = \frac{\sigma_A}{t}$ is the standard deviation of *R*.

Transmission

The transmission fraction *T* must be calculated at all transmission energies:

$$T = \frac{FEIR}{FEIR_{DC-ST}}$$

and

$$\left(\frac{\sigma_T}{T}\right)^2 = \left(\frac{\sigma_{FEIR}}{FEIR}\right)^2 + \left(\frac{\sigma_{FEIR_{DC-ST}}}{FEIR_{DC-ST}}\right)^2$$

where $DC-ST$ denotes the value for the corresponding ROI in the most recent Straight-Through measurement, corrected to the current time for decay of the transmission source.

This transmission calculation applies to an ordinary segment transmission determination during any kind of measurement run as well as when the container correction factor is determined during an Empty Container run.

Container Correction Factor

During an Empty Container run, an empirical container correction factor CCF is determined for each of the n transmission energies:

$$CCF = T^{-1/2}$$

and

$$\left(\frac{\sigma_{CCF}}{CCF}\right)^2 = \frac{1}{4} \left(\frac{\sigma_T}{T}\right)^2$$

Then a set of $n-1$ coefficients A_i is obtained by performing a least-squares polynomial fit of the empirical CCF_i to the transmission energies E_i for which they were determined:

$$\begin{pmatrix} CCF_1 \\ CCF_2 \\ CCF_3 \\ \vdots \\ CCF_n \end{pmatrix} = \begin{pmatrix} 1 & E_{t1} & E_{t1}^2 & \Lambda & E_{t1}^{n-1} \\ 1 & E_{t2} & E_{t2}^2 & \Lambda & E_{t2}^{n-1} \\ 1 & E_{t3} & E_{t3}^2 & \Lambda & E_{t3}^{n-1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & E_{tn} & E_{tn}^2 & \Lambda & E_{tn}^{n-1} \end{pmatrix} \begin{pmatrix} A_0 \\ A_1 \\ A_2 \\ \vdots \\ A_{n-1} \end{pmatrix}$$

Finally, $CCFs$ are calculated for the assay energies E_a :

$$CCF(E_a) = \sum_{i=1}^n A_{i-1} E_a^{i-1}$$

and

$$\sigma_{CCF}^2 = s^2$$

where s^2 is the sum of the squares of the deviations about the fitted data values.

Attenuation Correction Factor

The correction factors for matrix attenuation $CFAT$ are determined for each assay energy at each segment by applying the coefficients B_i of a polynomial least-squares fit obtained from the transmission data:

$$\begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \\ \vdots \\ Y_n \end{pmatrix} = \begin{pmatrix} 1 & \ln E_{t1} & (\ln E_{t1})^2 & \Lambda & (\ln E_{t1})^{n-1} \\ 1 & \ln E_{t2} & (\ln E_{t2})^2 & \Lambda & (\ln E_{t2})^{n-1} \\ 1 & \ln E_{t3} & (\ln E_{t3})^2 & \Lambda & (\ln E_{t3})^{n-1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & \ln E_{tn} & (\ln E_{tn})^2 & \Lambda & (\ln E_{tn})^{n-1} \end{pmatrix} \begin{pmatrix} B_0 \\ B_1 \\ B_2 \\ \vdots \\ B_{n-1} \end{pmatrix}$$

where

$$Y_i = \ln(-\ln T_{E_u})$$

Then for each assay energy E_a , we calculate

$$Y(E_a) = \sum_{i=1}^n B_{i-1} (\ln E_a)^{i-1}$$

Next,

$$\ln T(E_a) = \exp[-Y(E_a)]$$

And finally,

$$CFAT(E_a) = \sum_{j=0}^4 C_j [\ln T(E_a)]^j$$

where the C_j are determined off-line by performing a quartic polynomial least-squares fit of 13 values for $CFAT$ (obtained by numerical integration) to the natural logarithms of their corresponding transmission fractions. This procedure is described in Reference 2, pp. 9-28. For the relative uncertainty, you may use the square root of

$$\sigma_{CFAT}^2 = \frac{s^2}{8}$$

where s^2 is the sum of the squares of the deviations about the fitted values, and 8 is the number of degrees of freedom (13-5). The $CFAT$ relative uncertainty is not calculated in *Win_SGS*; it is entered in the parameter database by the technical supervisor.

Corrected Rate

Segment by segment, the corrected rate CR is determined at each assay energy as follows:

$$CR = FEIR \times CFAT \times CCF$$

and

$$\left(\frac{\sigma_{CR}}{CR}\right)^2 = \left(\frac{\sigma_{FEIR}}{FEIR}\right)^2 + \left(\frac{\sigma_{CFAT}}{CFAT}\right)^2 + \left(\frac{\sigma_{CCF}}{CCF}\right)^2$$

Total Corrected Rate

Corrected rates for each assay energy are summed over all segments to give the total corrected rate TCR :

$$TCR(E_a) = \sum_{k=1}^{nsegs} CR_k$$

and

$$\sigma_{TCR}^2(E_a) = \sum_{k=1}^{nsegs} \sigma_{CR_k}^2(E_a)$$

Calibration Constant

During a Calibration run, the calibration constant k is calculated for each assay energy as the ratio of the TCR to the SNM mass M_{SRM} in the certified reference standard:

$$k(E_a) = \frac{TCR(E_a)}{M_{SRM}}$$

$$\left(\frac{\sigma_k}{k}\right)^2 = \left(\frac{\sigma_{TCR}}{TCR}\right)^2 + \left(\frac{\sigma_{M_{SRM}}}{M_{SRM}}\right)^2$$

Final Assay Result

Finally, we divide the TCR at each assay energy by the corresponding calibration constant to get assay mass m as a function of energy:

$$m(E_a) = \frac{TCR(E_a)}{k(E_a)}$$

$$\left(\frac{\sigma_m}{m}\right)^2 = \left(\frac{\sigma_{TCR}}{TCR}\right)^2 + \left(\frac{\sigma_k}{k}\right)^2$$

Advanced Features

Although the software "hooks" are in place, this version of *Win_SGS* does not contain the advanced algorithms needed to mitigate end effects or to deconvolve correlated segments. Segment-correlation correction methods are described in Reference 3. Typically, the height of the detector collimator opening is equal to the height of a segment, and its depth is no more than 4 times the height. As a result, SNM in more than one segment can contribute to a single measurement, and the emission data from adjacent segments are correlated. To account for segment correlations, a linear system of equations that describes the convolved response arising from the segment aligned with the detector collimator and its neighboring segments is solved. When the correlation between segments is ignored, significant bias can arise if there is variation in the fill height of the samples. By accounting for segment correlations, the effect of variable fill height (also known as end effects) is corrected for automatically. An iterative maximum-likelihood technique is used to solve the system. The technique is described in Reference 4. An implementation of the segment-correlation correction is planned for the early fall of 1996.

References

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