

Title:

**Operating Procedures for the Cascade Header
Enrichment Monitor: Non-Destructive Assay on 3-Inch
(7.62-cm) and 8-Inch (20.32-cm) Header Pipes at the
Portsmouth Gaseous Diffusion Plant**

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C. E. Moss, and C. D. Romero

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**Operating Procedures for the Cascade Header Enrichment Monitor:
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INTRODUCTION

In September, 1993 President Clinton issued Presidential Decision Directive 13 that offered excess fissile material no longer needed for national security for International Atomic Energy Agency (IAEA) inspections. In April 1996, certain facilities at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, became eligible for IAEA safeguards on material that met this requirement. The IAEA is conducting verification activities at the Portsmouth Gaseous Diffusion Plant to verify that highly-enriched uranium (HEU) is being blended to low-enriched uranium (LEU). The Los Alamos National Laboratory has installed the Cascade Header Enrichment Monitor (CHEM) to support the activities of the IAEA. The CHEM verifies the enrichment of the HEU and the blended LEU. This document describes the operating procedure for the CHEM. Section 1 lists preliminary steps and equipment setup. Section 2 provides detailed instructions to energy-calibrate the instrument. Section 3 lists in detail the steps required to operate the software for the CHEM to obtain an enrichment measurement. Section 4 describes data file structure conventions and the process required to retrieve stored data. Section 5 describes the steps required to shut down the equipment and leave it until the next Short Notice Random Inspection (SNRI). Section 6 describes installation of collimators in the blending cell. Appendix A discusses the algorithm for determining the enrichment of the gaseous UF_6 in the header pipe. Appendix B has cool-down and warm-up data for the electromechanically cooled germanium detector. Technical data for germanium detector performance is in Appendix C. Appendix D has the ^{57}Co source certificates for the sources in the 3-inch (7.62-cm) and the 8-inch (20.32-cm) collimators.

If questions or problems arise during an SNRI, please contact the following people by phone:

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Phil Kerr	505-667-9300
Chip Johnson	505-667-0635
NIS-6 Group Office	505-667-4839

1. PRELIMINARY ACTIVITIES AND EQUIPMENT SETUP

1. Obtain confined space work permit.
2. Locate the cabinet key left by the previous SNRI team.
3. Move the cabinet and the detector storage frame containing the detector and compressor to a convenient operating position near cell 25-7-3.
4. Unlock the front and back doors of the cabinet. Break and remove the tamper indicating device (TID).
5. Turn on the power to the computer monitor, computer, printer, and InSpector multichannel analyzer (MCA). The InSpector MCA is located in the rear of the cabinet.
6. Pull out the sliding tray bench beneath the keyboard. Remove the mouse from this tray. Pull out the sliding tray containing the keyboard.
7. Install paper in the printer tray. The paper is at the bottom of the cabinet.
8. Locate the tools and the leather gloves located on the floor of the cabinet.
9. Remove the tamper-indicating enclosure (TIE) on the 8-in. pipe (Section 6, Fig. 65). Use the leather gloves if the TIE is too hot to touch.
10. Remove the TIE on the 3-in. pipe (Section 6, Fig. 55). Use the leather gloves if the TIE is too hot to touch.
11. Remove the detector U-clamps from either the 3-in. or 8-in. collimator plate, depending on where they were left for storage.
12. Break the TIE seals on the detector and compressor storage frame.
13. Remove the TIE on the detector and compressor storage frame.
14. Remove the detector from the two “saddles” on the top shelf of the frame (Section 6, Fig. 46).
15. Unwind the cooling lines from the storage frame (Section 6, Fig. 45).
16. Insert the detector in the 3-in. collimator. Be sure the detector is inserted all the way (Section 6, Figs. 68 and 69). Note that the preamplifier box must be on top so that a piece near the bottom of the detector assembly will clear the saddle when the detector is inserted. Do all the energy calibration on the 3-in. process pipe. Minimize the time the detector is on the 8-in. process pipe because this is the hotter pipe and will cause more outgassing in the detector and detector resolution degradation.
17. Install the U-clamps to secure the detector to the 3-in. collimator saddles.

18. Insure both ^{57}Co XRF sources are finger tight in their housings. The vibration from the header pipes may have loosened them.
19. Open the 3-in. source shutter (Section 6, Fig. 54).
20. Arrange the cooling lines and preamplifier cable so that when the cell door is almost fully closed they are not easily stepped on.
21. Put the door block in place so that the door will not crimp the cooling lines and the preamplifier cable.

2. X-RAY FLUORESCENCE (XRF) ENERGY CALIBRATION

The CHEM software is based on the “Genie-PC” software and InSpector hardware from Canberra Industries. The software, created especially for this equipment, is called “XRF,” which stands for “x-ray fluorescence.” This section describes the energy calibration which must be performed on the equipment at the start of each Short Notice Random Inspection (SNRI) and prior to enrichment measurements. The “Genie-PC” manuals are available in the instrument cabinet for further reference, if needed.

Once the computer has booted up, the “GENIE-PC” program group icon should be visible on the screen. If it is not open, double click it to open. Figure 1 shows the open “GENIE-PC” program group. The three icons in the group of interest are “Virtual Data Manager (VDM),” “Spectroscopy Assistant,” and “XRF Enrichment Monitor” icons.

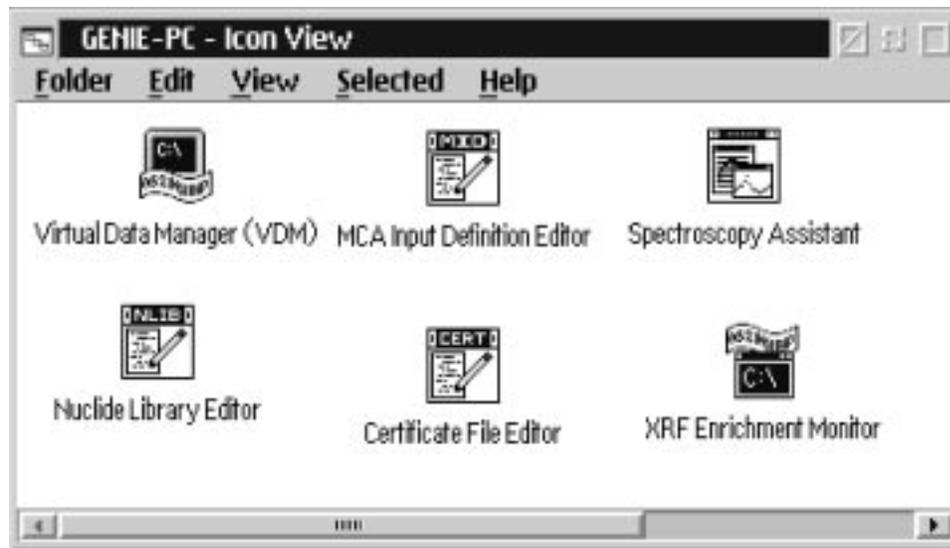


Figure 1. “GENIE-PC” Program Group.

1. Double-click the “VDM” icon. This must be running continuously for the “Genie-PC” and “XRF” software to work. If nothing appears to happen when the “VDM” icon is double-clicked, the “VDM” was already running. Another indication the “VDM” was already running is that the screen will become blank. To get back to the desktop screen, hold down the “Ctrl” key and press the “Esc” key.
2. Double-click the “Spectroscopy Assistant” icon. This brings up a window which allows operation of two programs. The first is “MCA View Control,” which displays the detector spectrum, and the second is “Gamma Spectroscopy Analysis” (GSA), which allows energy calibration and spectrum analysis.
3. Open the “MCA View Control” program using the Applications menu as shown in Figure 2.

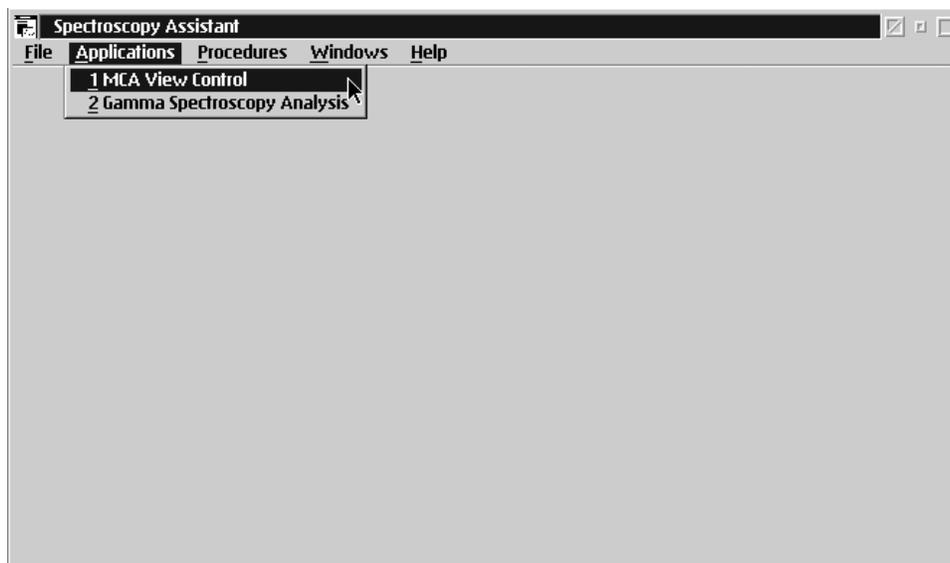


Figure 2. Window for opening “MCA View Control” and “GSA” applications from within “Spectroscopy Assistant.”

4. Open the “GSA” application in the same way as for “MCA View Control.”
5. Return to “MCA View Control” by clicking on an exposed part of the window or by selecting that window using the “Windows” menu in the “Spectroscopy Assistant” menu bar. Then, using the File menu in “MCA View Control,” select “Open Datasource” as shown in Figure 3.



Figure 3. Window for opening a Datasource from within “MCA View Control.”

6. As shown in Figure 4, select “Detector” for “Datasource Type” and “XRF” for “Inputs,” then click OK. This opens the “XRF” detector file for data acquisition. If a message appears saying “Detector has questionable calibration...,” answer “Yes” and continue with this procedure. The “MCA View Control” window title will change to “MCA:XRF.”



Figure 4. Window for selecting and opening the “XRF” file.

7. Select the “GSA” window; then, using the “File” menu in “GSA,” open the “XRF” detector file as for “MCA View Control.” The GSA window title will then change to “Gamma: XRF.”
8. Return to the “MCA View Control” window by selecting an exposed portion of the window.

9. When the “XRF” detector file opens in “MCA View Control,” the existing spectrum will be displayed. This spectrum may or may not have data present. Using the “Scale” menu in “MCA View Control,” select “Auto.” This ensures that any spectrum data will become visible. In either case, select “Clear” in “MCA View Control” as shown in Figure 5 to clear the data in preparation for energy calibration.

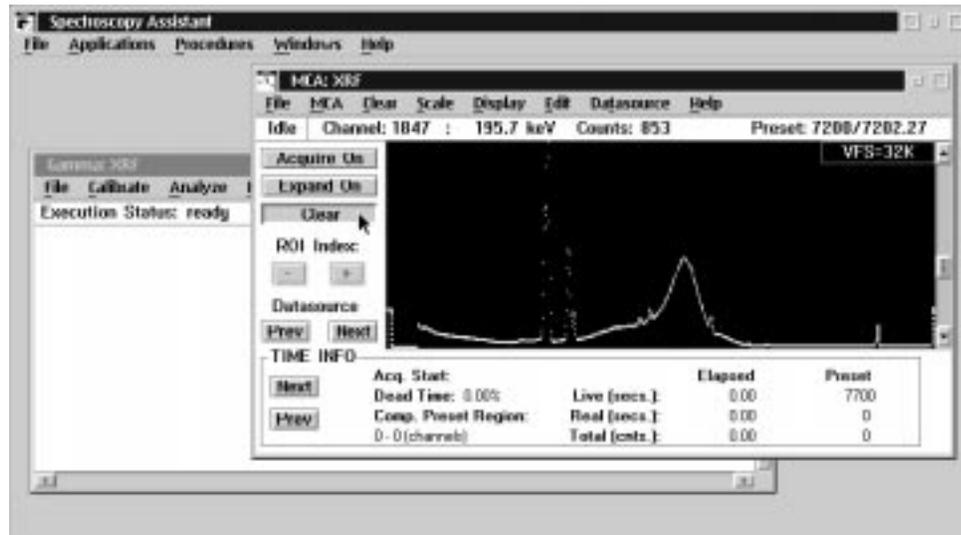


Figure 5. Window showing the open “XRF” detector and selection of the “Clear” button to clear the spectrum.

- Using the “MCA” menu in “MCA View Control,” select “Adjust” as shown in Figure 6.

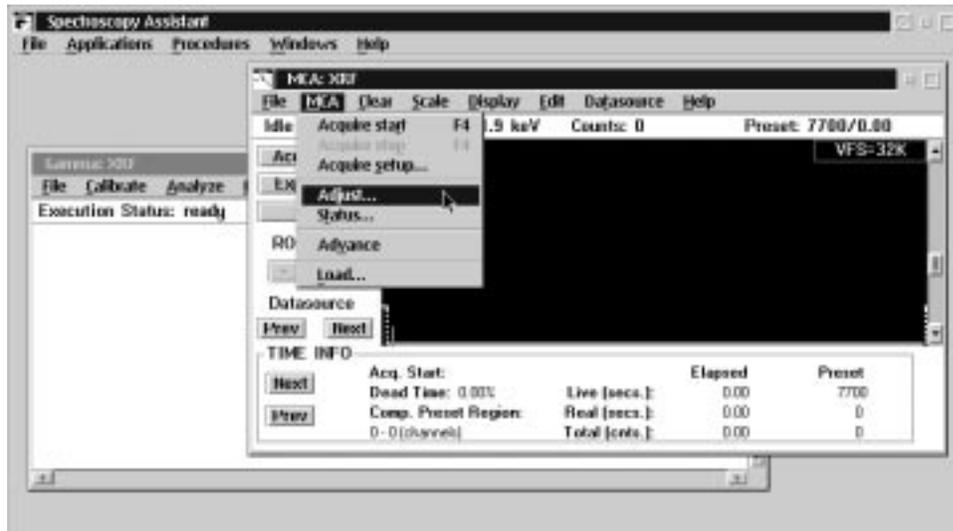


Figure 6. Window showing selection of “Adjust” menu item.

11. In the “Adjust” window, select “HVPS.” Make sure the high voltage (HV) is set to -1200.2 V, then select the “On” button (see Figure 7). The word “Wait” will appear in the top left corner while the voltage is being increased at a rate of 100 V/sec. Current values for the “ADC” and “Amp” settings normally should not be changed. They are as follows:
 “ADC”: Conv. Gain = 2048, LLD = 6.10%, ULD = 99.99%
 “Amp”: Course Gain = 33x, Fine Gain = 1.55x, S-fine = 0.98,
 Shaping = Slow ($4 \mu\text{s}$)
 The “Amp” gain settings place the 185.7-keV ^{235}U peak in approximately channel 1860.



Figure 7. The “Adjust” window. Notice that the HVPS button is selected, the voltage is set to -1200.2 V, and the “On” button is selected.

12. Select the “Exit” button in the “Adjust” window as shown in Figure 8.

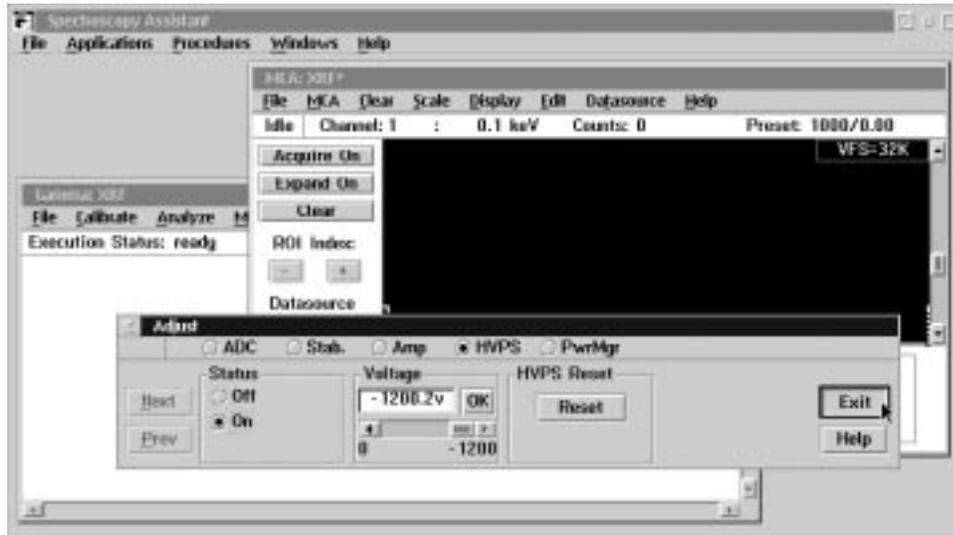


Figure 8. Window showing “Exit” button selected in the “Adjust” window after high voltage has been turned on.

13. Select the “Acquire On” button as shown in Figure 9. This starts the acquisition of data to be used in the energy calibration. Make sure the spectrum is cleared as described in Step 9, above. Also, make sure the “Scale” menu in “MCA View Control” is set to “Auto.”

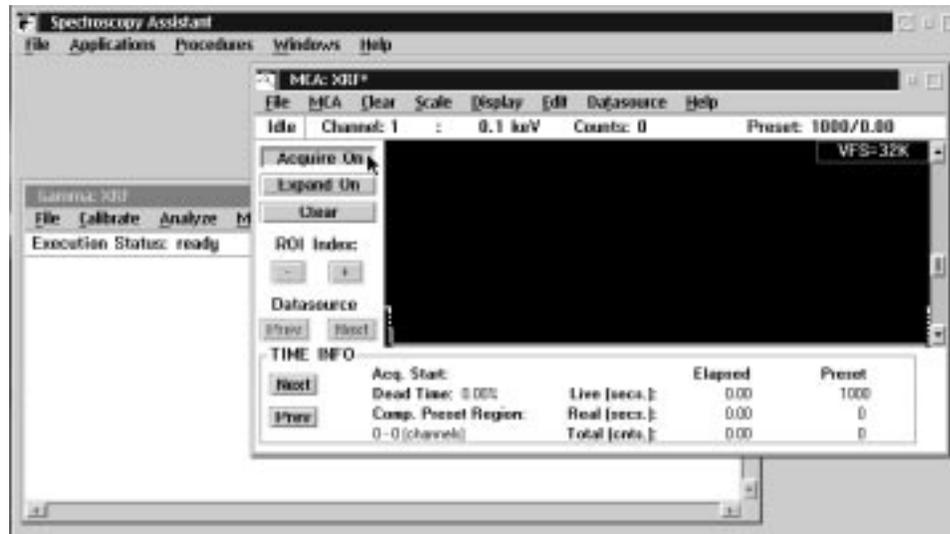


Figure 9. Window showing “Acquire On” being selected to start data acquisition for the energy calibration.

14. Select the “Expand On” button as shown in Figure 10. The spectrum window will then split into an upper spectrum and a lower spectrum. This allows the user to zoom in on the spectral region containing the 185.7-keV ^{235}U peak used in the energy calibration. The region within the white rectangle in the lower spectrum is expanded to create the upper spectrum.

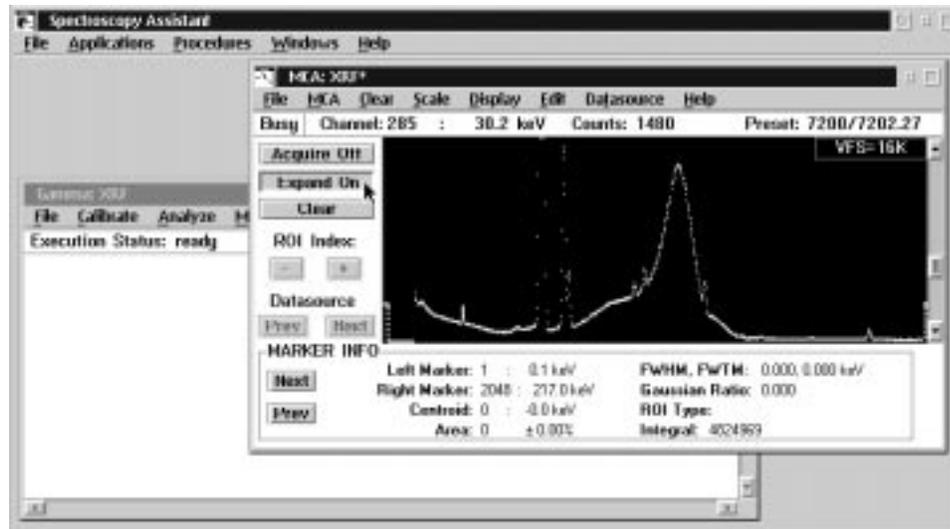


Figure 10. New data displayed in the spectrum and selection of the “Expand On” button.

15. Position the white rectangle towards the right side of the spectrum to focus in on the 185.7-keV peak of ^{235}U (see Figure 11). To move the rectangle, position the mouse in the center of the white rectangle until an “up, down, left, right” crossing arrow appears. Then hold the left mouse button down and move the mouse until the rectangle is moved to the desired location. To change the size of the rectangle, move the crossing arrow just outside one side of the rectangle until a black “up, down” or “left, right” arrow appears. Then, hold the left mouse button down and move the mouse until that side of the rectangle has been moved to the desired location. Alternatively, the expand rectangle can be moved and resized using the “Ctrl” + “arrow” keys and the “Alt” + “arrow” keys, respectively.

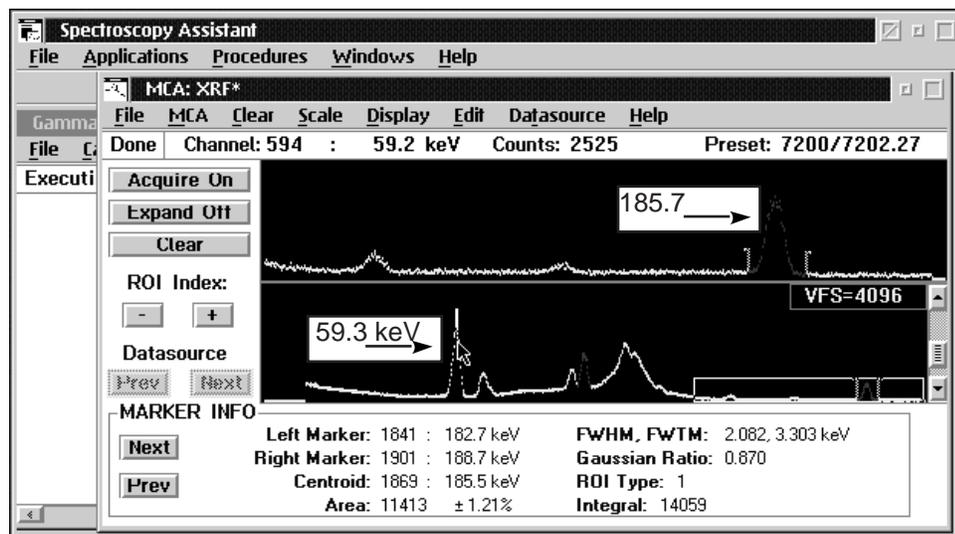


Figure 11. Window showing the white rectangle “Expand On” region on the bottom and the expansion of this region (with the 185.7-keV peak used for energy calibration) on the top.

16. When enough counts have been obtained to locate the 185.7-keV peak, position the white cursor on it using the mouse arrow cursor as shown in Figure 12. Record the channel number of this peak in a log book. In the example shown in Figure 12, channel number 1845 appears in the top left of the “MCA View Control” window.

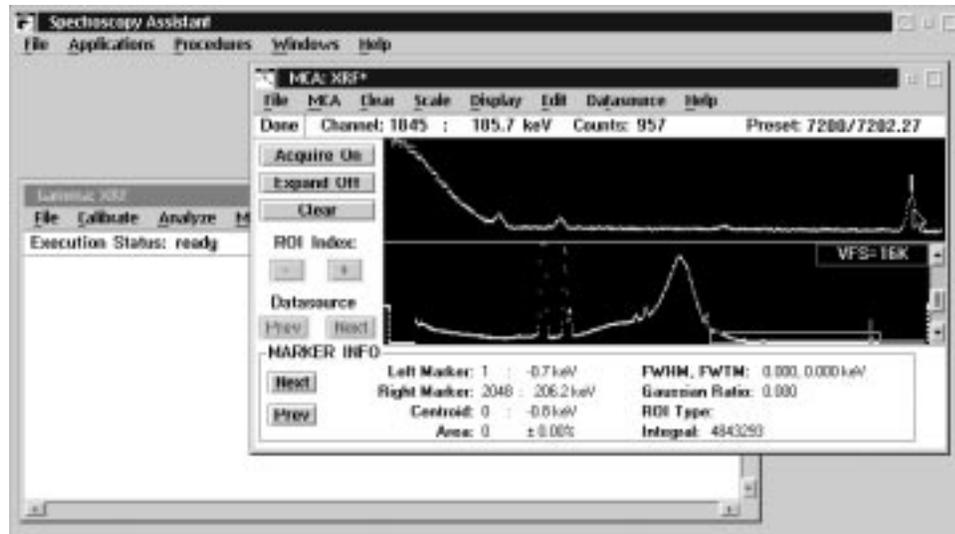


Figure 12. Window showing the white cursor placed on the 185.7-keV peak. Notice the relative positions and heights of other peaks in the spectrum. This will help the user locate the 185.7-keV peak.

17. The other peak used in the energy calibration is the tungsten 59.3-keV K_{α_1} x-ray. Position the white cursor on the 59.3-keV peak using the mouse arrow cursor as shown in Figure 13. Record this number in the log book.
18. The data points in red on the screen compose the regions of interest (ROIs) centered on the 98.4- and 185.7-keV peaks. The present energy calibration will correct any off-center ROIs seen on the screen. If the peaks appear broader than shown in Figure 13, there may be a problem with the germanium detector. This will compromise the precision and accuracy of the enrichment measurement. Please consult one of the authors of this manual.

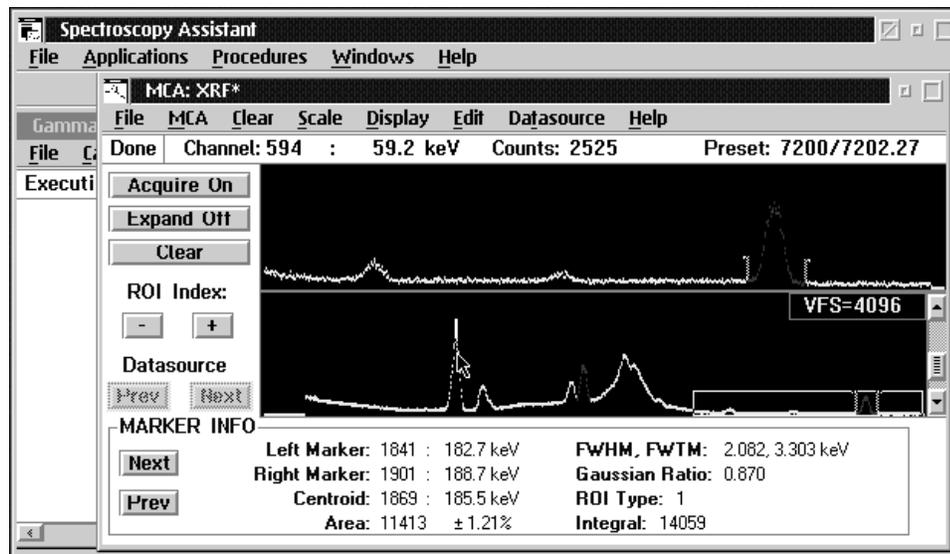


Figure 13. Window showing the white cursor placed on the 59.3-keV peak. Notice the relative positions and heights of other peaks in the spectrum. This will help the user locate the 59.3-keV peak.

19. Figure 13 shows a spectrum with a long counting time and therefore good statistics. Figure 14 shows a spectrum with a 10-min. counting time, which is sufficient for energy calibration.

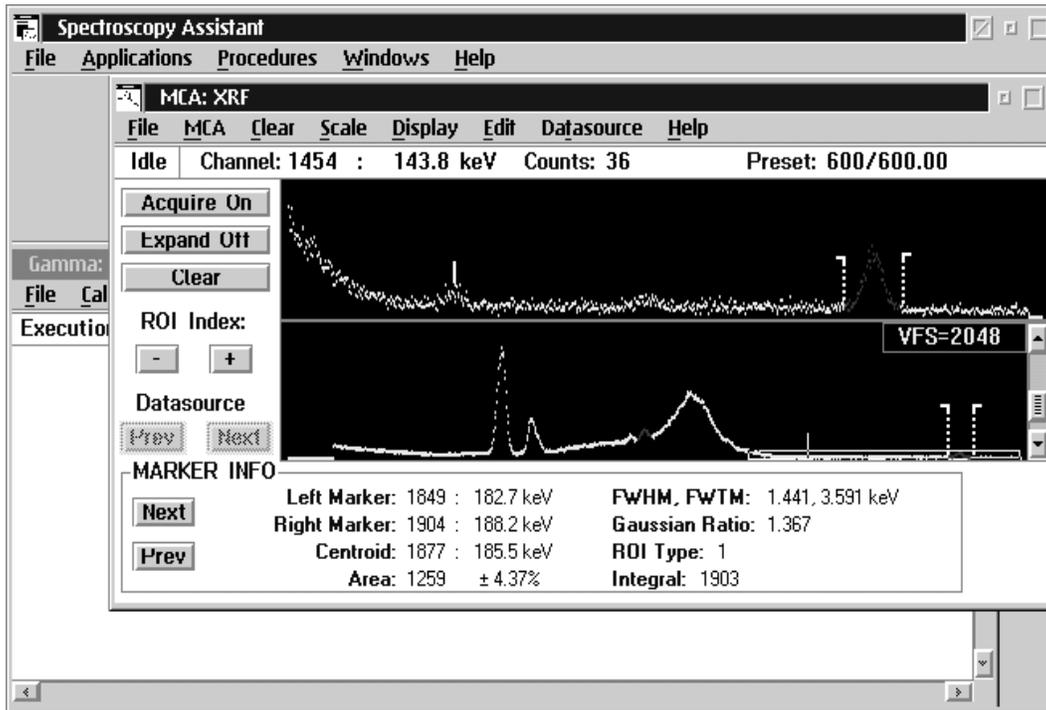


Figure 14. Spectrum with a 10-min. counting time, sufficient for energy calibration. Notice that the white cursor is on the 143.8-keV peak of ^{235}U , and ROI markers are on either side of the 185.7-keV peak.

20. Select the “Acquire Off” button in “MCA View Control” as shown in Figure 15 to halt data acquisition.

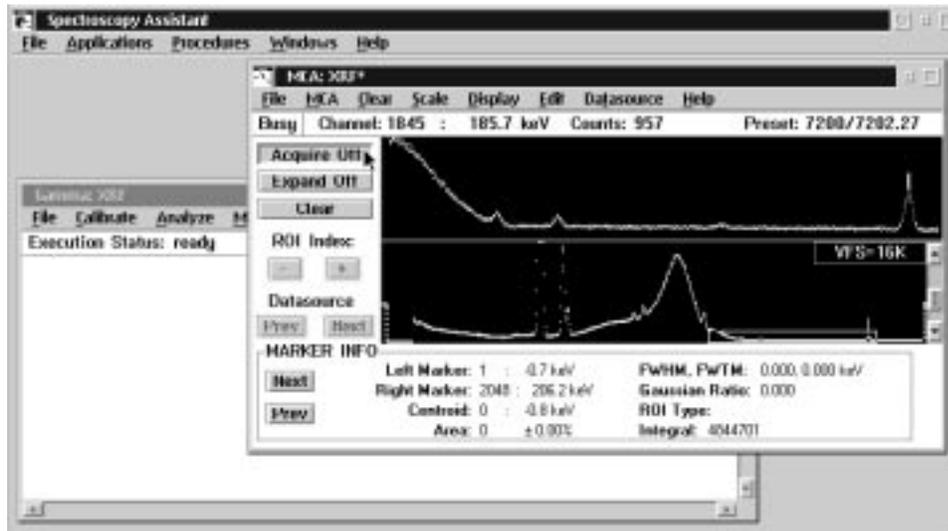


Figure 15. Window showing selection of “Acquire Off” button to halt data acquisition.

21. Select the “GSA” application window by selecting an exposed portion of the window or by using the “Windows” menu of “Spectroscopy Assistant.”
Then, using the “Calibrate” menu, select “Energy manual...” (see Figure 16).

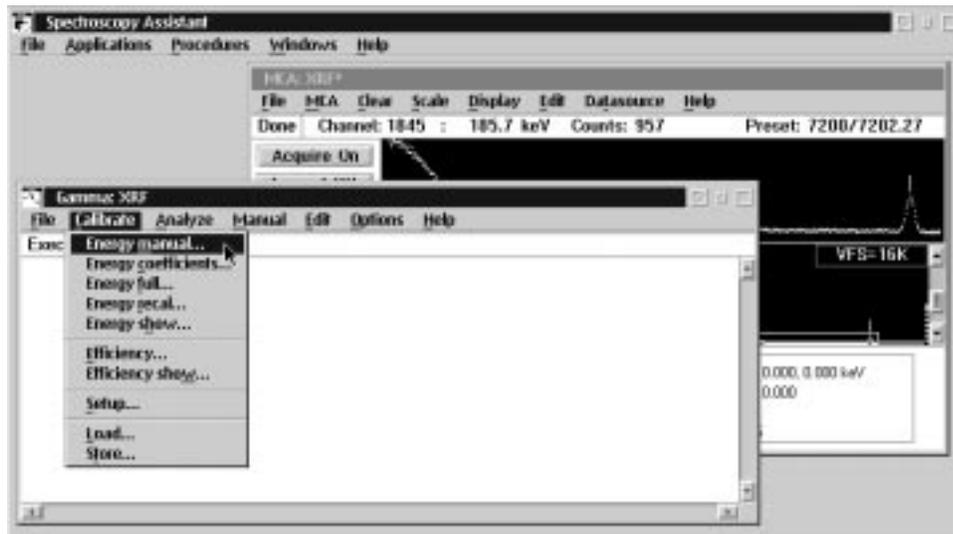


Figure 16. Window showing selection of “Energy manual...” under the “Calibrate” menu item in the “GSA” application.

22. In the “Energy Calibration – Manual” window, select the “Populate” button as shown in Figure 17.

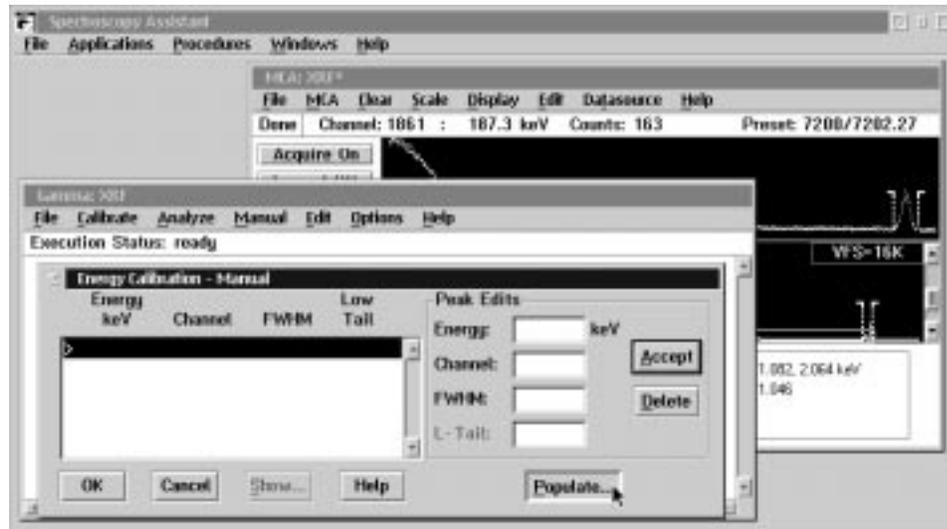


Figure 17. The “Energy Calibration – Manual” window showing selection of the “Populate” button.

23. Selecting the “Populate” button will activate the “Populate” window. In the “Populate” window, select “Current Datasource” and then select the “OK” button (see Figure 18).



Figure 18. The “Populate” window, showing selection of the “Current Datasource” button and then the “OK” button.

24. After selecting “OK” in the “Populate” window, the “Energy Calibration – Manual” window will return, showing the existing channel centroid and full-width at half-maximum (FWHM) data for the 59.3- and 185.7-keV peaks on the left side (see Figure 19). (If no values are present in the window, all values must be entered by hand. For the FWHM values, use 1 and 2 for the 59.3- and 185.7-keV peaks, respectively.)
25. Also shown in Figure 19 is the 59.3-keV channel number highlighted on the right side. To highlight the number, drag the cursor over the number while holding down the left mouse button. Once this number is highlighted, the new value obtained and recorded in Step 17 can be typed in.

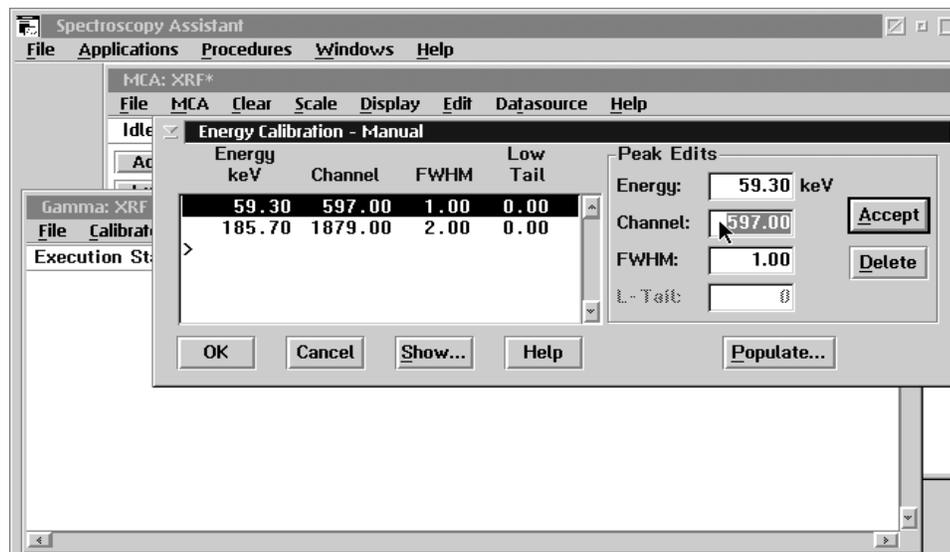


Figure 19. The “Energy Calibration – Manual” window, showing the current peak centroids and FWHMs. The 59.3-keV peak centroid is highlighted so that the new value recorded during Step 17 can be typed in.

26. Once this value is typed in, select the “Accept” button as shown in Figure 20. This enters the new value into the list on the left.
27. Make sure the second line on the left (for the 185.7-keV peak) is then selected and enter the new channel number for this peak, which was obtained in Step 16. Select “Accept” as was done for the 59.3-keV peak.

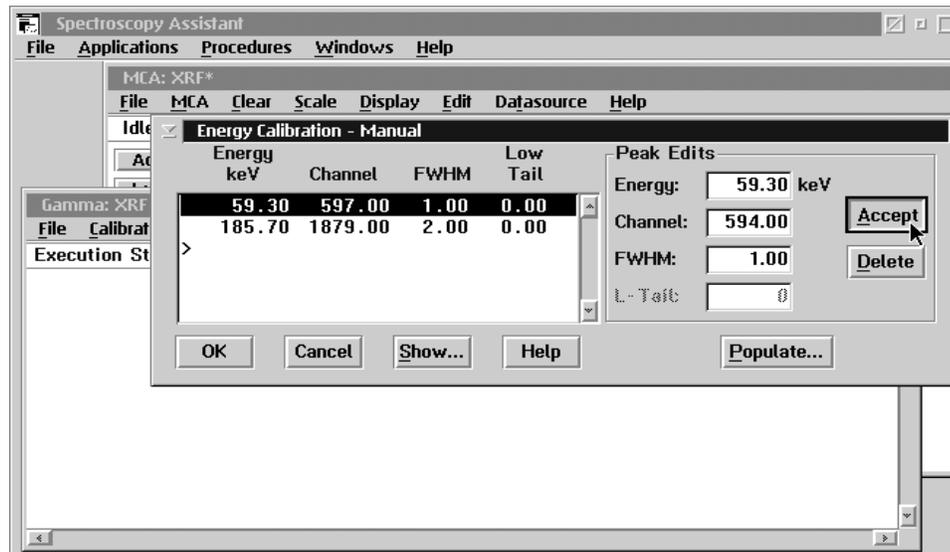


Figure 20. Window showing selection of the “Accept” button after entering the new channel value for the 59.3-keV peak.

28. Verify that both peaks have the correct new channel values, then select the “OK” button as shown in Figure 21.

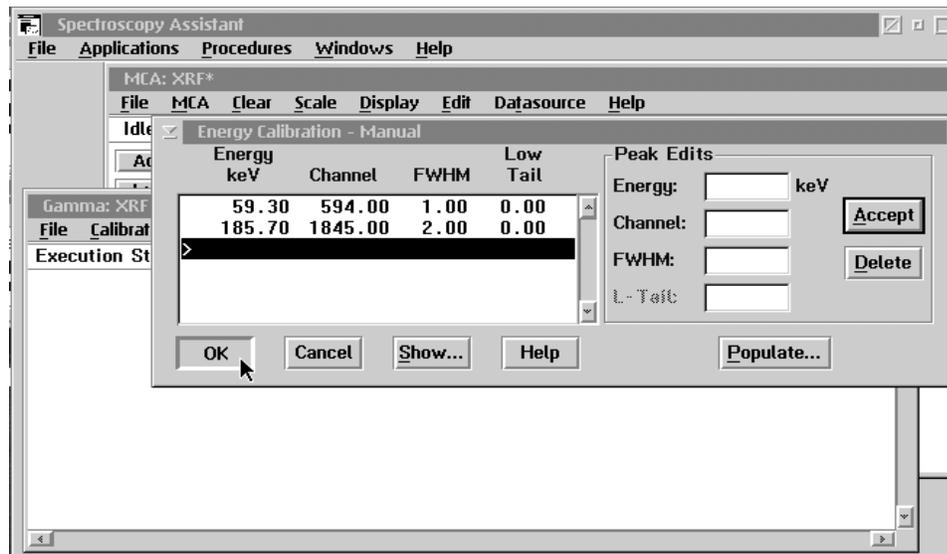


Figure 21. The “Energy Calibration – Manual” window showing new channel values and selection of the “OK” button to exit the window.

29. Using the “File” menu item in “GSA,” select “Save” to save the new calibration of the detector (see Figure 22).
30. Repeat for the “MCA View Control” window; using the “File” menu item, select “Save.”



Figure 22. Window showing the use of “Save” to save the new energy calibration.

- Using the “File” menu item in the “Spectroscopy Assistant” window, select “Exit” to close the “MCA View Control” and “GSA” windows and exit “Spectroscopy Assistant” as shown in Figure 23. This completes the XRF energy calibration.

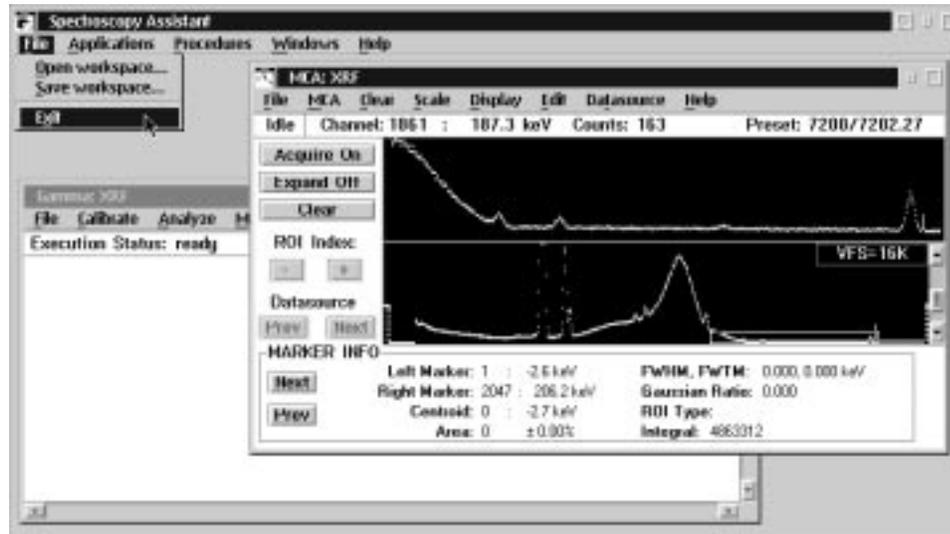


Figure 23. Window showing exit from “Spectroscopy Assistant.” This concludes the XRF energy calibration.

3. MAKING AN ENRICHMENT MEASUREMENT: XRF SOFTWARE AND HARDWARE OPERATION

This section describes the procedure for obtaining enrichment measurements on the 3- and 8-in. process pipes at the Portsmouth Gaseous Diffusion Plant. This includes operation of the XRF software and hardware. Either the 3- or 8-in. pipe measurement can be performed first.

1. Make sure the source is installed in the collimator that is attached to the pipe to be measured. When moving the source, be sure to point it away from you and other personnel and minimize time spent holding the source.
2. Start the XRF software.

The XRF CHEM software is started by double clicking the “XRF Enrichment Monitor” icon in the “GENIE-PC” program group (see Figure 1). This program presents the user with the main menu shown in Figure 24. Depending on the location of the detector, the user may decide to first do a measurement on either the 3-in. pipe or on the 8-in. pipe. The 3-in. pipe measurement requires about two hours. The 8-in. pipe measurement requires about 30 minutes.

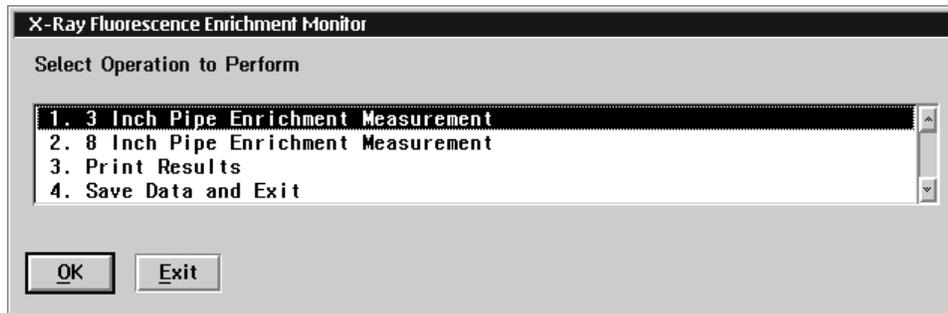


Figure 24. XRF Software main menu.

3. Select either the 3- or 8-in. pipe and click “OK” (or double click one of the entries).
4. Make sure the collimator slot is set parallel to the pipe. The user is reminded of this step by the XRF software as shown in Figure 25. Select “OK” when the collimator has been set.

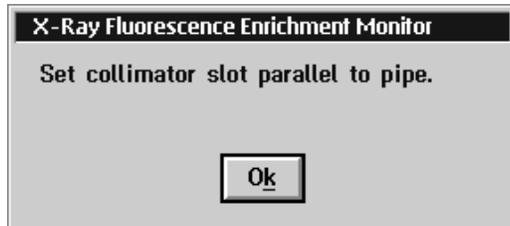


Figure 25. Message box reminding user that the collimator must be in the parallel position for this measurement.

5. Open the source shutter. The user is reminded of this step by the XRF software as shown in Figure 26. Select “OK” when the shutter is open.



Figure 26. Message box reminding user that the XRF source shutter must be open for this measurement.

6. A dialog box will then appear for the user to enter the acquisition time in minutes. Alternatively, the default value can be accepted as given. Select “OK” to continue. Figure 27 shows this dialog box with a value of 120 minutes. The value seen may be different from this. A value of 30 minutes may be sufficient for the 8-in. pipe. Minimize the time the detector is on the 8-in. process pipe because this is the hotter pipe and will cause more outgassing in the detector and detector resolution degradation.

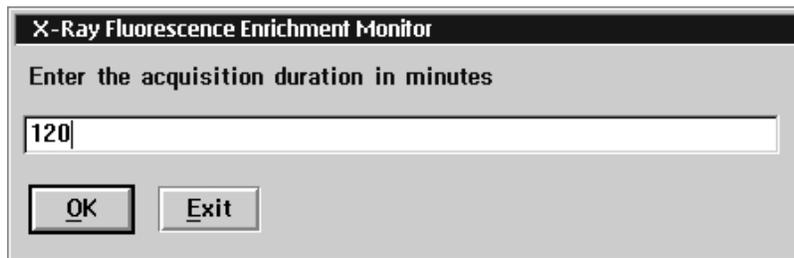


Figure 27. Message box that allows the user to enter a data acquisition time. Here the box contains a default value of 120 minutes.

7. Several message boxes will then appear indicating acquisition status. Figures 28–31 show the normal sequence of message boxes prior to the “MCA View Control” window appearing. The “MCA View Control” window will display the new spectral data being acquired for the enrichment measurement. Since the detector high voltage is normally left on after the energy calibration, Figure 30 may not be seen.

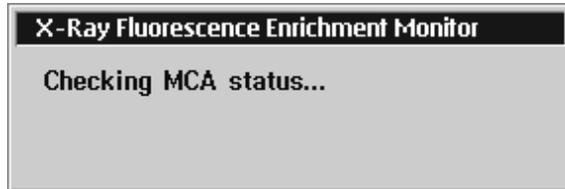


Figure 28. Message box indicating that the XRF software is checking MCA status.



Figure 29. Message box indicating that the XRF software is checking the MCA hardware and configuration.

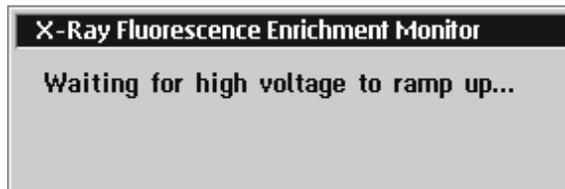


Figure 30. Message box indicating that the XRF software is waiting for high voltage to reach a preset value.

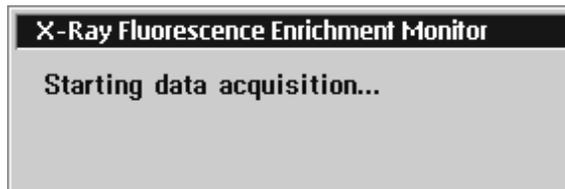


Figure 31. Message box indicating that the XRF software is starting data acquisition.

- After the message box shown in Figure 31 disappears, the “MCA View Control” window will appear, showing the accumulating spectrum of data from the selected process pipe. Figure 32 shows an example spectrum. The white cursor is on the 98.4-keV XRF peak, and ROI markers are on either side of the 185.7-keV ^{235}U peak. Also notice that the 98.4-keV peak and the 185.7-keV peak are in ROIs which are set automatically, based on the energy calibration performed in Section 2. The data in the ROIs are colored red on the computer screen.

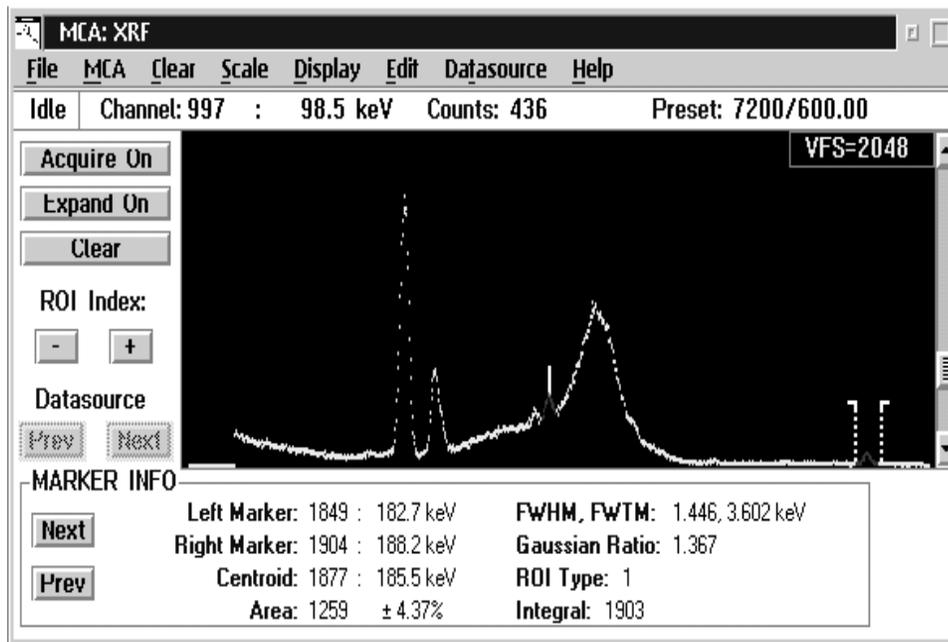


Figure 32. Spectrum showing the location of the 98.4-keV x-ray fluorescence peak and the 185.7-keV ^{235}U peak. The two ROIs containing these peaks are colored red on screen and are used to obtain the areas of these peaks.

9. The “Expand On” button (see Figure 10) can be used to zoom in on the peaks of interest to check for proper energy calibration and proper locations of the ROIs. If either the energy calibration or ROI locations appear incorrect, the program should be stopped and the energy calibration procedure of Section 2 repeated. Repeating the energy calibration procedure should correct the locations of the ROIs, since the ROIs are set automatically, based on the energy calibration. To stop the program, select the “Acquire Off” button to stop data acquisition. After a few seconds and two message boxes (Figures 33 and 34), the “MCA View Control” window will disappear. Then click “OK” in the results screen (see Figure 35) and click “Exit” in the next window (see Figure 36). Using the clear button does clear the spectrum, but does not reset the XRF acquisition time.
10. If the energy calibration is correct, continue with this list.
11. Once the preset acquisition time is reached, the “MCA View Control” window will disappear and two message boxes will appear. The first indicates that data acquisition is being stopped (see Figure 33) and the second indicates that MCA data acquisition is off (see Figure 34).

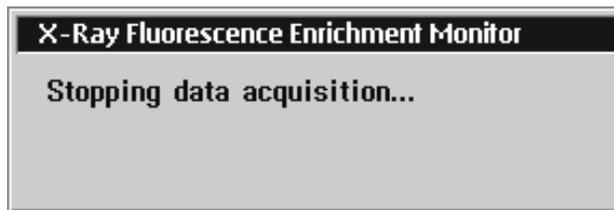


Figure 33. Message window, indicating that data acquisition is being stopped.

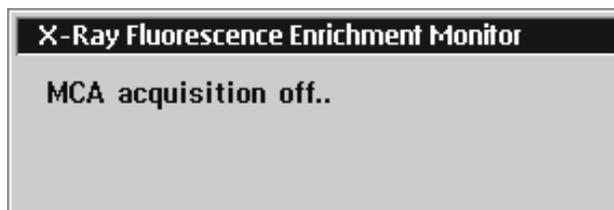


Figure 34. Message window, indicating that MCA acquisition has been stopped.

- The XRF software will then extract the peak areas from the spectrum and calculate an enrichment for the present pipe. A screen will appear, showing the results of the calculation (see Figure 35). Select "OK" when finished reviewing the results. These results can be printed from the main menu shown in Figure 24 or printed after the gas enrichment measurement for the next process pipe has been completed (see Steps 26 and 27, below). They are not saved until they are printed or until "OK" or "Exit" is selected from the main menu (see Figure 24). However, once the results screen is seen, the spectrum has been saved.

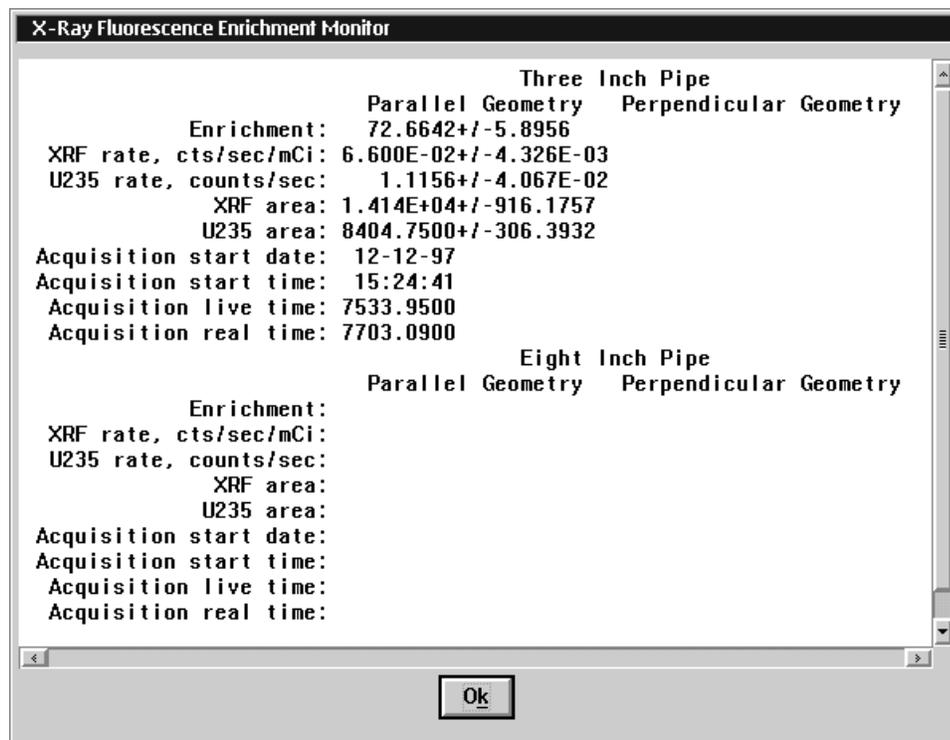


Figure 35. Window displaying the results of the enrichment calculation for the 3-in. pipe parallel geometry.

13. The user will then be asked whether or not to proceed with the perpendicular geometry measurement (see Figure 36). The perpendicular geometry is not necessary for these measurements because the ^{235}U deposits have been accounted for in the parallel geometry measurement by subtracting a count rate for the deposit from the 185.7-keV count rate. Therefore, select “No” in this dialog box.

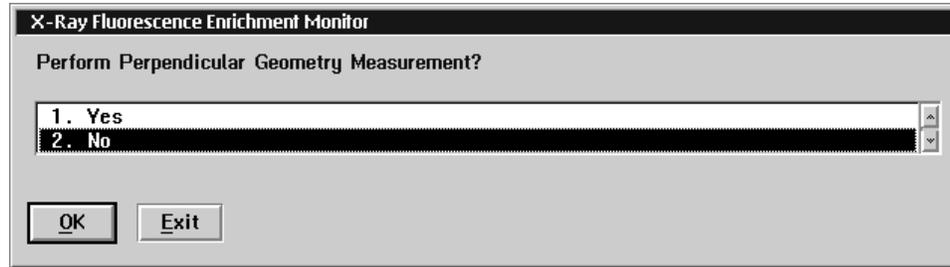


Figure 36. Dialog box that allows user to perform perpendicular geometry measurement if desired. Select “No,” since only the parallel geometry measurement is normally needed.

14. The user is then returned to the main menu, where the next pipe measurement can be performed. In addition, the user can repeat the previous measurement by selecting that pipe again. Calculations for all repeated measurements are saved and can be printed, but only the two most-recent spectra are saved.
15. If the next pipe measurement is desired, the detector must be moved as described in Steps 16-22 before the XRF software can continue with the next pipe. Refer to the photographs and their accompanying descriptions in Section 6 for more information.
16. Close the source shutter for both the 3- and 8-in. pipe collimators.

17. Make sure the detector collimator on the second process pipe is set to “parallel.”
18. Remove the detector clamps from around the detector.
19. Remove the detector and install it in the collimator for the second pipe.
20. Install the detector clamps around the detector.
21. Open the shutter in front of the source on the second pipe.
22. Place a block in the door and arrange the cooling lines and cables so that the door will close onto the block but not press against the lines and cables.
23. Continue with the XRF software by selecting the next pipe for measurement in the main menu (Figure 24). The steps and messages for each pipe measurement are identical.
24. When the measurement for this pipe is finished, the results screen will appear again for evaluation. Select “OK” when finished evaluating the results. This returns the user to the main menu.
25. Once back in the main menu, the results obtained so far can be printed by selecting “Print Results” then “OK” (see Figure 37).

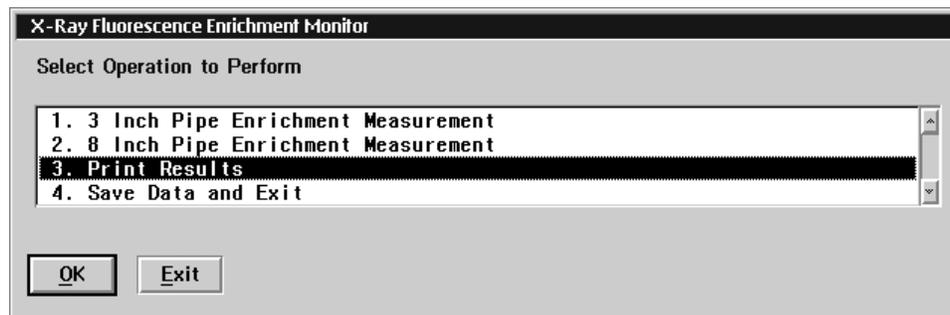


Figure 37. Main menu, indicating selection of “Print Results” to print results of all current measurements.

26. Selecting “Print Results” will present the screen shown in Figure 38a. The bottom of the “Print Results” screen can be seen by using the scroll bar on the right (see Figure 38b). Select “Print” to print the results and return to the main menu.

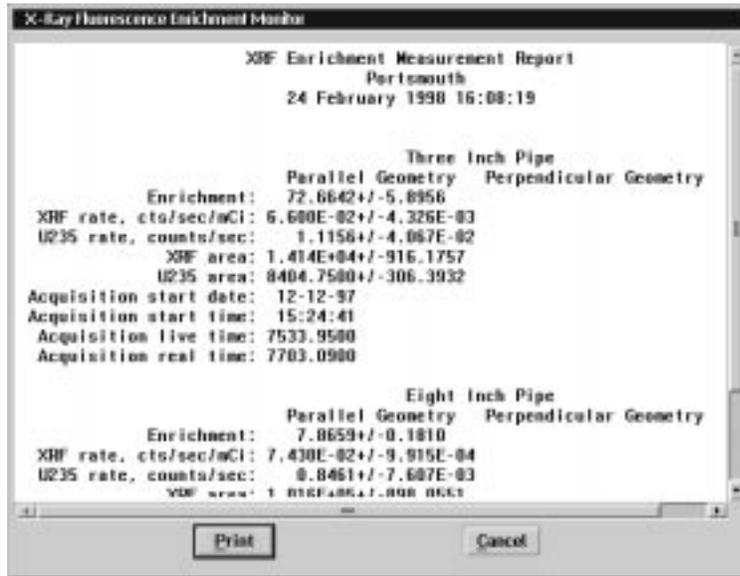


Figure 38a. The “Print Results” window.

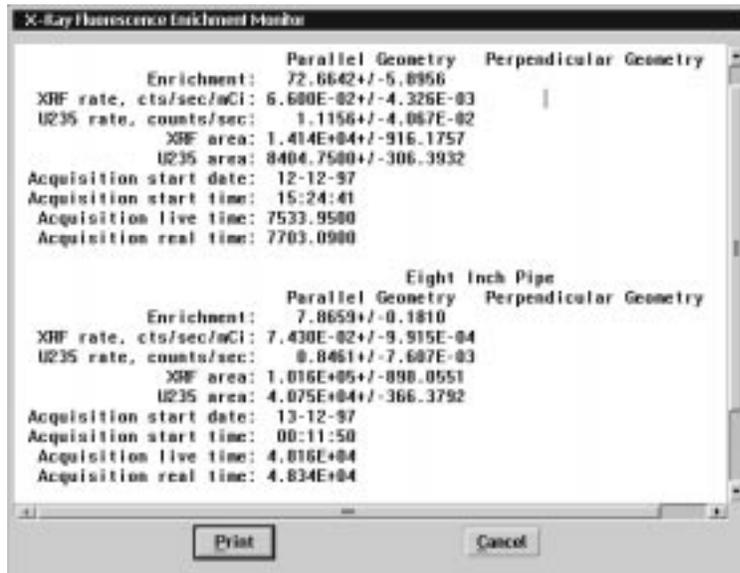


Figure 38b. The bottom of the “Print Results” window.

27. Once back in the main menu, measurement for either pipe can be repeated. If all measurements are completed satisfactorily, or if the program must be exited to repeat the energy calibration, select “Save Data and Exit” as shown in Figure 39 to save results and exit the program. In other menus, the “Exit” button will exit the program and may result in the loss of data, but in this menu the “Exit” button will exit the program without loss of data.

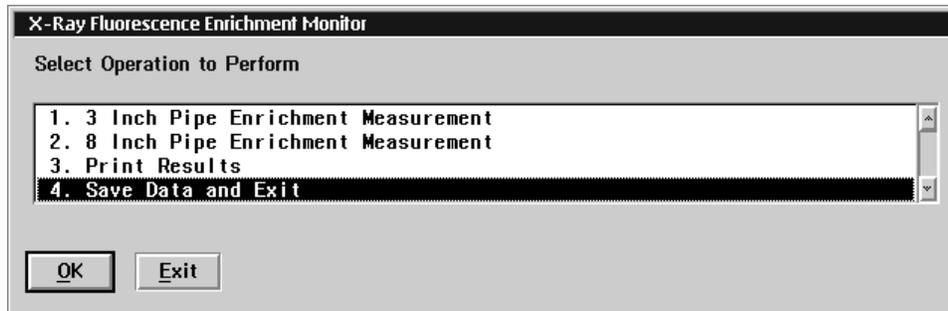


Figure 39. Main menu indicating selection of “Save Data and Exit” to save data and exit the XRF software.

28. Upon exiting the program, the XRF software will present two message boxes as shown in Figures 33 and 40, indicating that data acquisition is stopping and the high voltage is being turned off. This takes a few seconds because the voltage is reduced at a rate of 100 V/sec. All XRF software windows will then disappear. This completes the enrichment measurements.

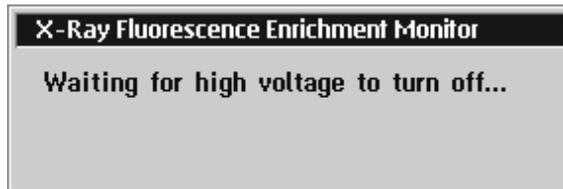


Figure 40. Message box seen at exit of XRF software, indicating that the high voltage is being turned off.

ERROR MESSAGES

In the event that the peak locations are incorrect or the areas are negative, the XRF software will present message boxes indicating these problems. Figures 41–44 indicate the most common error messages. Such a message could indicate that the measurement time was not long enough to get enough peak statistics, that the energy calibration is incorrect, or that there is no UF_6 gas in the header pipe. (Check with plant personnel to ensure there is gas in the header pipe.) Check the energy calibration again using the steps outlined in Section 2, above, and adjust if necessary. If the energy calibration is good, and gas is present, increase the counting time from within the XRF software, using the dialog box as shown in Figure 27.

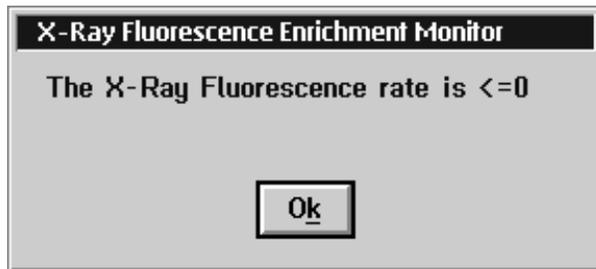


Figure 41. Message box indicating that the 98.4-keV x-ray fluorescence peak area is negative.



Figure 42. Message box indicating that the 185.7-keV ^{235}U peak area is negative.



Figure 43. Message box indicating that no 98.4-keV x-ray fluorescence peak was found in the spectrum.

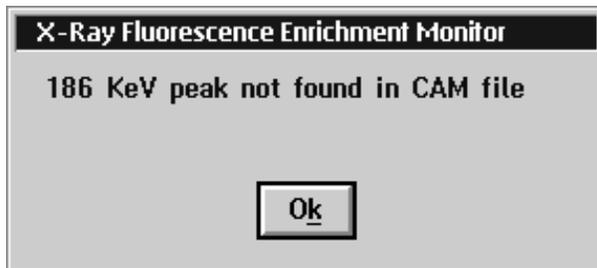


Figure 44. Message box indicating that no 185.7-keV ^{235}U peak was found in the spectrum.

4. FILE STRUCTURE AND DATA RETRIEVAL

The data are stored in directories according to the date and time at which the XRF Enrichment Monitor software program was started. For example, if the software was started on March 5, 1998 at 14:35:00 hrs, the data for that run would be stored in the directory "C:\XRF\DATA\19980305\143500."

The results of all calculations for that run are stored in the file named REPORT.TXT in that directory. The spectrum for the 3-in. pipe measurement is stored in the file PIPE_3_1.CNF. The spectrum for the 8-in. pipe measurement is stored in the file PIPE_8_1.CNF. The "1" in the file name means the parallel collimator geometry was used for the measurement. This is the first and only collimator used. The program has the capability to make a second measurement, the perpendicular collimator geometry. If this were made, a "2" would appear in the file name. If two or more runs are taken, only the two most recent spectra are saved. The most recent is stored in the file with a .CNF extension, and the second most recent is stored in the file with a .BAK extension.

The computer has virus-scan software preinstalled. The hard disk has been checked and is clean of viruses. When copying data to floppy disks, make sure the floppies have been scanned for viruses and cleaned if found to be infected.

5. SYSTEM SHUTDOWN AND SEALING

The following steps should be followed to shut down the equipment and seal the TIEs to secure the equipment until the next SNRI.

1. Close the shutter for both the 3- and 8-in. pipe collimators (Section 6, Figs. 54 and 64).
2. Seal the sources, if not already sealed.
3. Do not disconnect the cooling lines. It is not necessary to disconnect the preamplifier, high-voltage, and signal cables from the detector. Push the excess preamplifier and signal cable through the large opening in the bottom of the electronics cabinet and coil the preamplifier and signal cable in the bottom of the electronics cabinet for storage.
4. Remove the detector clamps from around the detector.
5. Remove the detector from the collimator. If the detector is very hot, use the leather gloves to avoid getting burned or dropping the detector.
6. Coil the cooling lines on the storage frame (Section 6, Fig. 45).

Time and patience are required to coil the cooling lines and place the detector on the support frame. The cooling lines are very stiff and awkward to manipulate. The following are some general instructions. Two inspectors are required to coil the cooling lines and place the detector on the support frame. Cradle the detector loosely but securely in your arms, so that the detector can rotate safely as needed. You may need to extend the cooling lines to their full extent, approximately 25 feet (7.6 m), with the detector cradled in your arms. The second inspector can start to coil the cooling lines on the frame, starting at the bottom of the frame in a clockwise direction. This motion may require the detector to rotate in the arms of the first inspector. Two loops will allow the detector to be positioned on the top of the frame. Because of the stiffness of the cooling lines, two loops of the cooling lines are the maximum number of loops.

7. Clamp the detector to the two “saddles” on the top shelf of the frame (Section 6, Figure 46). Align the black line on the back flange of the detector with the black line on one of the U-clamps (Section 6, Figure 47).

8. Place the TIE over the detector and bolt it to the top shelf of the storage frame.
9. Seal the TIE.
10. For storage, reinstall the U-clamps removed in Step 4.
11. Install the TIE and seal on 3-in. pipe (Section 6, Fig. 55).
12. Install the TIE and seal on 8-in. pipe (Section 6, Fig. 65).
13. Store the door block in the bottom of the cabinet.
14. Store all tools, leather gloves, and other small miscellaneous items in the cabinet.
15. Remove the paper from the printer tray and slide the purple paper-holder/tray in so that the front door of the cabinet can be closed.
16. Shut down the computer by selecting the small icon in the upper left corner of the computer screen depicting a small computer overlaid with a red X.
17. Message boxes will appear asking if you want to shut down the system and end the active programs. Answer “Yes” to all message boxes. Wait to turn off the computer until a message box appears instructing it is safe to turn off the computer.
18. Turn off the power to the computer monitor, computer, printer, and InSpector MCA. The InSpector MCA is located in the rear of the cabinet.
19. Lock the front and back doors of the cabinet and seal as appropriate.
20. Position the cabinet and the detector storage frame containing the detector and compressor in a storage location near cell 25-7-3.
21. The compressor must remain connected to AC power and must be switched on at all times so that the detector remains cold for the next SNRI.
22. Store the cabinet key so that the next SNRI team can find it.

6. COLLIMATOR INSTALLATION

This is a complete set of installation instructions. It is not expected that the collimators will have to be installed as a routine operation during an SNRI unless a different cell is used for the blending operation. The steps that must be followed during each SNRI have been listed in Sections 1-5.



Figure 45. During those periods when the IAEA is not making an SNRI, the electromechanically cooled germanium detector should be stored on the special frame provided. This figure shows the germanium detector and the compressor on the frame. Pay special attention to the placement of the compressor, the detector head, and the cooling lines. This shows how the cooling lines are to be coiled on the frame. There are two sets of brackets to help organize the cooling lines. Do not remove the tie wraps on the cooling lines. The cooling lines are very stiff, and these tie wraps keep the cooling lines organized.

Time and patience are required to coil the cooling lines and place the detector on the support frame. The cooling lines are very stiff and awkward to manipulate. The following are some general instructions. Two inspectors are required to coil the cooling lines and place the detector on the support frame. Cradle the detector loosely but securely in your arms so that the detector can rotate safely as needed. You may need to extend the cooling lines to their full extent, approximately 25 feet (7.6 m), with the detector cradled in your arms. The second inspector can start to coil the cooling lines on the frame, starting at the bottom of the frame in a clockwise direction. This motion may require the detector to rotate in the arms of the first inspector. Two loops will allow the detector to be positioned on the top of the frame. Because of the stiffness of the cooling lines, two loops of the cooling lines are the maximum number of loops.



Figure 46. The detector head is supported by two “saddles” on the top shelf of the frame. The U-clamps attached to the saddles hold the detector in place.

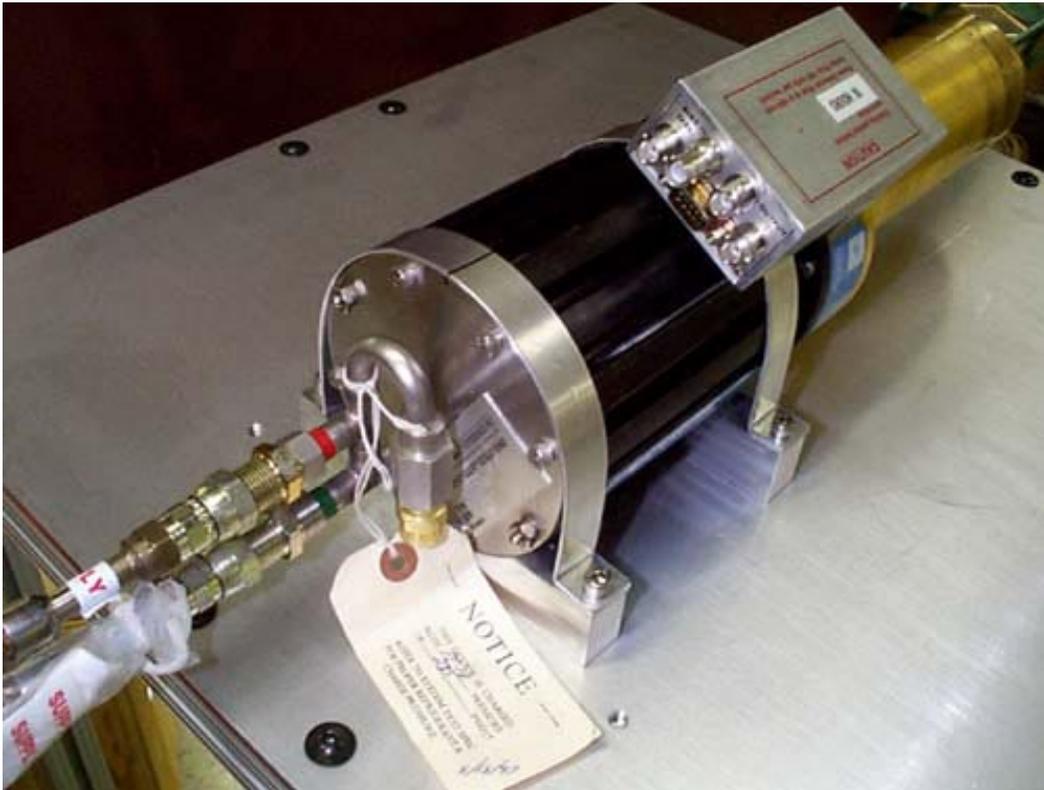


Figure 47. There is a black line on one of the U-clamps and on the back flange of the detector head. These must be aligned for proper orientation of the detector head on the top shelf. This orients vertically the connectors for the cooling lines on the detector head. This orientation is required so that the TIE can be placed over the detector head and bolted to the top shelf. The preamplifier cables (not shown in the photograph) are attached to the preamplifier and placed beneath the cooling lines when the TIE is in position over the detector head.

NOTE: The preamplifier will be rotated about thirty degrees from horizontal in this proper orientation.

At the start of the SNRI, remove the TIE from the detector head. At the conclusion of these measurements during the SNRI, replace the TIE over the detector head.

Figures 48-56 show the installation of the collimator for the 3-in. (7.62-cm) header pipe.

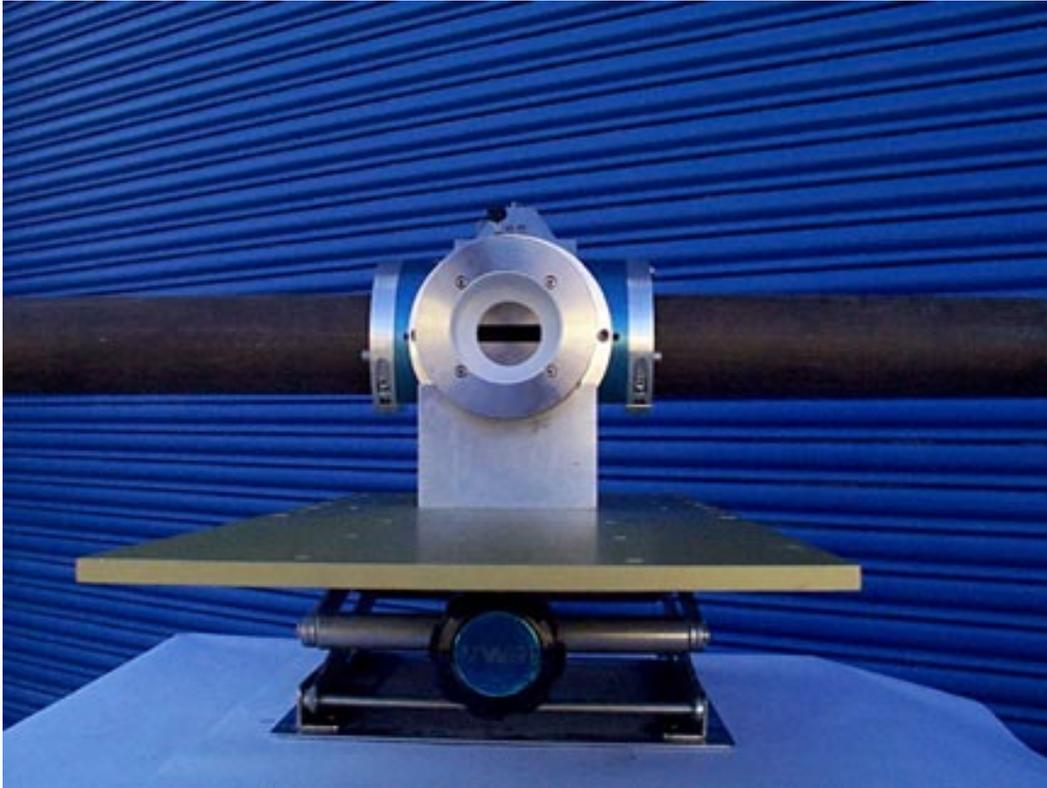


Figure 48. The 3-in. (7.62-cm) collimator attaches to a large lab jack, as shown. The lab jack sits directly on the floor beneath the header pipe.

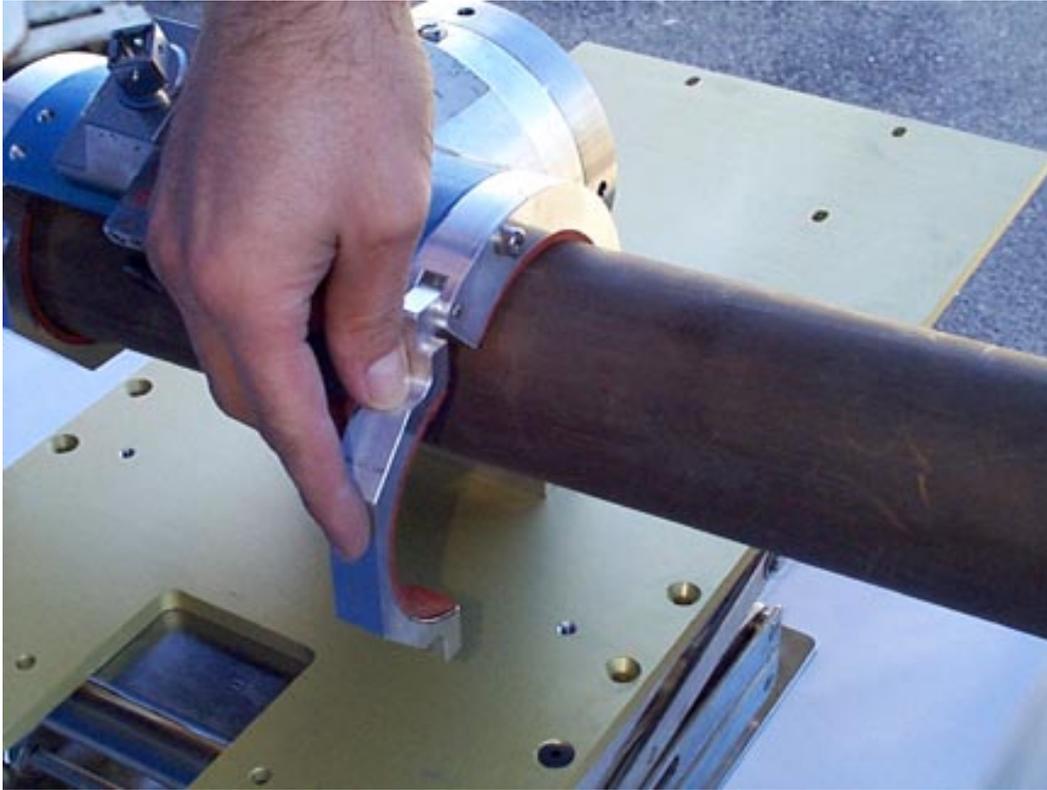


Figure 49. The collimator for the 3-in. (7.62-cm) header pipe is placed in position around the header pipe. The clamps, one on each edge of the collimator, need to be opened for the collimator to initially fit over the pipe. The collimator is already attached to the “saddle” and the base plate. Initially, the base plate may be supported by, but not attached to, the lab jack.

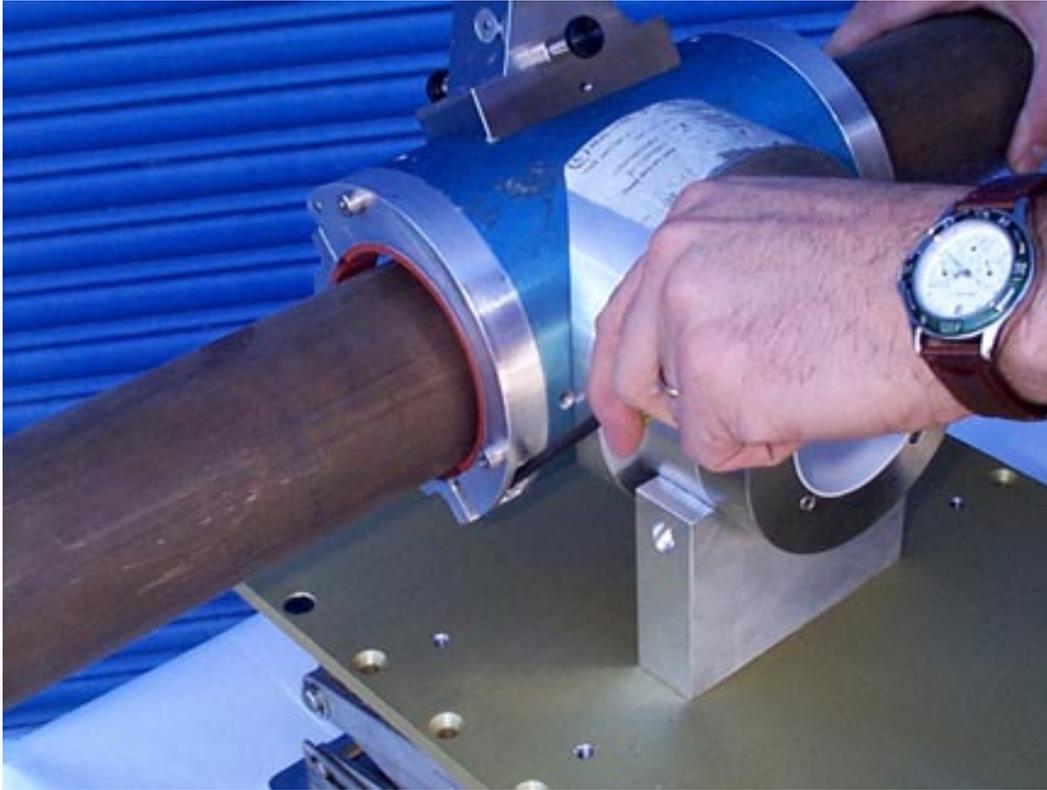


Figure 50. Use an Allen wrench to initially tighten both clamps around the header pipe. Raise the lab jack as required. Finish tightening the clamps around the header pipe. Fasten the base plate to the lab jack. There are two aluminum channels that support the lead back shield. Attach the two aluminum channels to the back of the collimator base plate. Insert the lead for the back shield in the channel and tighten the two Allen screws, one in each aluminum channel, to hold the lead in position. (The back shield is not shown in the figure.)

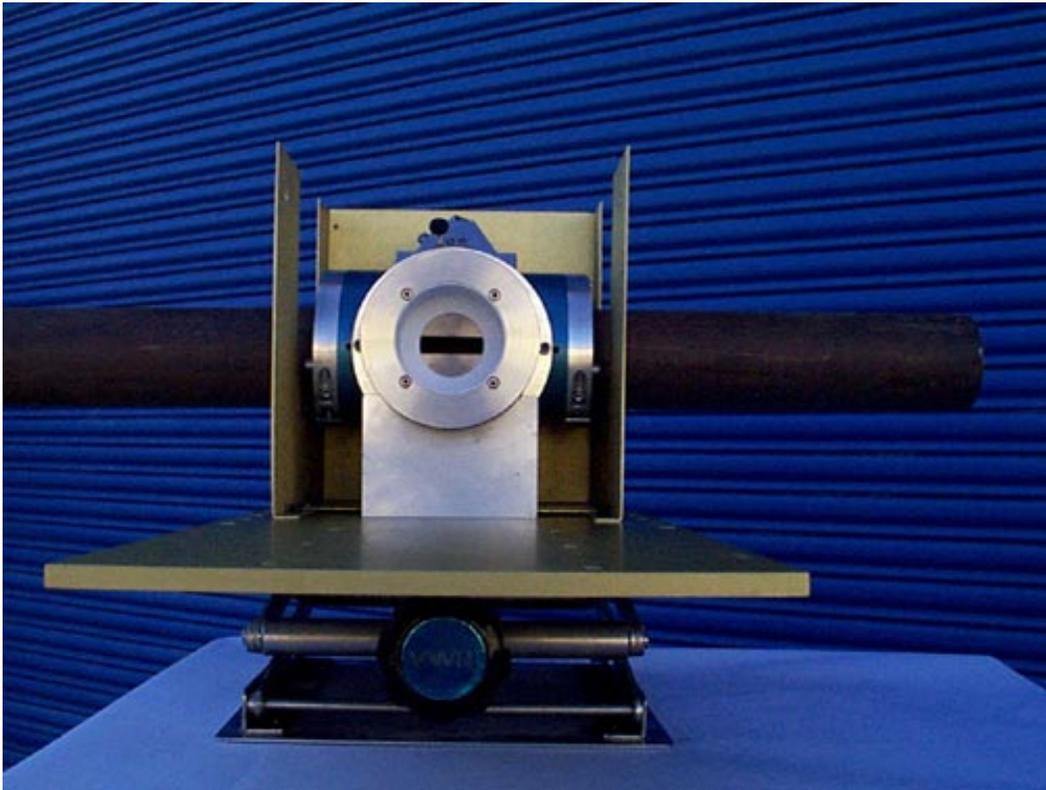


Figure 51. The detector collimator must be in the “parallel,” or horizontal, position. This is the only orientation of the detector collimator that will be needed initially. A direct deposit subtraction to the data is made, eliminating the need for the two-geometry technique. If the deposits change significantly during this verification exercise, then either the two-geometry technique will have to be used or the deposit will have to be remeasured.

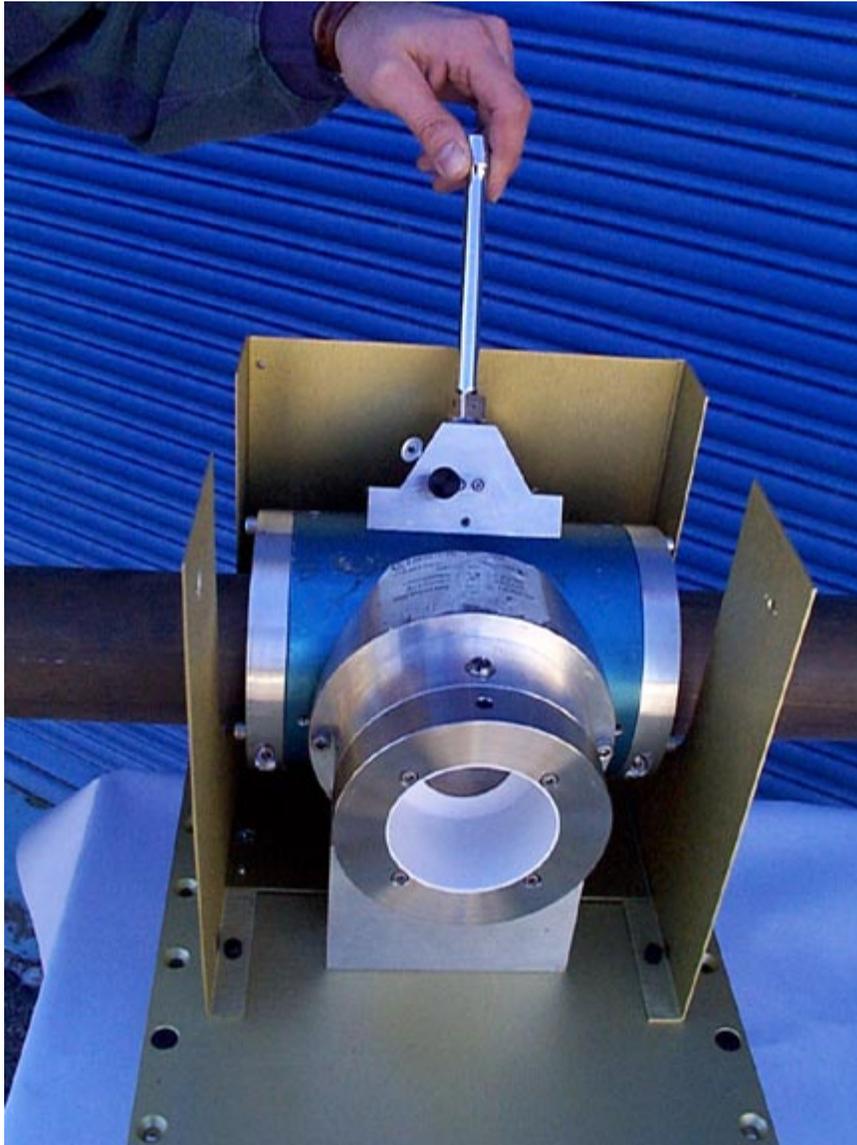


Figure 52. A “socket driver” is used to place the XRF source plug in the source housing. Tighten finger tight. Seal the XRF source plug using the eyelet on the source housing. This will keep the source plug from coming loose because of the vibrations of the header pipe.



Figure 53. The XRF source is located in the end of the threaded tungsten source plug, behind the aluminum retainer cap.

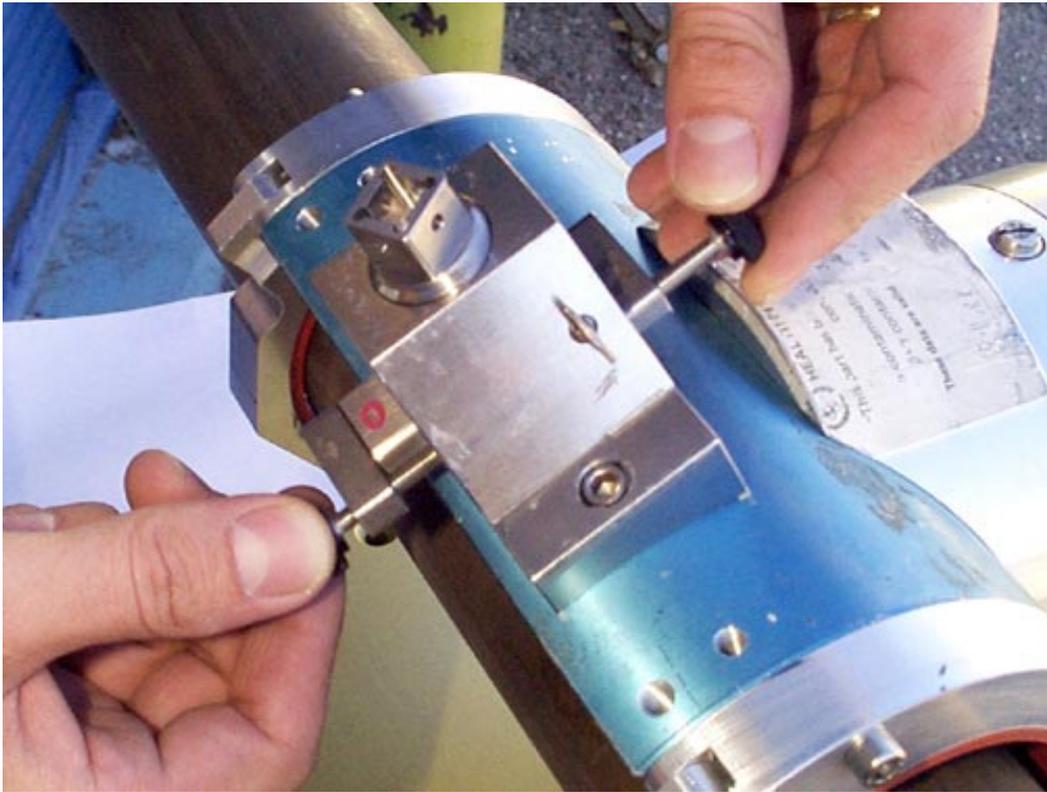
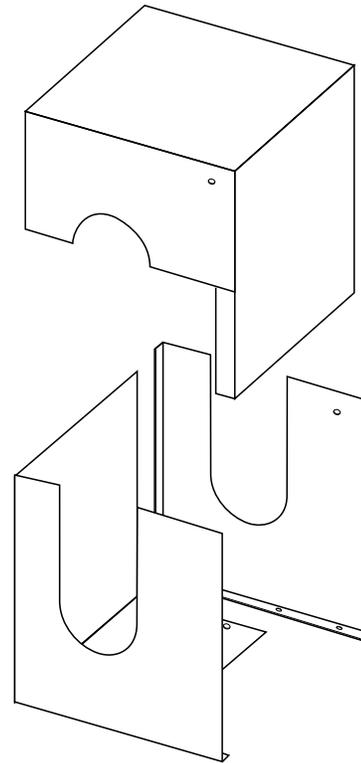


Figure 54. The source shutter is opened and closed using the two thumbscrews. When the “O” (open) is seen on the tungsten shutter bar, the XRF source is exposed to the instrument as required for the measurement. The source is in the “O” position when the shutter bar is pushed to the maximum extent possible away from the door to the cell housing. When the “X” (closed) marking on the other end of the tungsten shutter bar is visible, the XRF source is not exposed to the instrument. At the completion of the measurement, the XRF shutter should be closed.



(a)



(b)

Figure 55. (a) After all adjustments to the collimator are completed, the TIE is attached around the collimator. First, attach the single right half of the TIE to the support plate for the collimator. Second, attach the left half and the back of the TIE to the support plate for the collimator. The left half and the back of the TIE have been riveted together for ease of installation. Third, attach the top of the TIE (not shown in the figure). Seal the TIE as appropriate. The TIE must be removed during an SNRI to allow the detector to be positioned and to open and close the shutter.

(b) The three components of the TIE are shown schematically being assembled.

WARNING: The TIE will be very hot in the cell, and may cause burns. Use leather gloves to remove the TIE.



Figure 56. If the two-geometry technique is needed in the future, a special tool is supplied to ease rotating the detector collimator slit from the “parallel” position to the “perpendicular” position.

Figures 57-67 show the installation of the collimator for the 8-in. (20.32-cm) header pipe.



Figure 57. The 8-in. (20.32-cm) collimator and TIE are attached to a plate. Three threaded rods, used for height adjustment, attach this plate to a second plate that is subsequently attached to a frame (not shown in the figure) made of 80/20 aluminum extruded stock. This 80/20 frame sits directly on the floor beneath the header pipe.



Figure 58. The collimator for the 8-in. (20.32-cm) header pipe is placed in position around the header pipe. The clamps, one on each edge of the collimator, need to be opened for the collimator to initially fit over the pipe. The collimator is already attached to the “saddle” and the base plate.



Figure 59. Use an Allen wrench to initially tighten both clamps around the header pipe.



Figure 60. Use the three threaded rods underneath the support plate to raise, lower, and level the plate, as required. Securely tighten the locking nuts under the bottom plate to prevent them from becoming loose due to severe vibrations. Finish tightening the clamps around the header pipe. Fasten the base plate to the 80/20 aluminum frame. Attach the aluminum channel to the back of the collimator base plate. Insert the piece of lead for the back shield in the channel and tighten the two Allen screws, one on each side, to hold the lead in position. (The back shield is not shown in the figure.)



Figure 61. The detector collimator must be in the parallel, or horizontal, position. This is the only orientation of the detector collimator that will be needed initially. A direct deposit subtraction to the data is made, eliminating the need for the two-geometry technique. If the deposits change significantly during this verification exercise, then either the two-geometry technique will have to be used or the deposit will have to be remeasured.



Figure 62. A “socket driver” is used to place the XRF source plug in the source housing. Tighten finger tight. Seal the XRF source plug using the eyelet on the source housing. This will keep the source plug from coming loose because of vibrations of the header pipe.



Figure 63. The XRF source is located at the end of the threaded tungsten source plug, behind the aluminum retainer cap.

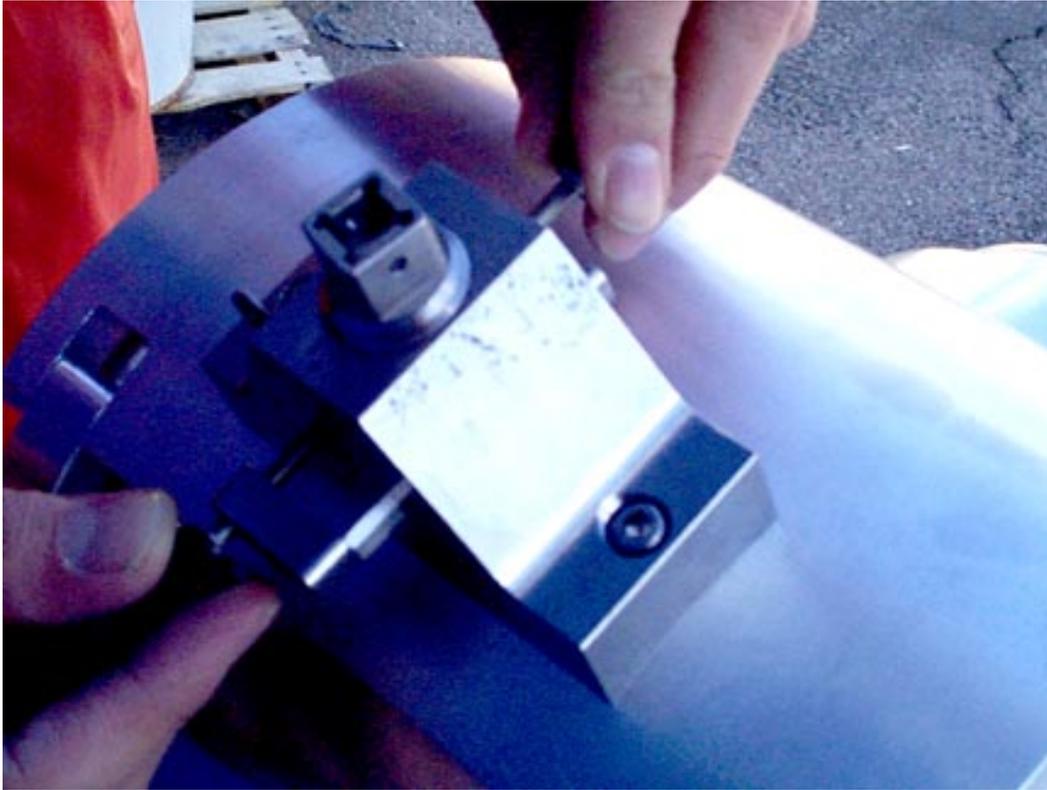
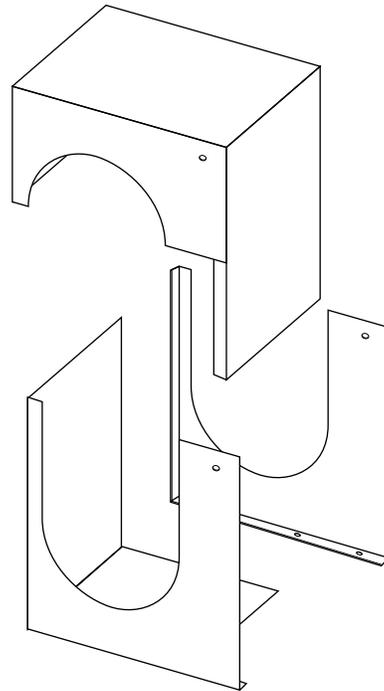


Figure 64. The source shutter is opened and closed using the two thumb screws. When the “O” (open) is seen on the tungsten shutter bar, the XRF source is exposed to the instrument as required for the measurement. The source is in the “O” position when the shutter bar is pushed to the maximum extent possible away from the door to the cell housing. When the “X” (closed) marking on the other end of the tungsten shutter bar is visible, the XRF source is not exposed to the instrument. At the completion of the measurement, the XRF shutter should be closed.



(a)



(b)

Figure 65. (a) After all adjustments to the collimator are completed, the TIE is attached around the collimator. First, attach the right half of the TIE to the support plate for the collimator. Second, attach the left half and the back of the TIE to the support plate for the collimator. The left half and the back of the TIE have been riveted together for ease of installation. Third, attach the top of the TIE. Seal the TIE as appropriate. The TIE must be removed during an SNRI to allow the detector to be positioned and to open and close the shutter.

(b) The three components of the TIE are shown schematically being assembled.

WARNING: The TIE will be very hot in the cell, and may cause burns. Use leather gloves to remove the TIE.



Figure 66. The TIE completely encloses the collimator.

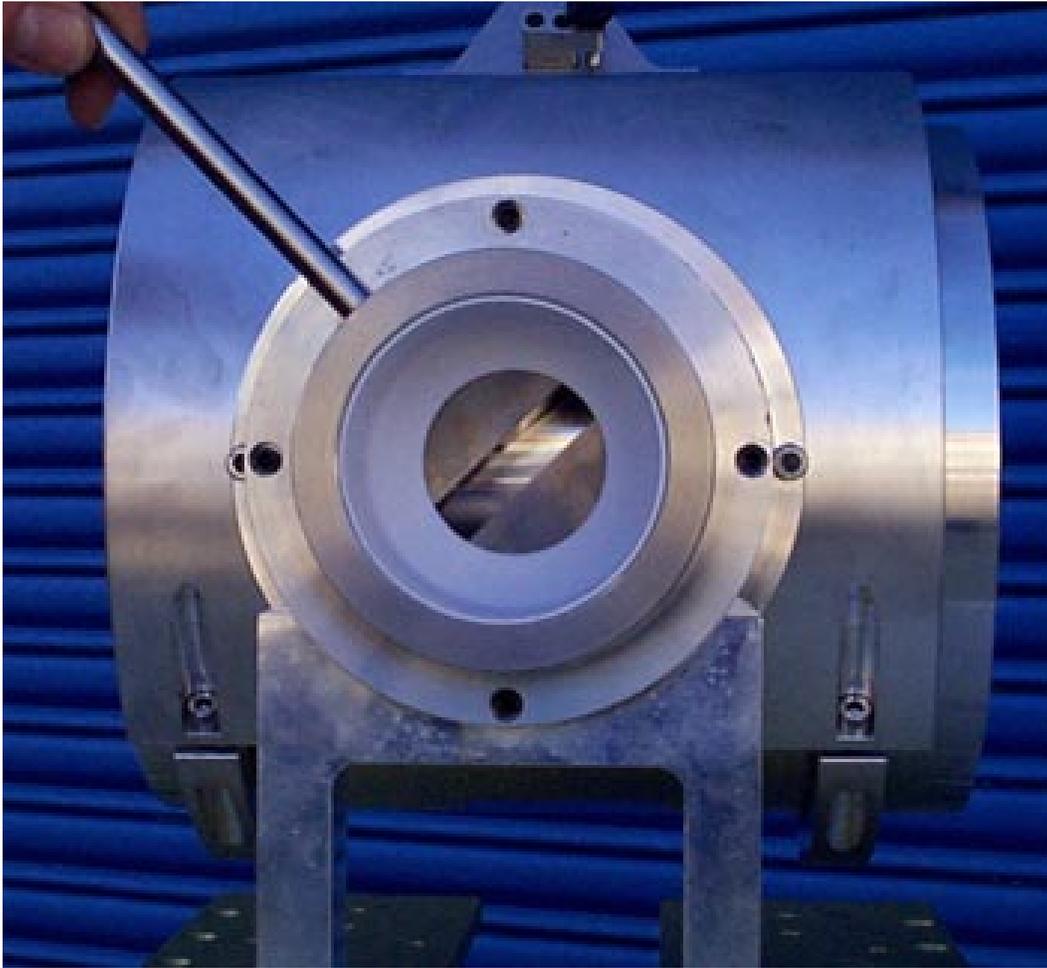


Figure 67. If the two-geometry technique is needed in the future, a special tool is supplied to ease rotating the detector collimator slit from the parallel position to the perpendicular position.

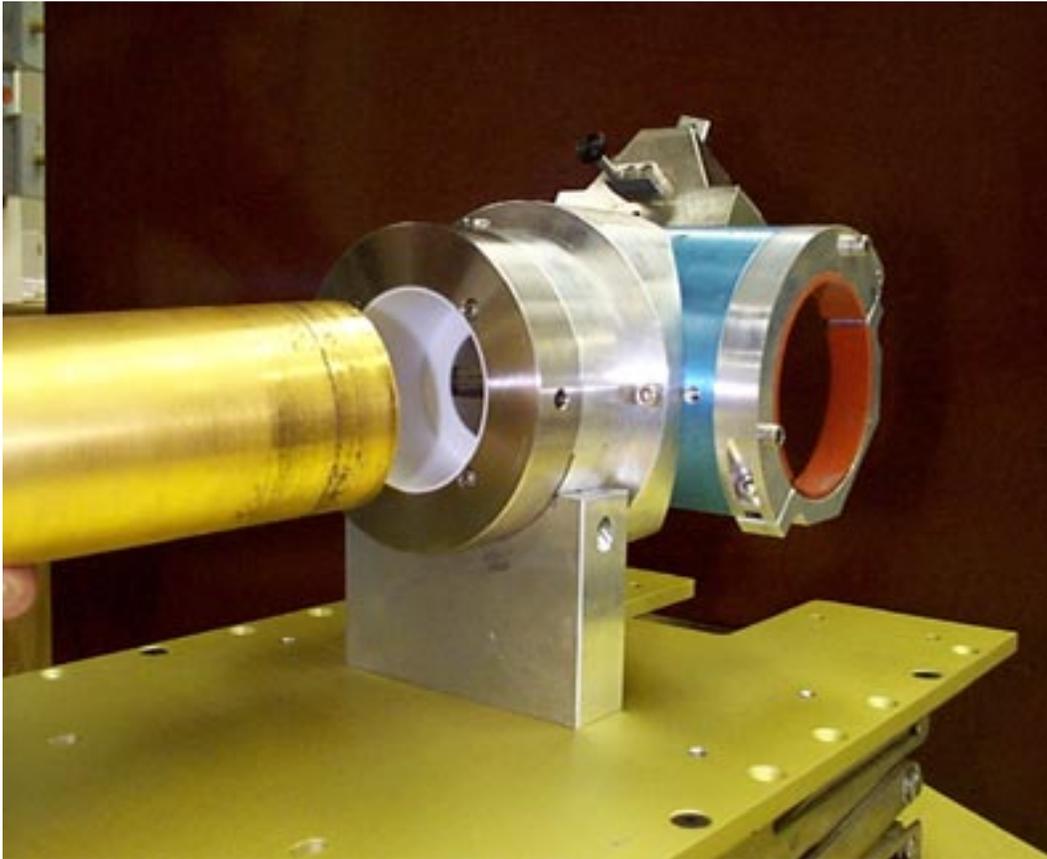


Figure 68. Carefully insert the detector into the Teflon sleeve in the detector collimator until the front face of the detector touches the end of the detector collimator.

WARNING: BE CAREFUL. The detector becomes very hot in the cell, and may cause burns, especially when in the 8-in. (20.32-cm) collimator. Use leather gloves kept in the electronics cabinet if necessary. Be careful not to drop the detector.

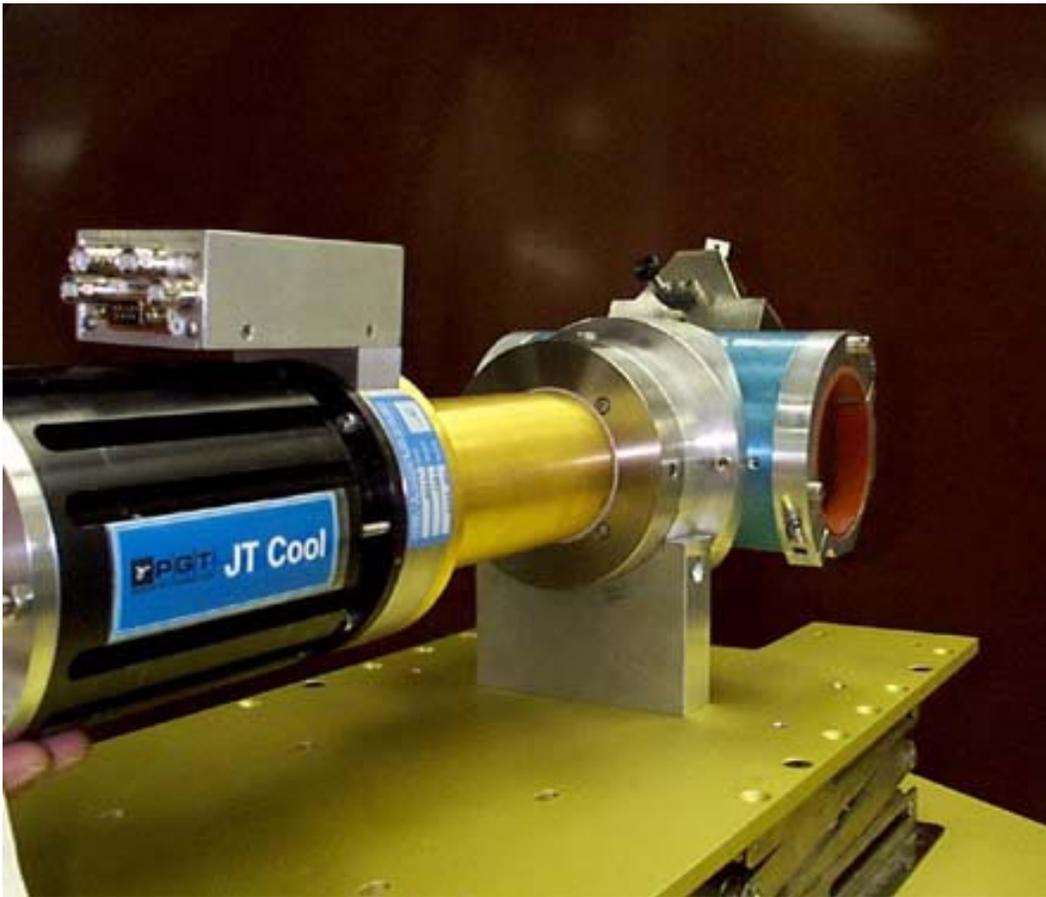


Figure 69. The detector is fully inserted into the detector collimator when the black line around the detector head is next to the detector collimator.

APPENDIX A

Enrichment Measurement and Enrichment Determination

The measurement to verify the enrichment of gaseous uranium in header pipes requires knowing both the total amount of uranium in the gas and the amount of only ^{235}U in the gas. An XRF measurement is made to determine the total amount of all uranium in the gas. A measurement of the 185.7-keV gamma ray from the decay of ^{235}U determines the amount of ^{235}U in the gas. The ^{235}U gamma ray at 185.7 keV is measured simultaneously with the XRF measurement. The ratio of these two quantities gives the enrichment of the gas.

A separate measurement of the deposits has been made. This background contribution to the 185.7-keV signal has been directly subtracted in the analysis. This approach is used instead of the two-geometry technique.

If the deposits increase significantly during the blending operation, then the deposits must be remeasured or the two-geometry technique must be implemented. The presence of a deposit on the surface of a header pipe may require two measurements of the ^{235}U gamma ray at 185.7 keV, under two different geometries, to determine the amount of ^{235}U only in the gas.

The enrichment of the $^{235}\text{UF}_6$ process gas in the header pipe is calculated using the expression

$$E = [(^{235}\text{U}-\text{C})/\text{XRF}] * K ,$$

where

- E = ^{235}U enrichment (in percent) of the process gas in the header pipe,
- ^{235}U = count rate (counts per second) of the 185.7-keV gamma ray from ^{235}U ,
- C = deposit correction count rate (counts per second) for the 185.7-keV gamma ray,
- XRF = count rate (counts per second per milliCurie) of the 98.4-keV uranium K x-ray induced by the fluorescence with the 122.1-keV gamma ray from ^{57}Co , and
- K = calibration constant.

The uncertainty in the enrichment is calculated using the expression

$$dE = \{E^2[(d\text{XRF}/\text{XRF})^2 + (dK/K)^2] + (K/\text{XRF})^2[(d^{235}\text{U})^2 + (dC)^2]\}^{1/2},$$

where

- E = ^{235}U enrichment (in percent) of the process gas in the header pipe,
- dE = uncertainty in the enrichment E,
- $d^{235}\text{U}$ = uncertainty in the ^{235}U count rate,
- dC = uncertainty in the deposit correction C count rate,
- XRF = count rate (counts per second per milliCurie) of the 98.4-keV uranium K x-ray induced by the fluorescence with the 122.1-keV gamma ray from ^{57}Co ,
- dXRF = uncertainty in the XRF count rate,
- K = calibration constant, and
- dK = uncertainty in the calibration constant K.

APPENDIX B

Operation of Electromechanically Cooled Germanium Detector

The electromechanically cooled, hyperpure germanium detector has a cooling time of 16 hours before it can be operated. The pressure on the compressor (meter on the back of the compressor) reads greater than 200 at room temperature when the compressor is off. (The compressor was pressurized to 240 psi on 24 January 1998.) The pressure on the operating compressor must read 0 at operating temperature. The resistance between pin 8 on the preamplifier connector and ground reads about 110 ohms at room temperature. The resistance between pin 8 on the preamplifier connector and ground reads about 45 ohms at operating temperature. Figure B-1 plots the resistance as a function of time during cooling of the detector. The pressure drops from about 200 to 0 in the first minute after the compressor is turned on.

Figures B-2 and B-3 plot the resistance and the pressure, respectively, as a function of time as the detector warms up to room temperature.

Do not tip the compressor. Do not disconnect the cooling coils from the detector or the compressor until the detector has been warmed to room temperature. The cooling medium is lost if the coils are disconnected before the detector is at room temperature.

The cooling coils are color coded: Red – “SUPPLY,” Green – “RETURN.”

The compressor can be off no more than 30 minutes without affecting the temperature of the detector. If the compressor is off for more than 30 minutes, the getter in the detector warms up enough to begin releasing absorbed gases, which condense on the still-cold germanium crystal. This condensation causes increased surface leakage currents and electrical noise that degrades the detector resolution. If the condensation is unusually severe, high-voltage breakdown can occur and permanently damage the crystal. To eliminate the condensation on the crystal, the detector must be warmed completely to room temperature, which takes about 24 hours, and then re-cooled, which takes 16 hours. The total time the detector cannot be used is 40 hours. The temperature can be monitored by measuring the resistance between Pin 8 on the preamplifier connector and ground and referring to the plots in Figures B-1 and B-2. See Appendix C which contains operating instructions from Princeton Gamma-Tech (PGT) for additional information about the detector.

In summary, IF THE COMPRESSOR IS OFF FOR MORE THAN 30 MINUTES, LEAVE IT OFF FOR 24 HOURS BEFORE TURNING IT BACK ON.

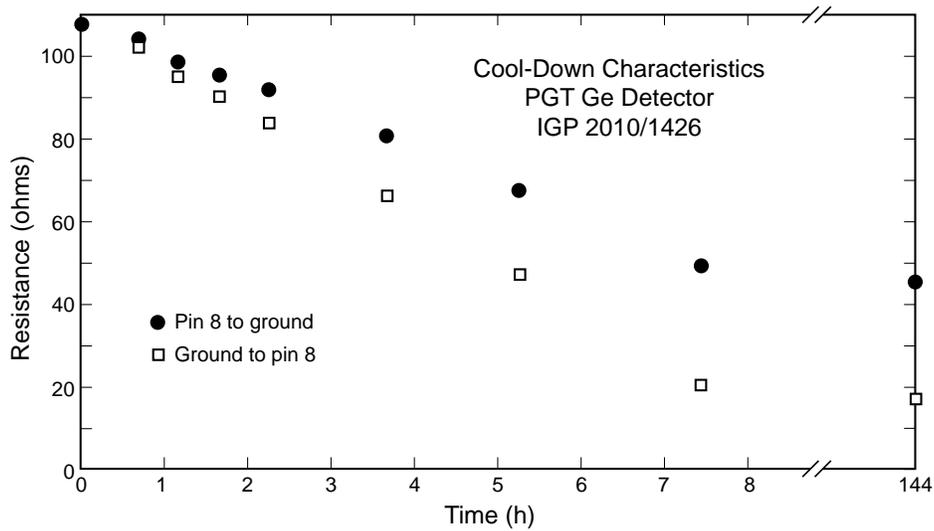


Figure B-1. Cool-down characteristics of the PGT electromechanically cooled germanium detector. Resistance between pin 8 on the preamplifier connector and ground is plotted. Two sets of data are shown because the sensor is polarized below room temperature.

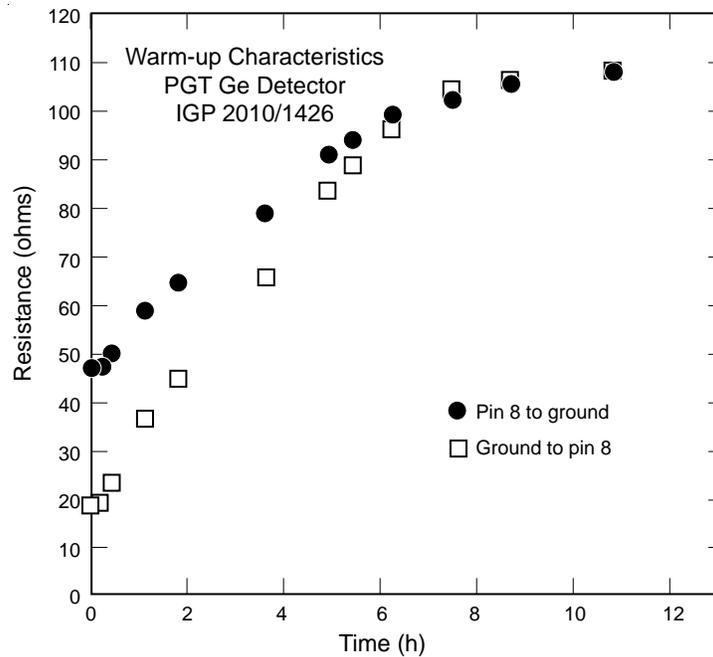


Figure B-2. Warm-up characteristics of the PGT electromechanically cooled germanium detector. See the caption for Figure B-1.

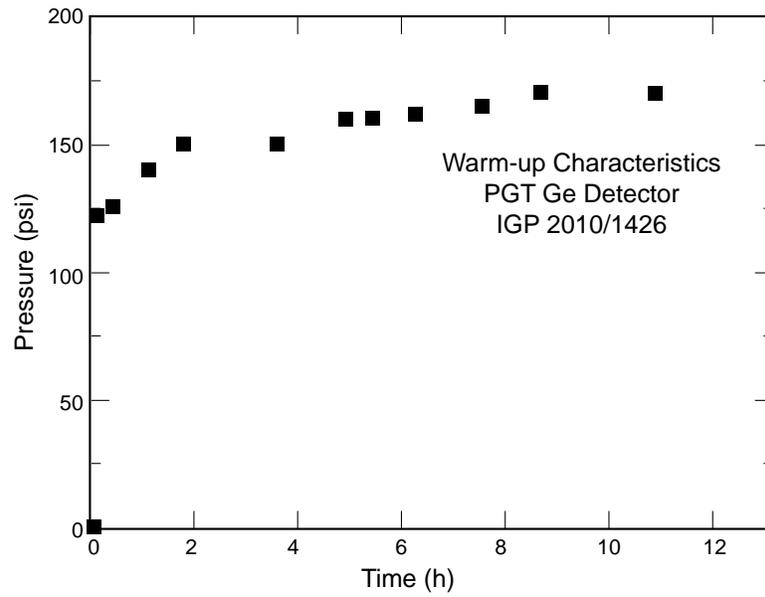


Figure B-3. Warm-up pressure characteristics of the PGT electromechanically cooled germanium detector. These data were measured when the maximum pressure in the compressor was less than 200 psi, before it was refilled to 240 psi on 24 January 1998.

APPENDIX C
Detector Specifications and Operating Instructions
for the PGT Electromechanically Cooled Germanium Detector

PGT
PRINCETON GAMMA-TECH

DETECTOR SPECIFICATIONS

	<u>MODEL NUMBER</u>	<u>SERIAL NUMBER</u>
DETECTOR	<u>IGP 2010</u>	<u>1426</u>
PREAMPLIFIER	<u>EG11B/C</u>	<u>2289</u>
CRYOSTAT TYPE	<u>JTC-SD/s</u>	<u>T01092</u>
DETECTOR GEOMETRY	<u>P TYPE PLANAR</u>	
	<u>AREA</u>	<u>THICKNESS</u>
DETECTOR ACTIVE VOLUME	<u>2000</u> mm ²	<u>10</u> mm
DETECTOR / WINDOW DIST.	<u>3.5</u> mm	
RESISTANCE AT OPERATING TEMPERATURE	<u>33.8</u> ohms	
COOLING PERIOD BEFORE OPERATION	<u>16.0</u> hours	
MINIMUM WARM-UP PERIOD BEFORE RECOOLING	<u>24</u> hours	
DETECTOR BIAS	<u>- 1200</u> V	
BIAS POLARITY	<u>NEGATIVE</u>	
RAISE DETECTOR BIAS AT RATE NO FASTER THAN 100 VOLTS PER SECOND.		
PREAMPLIFIER OUTPUT POLARITY	<u>POSITIVE</u>	
FEEDBACK VOLTAGE AT OPERATING BIAS	<u>+ 0.07</u> volts	
PERFORMANCE:		
MEASURED SYSTEM RESOLUTION AT 122KeV	<u>691</u> eV	
TEST EQUIPMENT:		
	AMPLIFIER	<u>PGT 347</u>
	BIAS SUPPLY	<u>PGT 314</u>
	PULSE HEIGHT ANALYZER	<u>APTEC MCard</u>
TEST CONDITIONS:		
	COUNT RATE	<u>570</u> cps
	AMPLIFIER TIME CONSTANT	<u>4</u> us
	RESTORER	<u>LOW /SYM</u>
DATA FILE #	<u>90-256</u>	
REPORT #	<u>27-256</u>	
TESTED BY :	<u><i>Shw...</i></u>	DATE : <u>DEC-05-97</u>

PRINCETON GAMMA-TECH, INC. C/O 863 PRINCETON, NJ 08542-0863
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WARNINGS

FAILURE TO OPERATE THIS EQUIPMENT IN THE MANNER SPECIFIED IN THIS MANUAL MAY CREATE A HAZARDOUS CONDITION RESULTING IN DAMAGE TO EQUIPMENT AND/OR INJURY TO THE OPERATORS.

THE REFRIGERANT IS FLAMMABLE. REFER TO MSDS PRODUCT NAME PT-13, PT-14, PT-16, OR PT-30.

USE CAUTION WHEN CONNECTING AND DISCONNECTING THE GAS LINES SO THAT GAS DOES NOT ESCAPE. WORK IN A VENTILATED AREA THAT HAS NO IGNITION SOURCES NEAR-BY.

LIQUID, FLAMMABLE REFRIGERANT COLLECTS IN THE CRYOCOOLER DURING OPERATION. THE GAS LINES OR OTHER COMPONENTS MUST NEVER BE DISCONNECTED UNTIL THE CRYOCOOLER HAS BEEN WARMED TO 10° TO 30°C (50° TO 86°F). AN OVER-PRESSURE CONDITION WILL OCCUR IF THE LIQUID IS CONFINED. COLD GAS OR LIQUID TRAPPED IN THE CRYOCOOLER CAN REACH HIGH PRESSURES AS IT WARMS AND VENT FLAMMABLE GAS THROUGH THE PRESSURE RELIEF VALVE LOCATED ON THE CRYOCOOLER.

ALL ELECTRICAL SUPPLY EQUIPMENT MUST MEET APPLICABLE CODES AND BE INSTALLED BY QUALIFIED PERSONNEL.

USE TWO WRENCHES WHEN CONNECTING OR DISCONNECTING A GAS LINE COUPLING TO AVOID LOOSENING THE BULKHEAD COUPLING. GAS PRESSURE CAN PROJECT THE COUPLING WITH ENOUGH FORCE TO CAUSE INJURIES.

WHEN HANDLING PRESSURIZED GAS LINES AND OTHER PRESSURIZED EQUIPMENT, ALWAYS WEAR EYE PROTECTION.

NEVER APPLY HEAT TO A PRESSURIZED GAS LINE OR OTHER PRESSURIZED COMPONENTS.

EXTREME COLD CAN CAUSE FROSTBITE. WHEN HANDLING SYSTEM COMPONENTS, BE CAREFUL NOT TO TOUCH ANY FROSTED PARTS.

DISCONNECT THE POWER TO THE COMPRESSOR BEFORE TROUBLESHOOTING THE ELECTRICAL COMPONENTS.

DURING OPERATION, SOME SURFACES UNDER THE COMPRESSOR'S COVER BECOME HOT. AVOID INJURY FROM BURNS BY ALLOWING THE COMPRESSOR TO COOL FOR 1/2 HOUR AFTER SHUTDOWN BEFORE REMOVING THE COVER FOR MAINTENANCE.

PERMIT ONLY QUALIFIED ELECTRICAL TECHNICIANS TO OPEN ELECTRICAL ENCLOSURES, TO PERFORM ELECTRICAL CHECKS OR TO PERFORM TESTS WITH THE POWER SUPPLY CONNECTED AND WIRING EXPOSED. FAILURE TO OBSERVE THIS WARNING CAN RESULT IN INJURY OR DEATH FROM ELECTRIC SHOCK.

CHARGE AND PURGE THE COMPRESSOR WITH NITROGEN TO REMOVE ANY RESIDUAL, FLAMMABLE REFRIGERANT PRIOR TO UNBRAZING. OIL WHICH IS FLAMMABLE MAY ALSO BE PRESENT IN THE GAS LINES. USE CAUTION WHILE UNBRAZING TUBES.

TOUCHING A FULLY-CHARGED CAPACITOR CAN CAUSE SEVERE ELECTRICAL SHOCK RESULTING IN INJURY OR DEATH.

FOR CRYOTIGER® SYSTEMS ONLY:

CUSTOMER MUST PROVIDE A PRESSURE RELIEF VALVE ON THE VACUUM VESSEL TO PREVENT AN OVER-PRESSURE CONDITION IF A LEAK OF HIGH-PRESSURE REFRIGERANT OCCURS WITHIN THE VACUUM VESSEL. IF THE CRYOCOOLER IS ALLOWED TO WARM ABOVE OPERATING TEMPERATURE, THE ACTIVE PUMPING MATERIAL IN THE SYSTEM WILL RELEASE GAS TO INCREASE THE PRESSURE IN THE VACUUM VESSEL.

CAUTIONS

DE-PRESSURIZATION AND/OR EXPOSURE TO AMBIENT CONDITIONS OF THE INTERNAL GAS CIRCUITS MAY RESULT IN CONTAMINATION AND DAMAGE TO EQUIPMENT. THIS TYPE OF MAINTENANCE SHOULD BE PERFORMED ONLY BY APD CRYOGENICS SERVICE PERSONNEL. MAINTENANCE OF THIS TYPE PERFORMED BY UNAUTHORIZED PERSONS WILL VOID THE WARRANTY.

DO NOT TIP THE COMPRESSOR GREATER THAN 30 DEGREES TO AVOID FLOWING OIL INTO UNWANTED PLACES AND CAUSING A NUISANCE SHUTDOWN, SYSTEM CONTAMINATION, OR MOTOR FAILURE. IF THE COMPRESSOR IS TIPPED BEYOND 30 DEGREES, ALLOW IT TO STAND UPRIGHT FOR AT LEAST FOUR (4) HOURS BEFORE RUNNING TO ALLOW ANY DISPLACED OIL TO RETURN TO THE COMPRESSOR MOTOR.

THE CRYOCOOLER CAN BE DAMAGED DURING INSTALLATION AND REMOVAL IF THESE OPERATIONS ARE NOT DONE BY TRAINED PERSONNEL.

DO NOT CRIMP THE GAS LINES. REPEATED ATTEMPTS TO BEND AND REPOSITION THE GAS LINES CAN DAMAGE THEM.

KEEP THE GAS LINE COUPLINGS ALIGNED WHEN MAKING OR BREAKING A COUPLING CONNECTION. LEAKAGE CAN OCCUR DUE TO THE WEIGHT OF THE GAS LINE OR DUE TO A SHARP BEND NEAR THE CONNECTION.

DO NOT OPERATE THE SYSTEM WITH THE AMBIENT TEMPERATURE OUT OF SPECIFICATION. EQUIPMENT DAMAGE CAN RESULT.

CHECK THE CONDITION OF THE GASKET SEAL ON THE MALE HALF OF EACH GAS COUPLING. BE SURE THE GASKET SEAL IS IN PLACE AND THE SEALING SURFACES ON BOTH THE MALE AND FEMALE HALVES ARE CLEAN BEFORE CONNECTING. REPLACE THE GASKET SEAL IF IT IS DAMAGED OR MISSING.

MODIFICATION TO EQUIPMENT WITHOUT THE CONSENT OF THE MANUFACTURER WILL VOID THE WARRANTY.

FOR CRYOTIGER® SYSTEMS ONLY:

IF THE CRYOCOOLER IS RETURNED TO APD FOR SERVICE, THE SHIPPING COVER MUST BE SECURED TO THE COLD TIP AND THE WARM FLANGE TO PREVENT DAMAGE. FAILURE TO PROTECT THE CRYOCOOLER WILL VOID THE WARRANTY.

FOR AquaTrap™ SYSTEMS ONLY:

IF THE CRYOCOOLER IS RETURNED TO APD FOR SERVICE, THE SHIPPING COVER PLATE MUST BE SECURED TO THE FLANGE TO PREVENT DAMAGE. FAILURE TO PROTECT THE CRYOCOOLER WILL VOID THE WARRANTY.

APPENDIX D
⁵⁷Co Source Certificates

Source number MM-210 is in the collimator on the 3-inch header pipe.

NOMINAL SOURCE DATA SHEET

Customer: U.C. LOS ALAMOS NATIONAL LAB **Date:** 4 Feb 98

P.O. Number: G3824TEL8-9M

Catalog No.: PHI-057 **Quantity:** 1

Capsule Type: IPL type 3204

Nature of Active Deposit: Cobalt chloride on ceramic matrix

Active Diameter/Weight: 0.210"

Backing: Stainless Steel

Cover: 0.010" Beryllium

Nuclide	Source No.	Activity	Ref. Date	Leak Test
Co-57	MM-210	40 mCi	1 Feb 98	See reverse

Leak Test Information is on the reverse side.

Impurities: Co-56 = 0.0779%; Co-58 = 0.00947% as of 26 Jan 98.

Remarks: None

Lab Book-Page: 569-67

05 Feb 98 
Date, Signature



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1800 N. KEYSTONE STREET
BURBANK, CALIFORNIA 91504
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Source number LL-148 is in the collimator on the 8-inch header pipe.

NOMINAL SOURCE DATA SHEET

Customer: UC-Los Alamos National Lab

Date: 12 Aug 97

P.O. Number: F6849SML 7-9E

Catalog No.: PHI-057-40M

Quantity: 1

Capsule Type: A3204-03

Nature of Active Deposit: Cobalt chloride in ceramic matrix

Active Diameter/Weight: 0.210"

Backing: Stainless steel

Cover: 0.010" Beryllium

Nuclide	Source No.	Activity	Ref. Date	Leak Test
Co-57	LL-148	40 mCi	1 Aug 97	see reverse

Leak Test Information is on the reverse side.

Impurities: Co-56 = 0.12% & Co-58 = 0.025% as of 7 May 97.

Remarks: None

Lab Book-Page: 562-074

12 Aug 97, Stephen Toupin
Date, Signature



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