Automated Laboratory Quality Assurance Program: Using the ORTEC GammaVision®-32 Software

1. Introduction

Quality Assurance (QA) measurements are made by analysis laboratories to demonstrate that the equipment used in analysis is operating properly and that the analysis results are correct. These QA measurements are performed often, perhaps daily. The automation of the measurements and processing gives better results at lower cost. For the high-purity germanium (HPGe) spectroscopy systems, the QA tests ensure that the system is operating within specifications from day to day. The QA routines include the counting of a known radioactive source in a predetermined geometry for a specific count time. This seemingly simple measurement tests every aspect of the system used in the analysis of unknowns. After data collection, analysis is made to determine that critical parameters such as peak position, resolution, and efficiency are within acceptable limits. The results of these measurements are recorded and plotted against time. The acceptable ranges are clearly marked to show if the measurement value is nearing a limit.

The QA measurement is ***not*** a substitution for calibration. Energy and efficiency calibrations should be done on all systems periodically. A good calibration is time consuming especially for a system that has multiple geometries and therefore multiple calibrations. The QA measurements are simpler and quicker. A QA sample can show with a single measurement that the physical characteristics of the measurement system, including the HPGe detector and electronics, have not changed significantly. The QA results will show trends or slow changes in the system. These trends are hidden by the recalibration; thus no warning is given of a periodic failure. The use of the QA samples in the counting laboratories has become standard in part due to the fact that it is a relatively quick manner for verifying the system performance between routine re-calibrations. The use of QA measurements as such a means is accepted by many regulatory agencies and even specified in some standards such as **ANSI-N13.30:** *Performance Criteria for RadioBioAssay*, **ANSI N323:** *Radiation Protection Instrumentation Test and Calibration*, and **ANSI N42.23:** *Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories.*

ORTEC has produced an automated QA process to aid the production counting laboratory in making these measurements with little or no user interaction. The benefits in having such an automated system are as follows:

- Consistent data acquisition parameters
- Reduce the number of steps required by an operator
- Reduce the possibility of data entry errors
- Simplify the data calculation and storage process
- Provide a consistent data analysis and plotting function

2. GammaVision® Quality Assurance Program

GammaVision is ORTEC's comprehensive data acquisition and analysis package for gamma spectroscopy using HPGe detectors. The QA process built into the GammaVision software package uses the graphical user interface of Microsoft® Windows™ for Setup, Analysis, and Plotting of QA measurements.

The first step in the QA process is to select the parameters to be measured and to define a set of ranges for the measurement. Then, the operator of the HPGe system places the source in the predefined geometry, starts the "QA Measure Sample" process and waits for the acquisition to complete. The QA program in GammaVision automatically collects the data, runs the analysis engine, compiles the results, stores the results to a database, and compares the results to the parameter ranges. If a point is outside of a specified range, the operator is warned at the end of the QA process, and again before any measurement is made, that the QA procedure failed. The background (no source sample) can also be monitored in a similar process.

By following a few simple setup steps, the day-to-day QA measurements in a production laboratory can be automated to require only a few button clicks at an operator's workstation. This Application Note describes three procedures: (1) setup of the QA acceptable ranges for parameters, (2) setup of an automated procedure in the form of a JOB file, and (3) operation of the automated procedure through a variety of means.

3. Setup of the QA Process in GammaVision[1]

Before routine QA measurements are made, it is necessary to setup the measurement parameters and data quality ranges. This section describes a step-by-step recommended procedure for determining these parameters.

QA Source

For HPGe detector systems, almost any traceable radioactive source can be used for the routine QA measurement. The QA measurement only requires that the same source be used; therefore, any convenient geometry such as a point source or mock filter paper will suffice. It is recommended to use a source with only a few isotopes with relatively long half-lives. The reason for choosing long-lived isotopes is that the decay of short-lived isotopes over time will necessitate the purchase of new sources which will invariably not have the same activity. This will require redefinition of one of the parameters in the QA measurement – Total Activity, which measures the efficiency of the detector relative to a known source. A set of isotopes should be chosen such that the energies of the isotopes span as much of the counting region as possible from low to high energy (e.g. 100 keV to 2000 keV). A common mix of isotopes for this purpose is Co-57, Cs-137, and Co-60. If a source is available which contains these isotopes, and additional isotopes such as Y-88 or Cd-109, then this source can be used simply by omitting the shorter-lived isotopes from the analysis library. The total activity of any source should be less than what is necessary to avoid unnecessary dead time in the counting electronics. For the remainder of this Application Note, it is assumed that a source containing Co-57, Cs-137, and Co-60 is used.

[1] Before setting up any of the parameters or making the automated QA measurements in GammaVision, follow the instructions in the manual for first defining the database for storing the results. Until the database is defined no measurements can be made. The step-by-step procedure for doing this is described in the GammaVision manual, which is delivered with the software.

In summary, when choosing a source for the QA measurement, the following characteristics are ideal:

1. Point source or mock filter paper geometry
2. Mix of several, long-lived isotopes such as Co-57, Cs-137, and Co-60
3. Span of energy range in the isotopes to encompass as much of the usable spectrum
4. Relatively low total source activity

Determining the Counting and Analysis Parameters

The following steps should be completed to setup the counting and analysis parameters for the “QA Sample” measurement:

1. Place the selected source in front of the detector at a reproducible geometry (such as in the center of the end cap). Record the position by making a sketch or by using a jig.

2. Set the preset "Live" count time to a value such as 300 seconds as shown in Fig. 1. The value should be chosen such that the count time is sufficient enough to give good counting statistics (e.g., < 2%) for all peaks of interest in the source. *Note: If an ORTEC MCB with the Uncertainty or Integral ROI Area presets is available, it is recommended to select an ROI around the 1332 keV peak from Co-60 and enter "2.00" for uncertainty percent or "10,000" for ROI integral counts as shown in Figures 1 and 2.*

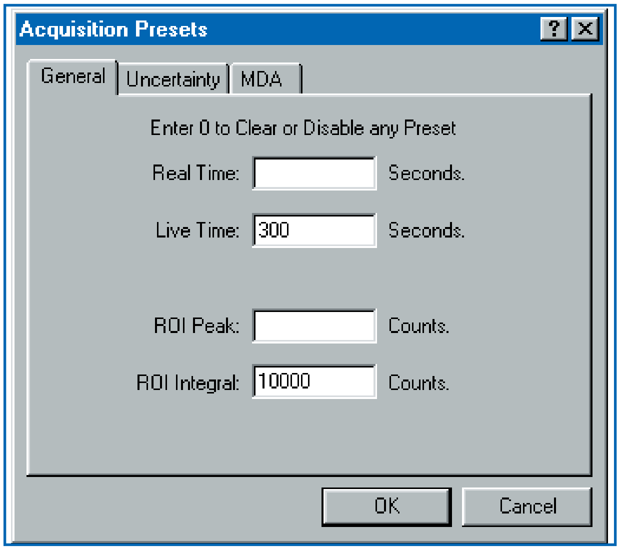

Figure 1. Counting Time and Region of Interest Preset.

3. Set up a library for the QA measurement with only the Co-57, Cs-137, and Co-60 isotopes in it. Note that even if the source has more than these three isotopes, such as the Mixed Gamma Standard with Cd-109, Y-88, and others, the QA measurement and analysis can be restricted to just these particular nuclides by only having them in the library. Save the library as "C:\User\QA.LIB".

4. Start the acquisition by clicking on the "Go" button in the Toolbar or by selecting "Acquire|Start" from the menu.

5. When the acquisition has stopped, analyze the QA sample using a known good energy, FWHM, and efficiency calibration. It is not necessary to use a calibration file which exactly matches the QA sample’s geometry. The QA measurement is a relative one made against a known good calibration. The settings for the analysis should be established so that the library file is selected to be "C:\User\QA.LIB" and the calibration is either internal or selects an appropriate filename. Ensure that the counting statistics for all nuclides show that the 1-sigma uncertainty is less than 2%. If the counting uncertainty is greater than 2%, increase the count time for the acquisition and repeat steps 4 and 5.

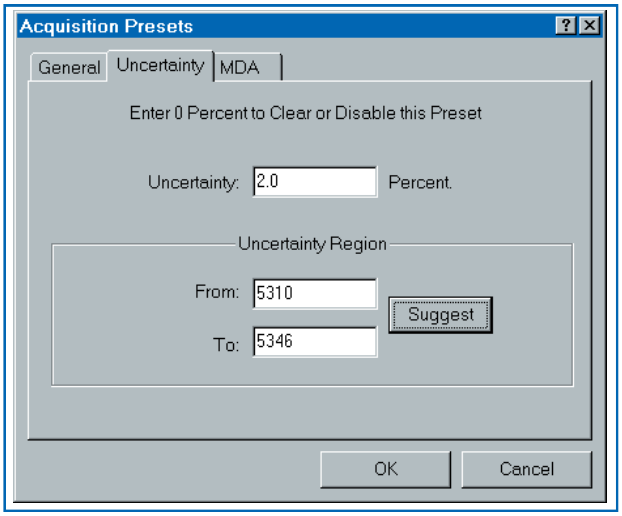

Figure 2. Uncertainty Preset.

6. With a printout of the activity in hand, repeat steps 4 and 5 nine (9) more times. The purpose of doing this measurement multiple times is to give a good statistical average of the activity measured in the QA sample using this calibration file.

7. The QA measurement parameter for efficiency is the sum of all nuclides in the library file (in this case Co-57, Cs-137, and Co-60). For each printout, sum the activity for these three nuclides.

8. Next calculate the average and the standard deviation of the sum of these activities from Step 7. (Do not forget to take into account the uncertainty of this activity.) This average value will be used as the value for the "Total Activity" in the QA measurement parameters. (Table 1 shows an example.)

In this example, we are using the values of $\pm 2\sigma$ (2 x the standard deviation) for the Alarm levels (high and low) and $\pm 1\sigma$ for the Warning levels (high and low). These values will be entered into the parameters dialog box in the following sections.

Table 1. Example Calculation for QA

	Co-57		Cs-137		Co-60			
Count	Activity (Bq)	Error[1] (%)	Activity (Bq)	Error (%)	Activity (Bq)	Error (%)	Sum (Bq)	Error[2] (%)
1	1216	2.96%	1928	2.12%	3101	1.89%	6246	4.10%
2	1042	2.64%	1952	2.10%	3134	1.70%	6128	3.78%
3	1236	3.38%	1900	2.42%	3119	1.96%	6255	4.59%
4	1223	3.04%	1963	2.06%	3162	1.67%	6348	4.03%
5	1238	3.27%	1718	2.00%	3132	1.66%	6088	4.17%
6	1214	3.11%	1719	2.02%	3078	1.91%	6012	4.17%
7	1225	3.02%	1928	2.66%	3110	1.89%	6264	4.45%
8	1234	3.25%	1870	2.90%	3116	2.10%	6220	4.83%
9	1214	3.30%	1952	2.26%	3164	1.65%	6330	4.33%
10	1196	3.15%	1933	2.35%	3142	1.66%	6271	4.27%
Average	**1204**	**3.11%**	**1886**	**2.29%**	**3126**	**1.81%**	**6216**	**4.27%[3]**
Std Dev.	**58.24**		**92.59**		**26.53**		**265.6[4]**	
						–2σ:	***5685***	***Alarm Lo***
						–1σ:	***5951***	***Warning Lo***
						+1σ:	***6482***	***Warning Hi***
						+2σ:	***6747***	***Alarm Hi***

[1]Error on individual counts is the total uncertainty in percent from the GammaVision report files.

[2]Percent error of the sum is the square root of the sum of the squares of the errors given by:

$$\mathit{Error} = \sqrt{\sigma^2_{Co\text{-}57} + \sigma^2_{Cs\text{-}137} + \sigma^2_{Co\text{-}60}}$$

[3]Average of the percent errors given by:

$$\mathit{Average\ Error} = \frac{\sum_{i=1}^{10} \sigma_{i\ Total}}{10} = 4.27\%$$

[4]Average standard deviation given by: *Average Std Dev. = Average Error x Average Sum* = 4.27% X 6216

Saving an SDF File for the QA Measurement

With the analysis settings dialog box open ("Analyze|Settings|Sample Type"), ensure that all settings are as they were in Step 5 above. On the "Decay to" correction tab, enter today's date and time. Since we have calculated the activity of the sample as determined by our analysis settings, the known activity is as of this date forward (rather than from the certificate sheet). Click on the "Presets" button in the "Sample" tab and enter the settings used in Step 2 above. Save the Settings as "C:\User\QA\QA SOP".

Setting the QA Measurement Parameters

Open the QA Measurement Parameters dialog box by clicking "Acquire|QA|Settings". The dialog box in Figure 3 will appear. In the "Sample Settings" box, click the "Browse" button. Choose the file "C:\User\QA\QA SDF" and click the OK button. If you wish to lock the detector on failure, check the box to the left of the statement "Lock on violation". Make sure the box next to "Do not clear on start" is not checked. Then check the box next to "Store peak information in database".

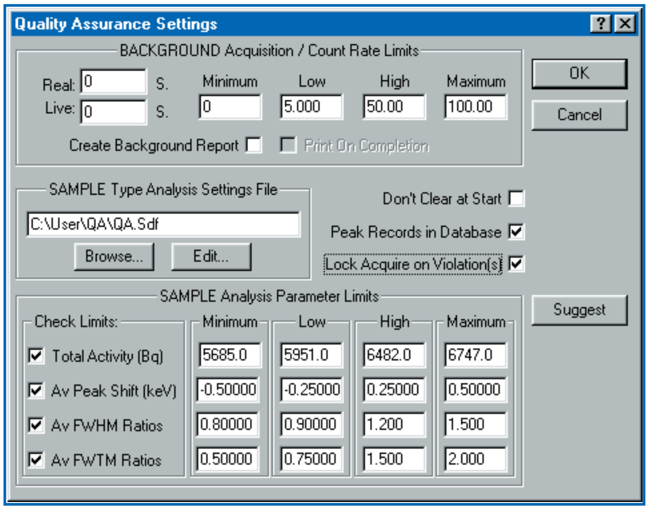

Figure 3. QA Settings Dialog Box.

Next, for the settings of the different parameters first click the "Suggest" button. This will fill in the factory defaults for the Peak Centroid, Peak FWHM Ratio, and FWTM Ratios. These values are sufficient for good quality assurance measurement in the HPGe detector system. Check the box next to each of these values on the left side of the dialog box.

With the activity values determined previously, fill in the Alarm and Warning levels in Bq for the QA measurements. Figure 3 shows the completed QA dialog box for the data collected in this example. After completing this, click the box next to the Total Activity, in the Check Limit box, to enable this parameter check.

Once a QA measurement is made, the values of the current spectrum analysis will be checked against these values. All values will be automatically exported to the Microsoft Access® database upon completion of the analysis. If a warning or alarm level exists, the operator will be notified at the end of the measurement as well as before every acquisition until the QA parameters are met.

4. Setup of an Automated QA Procedure

GammaVision uses JOB files for automating various functions within the operating environment. JOB files are created by entering commands via the GammaVision text editor or others such as Microsoft Notepad and then saving those files to the disk. For a complete list of JOB commands and functions, see the GammaVision Operator's Manual.

To create a JOB file, do the following:

1. Open Notepad by selecting: Start|Programs|Accessories|Notepad in Windows
2. Select "File|Save As"

3. In the Save As dialog box, change the file type to "All Files (*.*)"

4. Change the directory to "C:\User"

5. In the Filename box, type "QA.JOB"

Type the following commands in order in the QA.JOB file

```
SET_DETECTOR 1
RECALL_SETTINGS "C:\USER\QA.SDF"
QA_SAMPLE
WAIT_QA
```

Quit Notepad by selecting "File|Exit". When prompted to save the changes, click "Yes". The "Set_Detector" command sets the detector number being used in these QA measurements. The detector in this example is the detector whose ID has been set to No. 1, thus the detector is set to Number 1. If the detector ID is 12, then this command would be:

```
SET_DETECTOR 12
```

5. Running the QA Program

There are several ways to have GammaVision perform the QA measurements. Each of the options works equally as well as the others.

Running the QA from the GammaVision Menu Item

The GammaVision QA program can be started by simply selecting: Acquire|QA|Measure Sample. After an operator does this, a dialog box like the one shown in Figure 4 will appear. Note that the sample description in QA.SDF appears in this dialog box. Once the source is in place, click the OK button. The QA program will lock the detector from interference by other functions and run the data collection and analysis to completion.

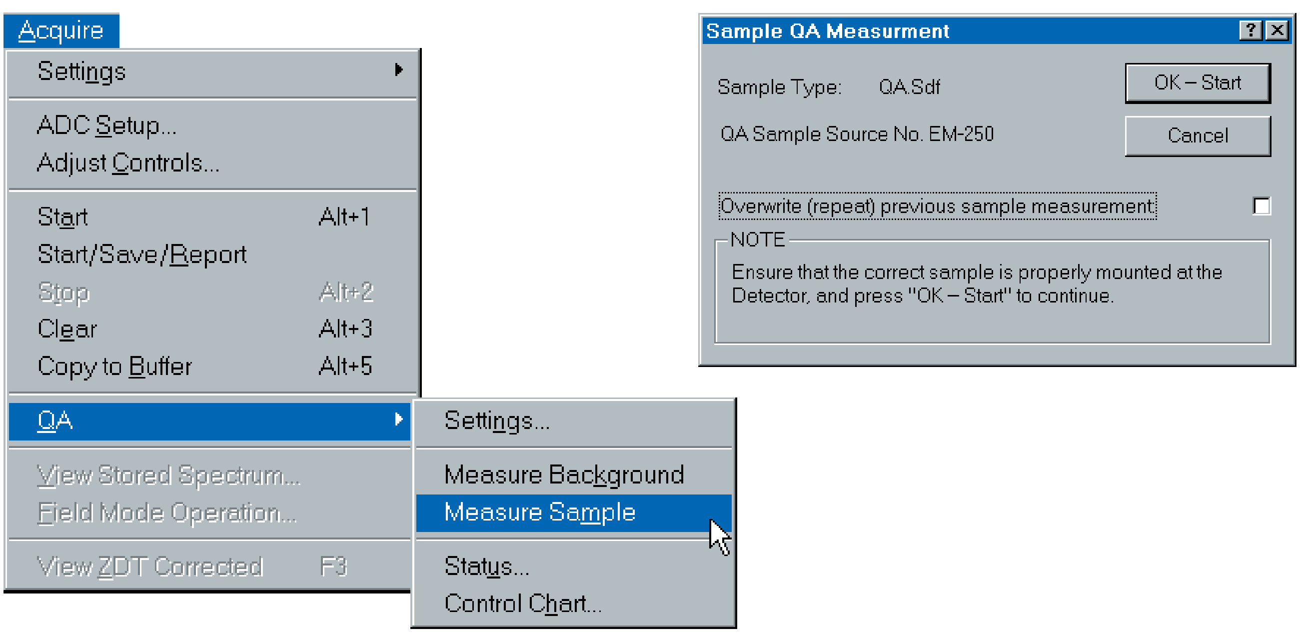

Figure 4. QA Menu Selection and Start Dialog Box.

Running the QA from a GammaVision JOB File

The JOB file created in Section 4 above can be executed from the menu in GammaVision. Click on the menu item "Services|Job Control". In the dialog box, change to the directory "C:\User\QA" if not already there. Double-click the file "QA.JOB". The JOB will run the entire QA sequence.

Note: Before double-clicking on the QA.JOB file, put the source in position. The JOB file QA command does not pause before starting the acquisition as in the method above.

Running the QA Automatically when GammaVision Starts

GammaVision JOB files can be run automatically when GammaVision starts by putting a reference to the JOB file in the command line. To do this, first create a new Icon for GammaVision on the desktop. To create an Icon, do the following:

1. Right click on the Windows Desktop.
2. In the pop-up menu, select "New|Shortcut".
3. Click the Browse button in the dialog box.
4. Change to the directory that GammaVision was installed to (the default is "C:\Program Files\GammaVision").
5. Double-click the Icon for GV32.EXE.
6. Click the Next button.
7. In the name of the Shortcut, type "GammaVision QA".
8. Click Finish.

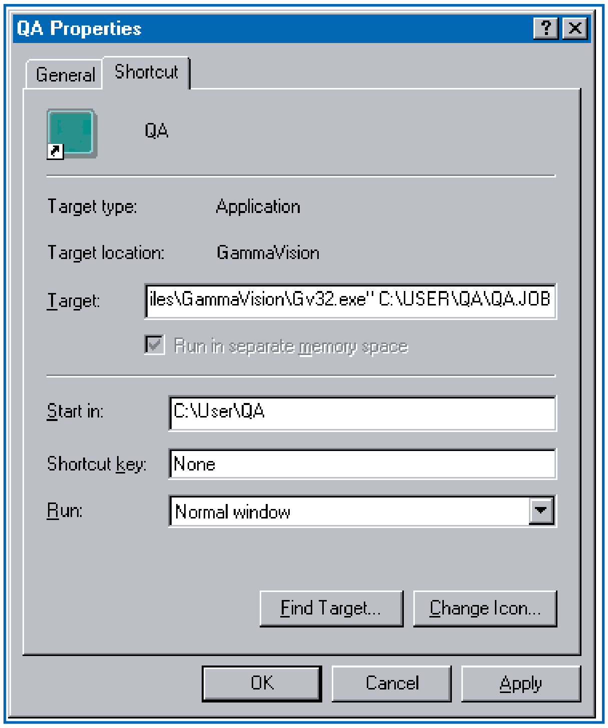

Figure 5. Properties Dialog Box for Automatically Starting the QA JOB File.

Once the Icon is created, right click on the new icon and select Properties from the pop-up menu. In the "Start-in Directory" type "C:\User". On the command line after the path to the GV32.EXE file, add the qualifier, the JOB file "C:\User\QA.JOB" as shown in the figure. Click OK.

Now, anytime this Icon is double-clicked, the QA program will automatically start and run to completion. *NOTE: Before double-clicking on the QA.JOB file, put the source in position. The JOB file QA command does not pause before starting the acquisition, as in the section Running the QA from the GammaVision Menu above.* It may be advantageous to add the "EXIT" command to the end of the JOB file so that after the QA measurement is complete, the JOB file will automatically exit GammaVision.

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6. QA Plots

GammaVision includes built-in charting routines for displaying the data collected with the QA program. As most Counting Lab QA policies require hard-copy printouts of the QA data, GammaVision also includes routines for sending these charts to the printer. Figure 6 below shows a plot of data collected over a two-month time period.

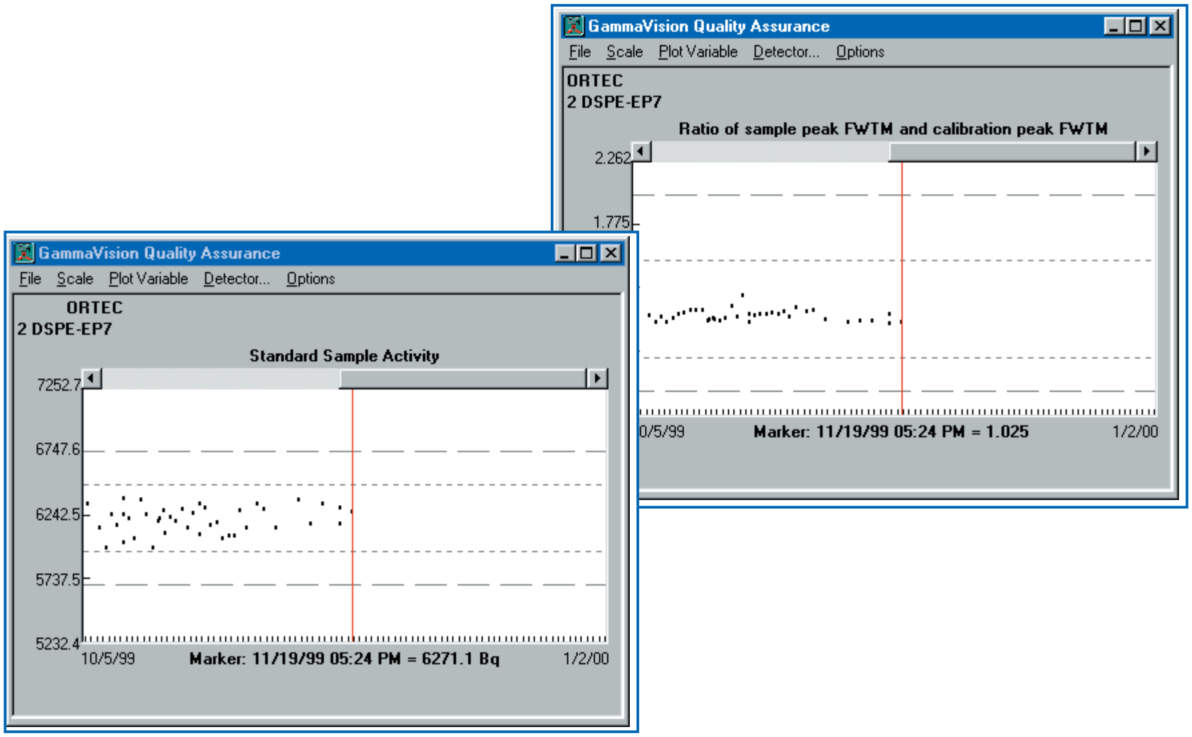

Figure 6. Activity and Peak Shape Plots.

Specifications subject to change
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