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Automated Calculation of Alpha Energy Spectra

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Restoration
and Waste Management

Westinghouse
Hanford Company Richland, Washington

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AUTOMATED CALCULATION OF ALPHA ENERGY SPECTRA

ABSTRACT

G. L. Troyer

The external and operating specifications for a general alpha energy analysis data reduction program are presented in this document. A brief description of the methodology is given to identify the main features and reasons for use. Specifications for the supporting data files are also presented. Brief operating step procedures are presented as appendixes.

CONTENTS

1.0 INTRODUCTION

The automated calculation of alpha energy spectra requires a computer program that can reliably determine isotopic identification and activity abundance. This document describes a general alpha energy analysis (AEA) program designed to determine peak quantities, relative abundance, and, where identification can be made, individual isotopic activities. Also, this program can automatically energy calibrate an instrument and allow for detector efficiency changes or monitoring information for final quantification of activities.

2.0 DESCRIPTION

2.1 METHODOLOGY

The performance of quality alpha energy analysis is highly dependent on sample preparation. The goal of sample preparation is to produce a virtually weightless source for counting using a vacuum chamber and a spectroscopy-grade solid state detector data collection system; this provides excellent results.

In many cases, preparation of weightless samples such as filters for air particulates, high salt solutions, and biological samples is difficult or nearly impossible. When these samples are analyzed, the AEA spectra are degraded such that most manual calculation methods are of questionable value or credibility.

The general AEA program (**GENAEA**) improves the quality of the data, determines spectral peaks, models the peaks, and, using the peak models, provides both qualitative and quantitative results (Troyer 1987).

The program accepts computer-stored, multichannel-analyzer data that describe the AEA spectra. The spectra are compressed and smoothed to reduce statistical noise found in counting systems and, in particular, AEA spectra. A peak search is performed by examining the second derivative of the conditioned spectra. This method is highly sensitive and, depending on the counting noise embedded in the spectra, may find too many peaks to analyze. Most peaks are eliminated by further testing the derivative slope in the region surrounding the peak. This procedure is applied until the sensed peaks are of a manageable number or the spectra have been compressed to 128 channels.

The conditioned peaks are modeled successively. Starting at the highest energy peak, sufficient data to describe the peak while avoiding near-peak interference are introduced to a simplex-fitting algorithm (Caceci and Cacheria 1984). The resulting fit is subtracted from the original spectrum, and the next lower energy peak is processed. This procedure is reapplied until all peaks are processed.

The calculated peak energies are compared to a table of valid isotope energies. When a match is found within an energy window, a quantitative activity can be calculated. Assigning quantitative values is dependent on the alpha-decay branching ratios, yield, and counting geometry or counting efficiency.

Matching the observed energy to the proper isotope is dependent on a previous energy calibration. A spectrum that is identified to the program as a calibration standard is used to automatically calibrate the system. Upon completion of peak analysis, the program uses the predefined calibration

standard peak definitions to fit an energy calibration curve for the geometry measured. The results of this calibration are automatically stored by instrument and geometry number for subsequent reference.

Detector counting efficiencies or geometry factors must be determined before accurate quantitative results can be provided. This determination can be provided through external measurements with the efficiency inserted in the calibration file. Alternatively, the program can be directed to automatically calculate the efficiency through the normal energy calibration feature.

2.2 LIMITATIONS

The basis of the program design was to provide a method yielding useful information without prior information about the sample matrix. This implies that the program can generate a useful report from an electroplated source, an aqueous evaporated mount, or at the extreme, a particulate air filter. In other words, reasonable success is not completely dependent on the sample matrix preceding the counting. However, a good understanding of the constraints of alpha energy analysis is helpful in interpreting any results of programs of this kind.

In practice, the program performs best if the peaks are somewhat apart from each other and have significant count accumulations. This implies long count times or fairly active samples. However, peaks with as little as four counts in the peak height (above interfering backgrounds) have been determined.

The peak model is independently fit to each detected peak. Therefore, the stability of resolution and tailing parameters is dependent on the quality of the data in the peak region. The statistical variation of data at low count values can cause overestimation or underestimation of actual peak activities. As aids, controls driven by error limits and displays of the program response have been provided to show how the results are obtained.

2.3 OPERATING ENVIRONMENT

This document describes a version for use with an IBM-PC* or compatible operating under DOS revision 3.0 or later. The program performs best with a floating point coprocessor on a PC-AT class or faster machine. Standard monochrome or better display is supported in monochrome mode. Screen mode and screen initialize functions require the DOS driver ANSI.SYS. The program is designed for a minimal amount of input by the user. Typical analytical parameters, such as geometry and count time, are requested from the user if they are not available from the spectral files. The program requires less than 150 kilobytes of main memory for operation. A hardcopy spooled printer is recommended for report output.

3.0 DATA FILES

Complete analysis and reporting depends on several supporting data files. These files describe startup parameters, detector efficiencies, energy calibration, and isotopic descriptions. The individual files are presented in the following sections.

*IBM is a trademark of the International Business Machines, Armonk, New York.

3.1 BATCH REQUEST FILE

The AEA uses a program batch request file that can be operated in an automatic mode. The user or a program source can generate a text file (**AEAREQST.SC**) containing the names of previously stored spectrum files. The program tests for the presence of this file and processes each listed file in turn until the entries in the file are exhausted.

File: **AEAREQST.SC**

Record N	
Byte	Description
0-11	ASCII numeric characters defining the stored spectrum number or identification
	[di] fname.ext
	[di] = optional device designator
	fname: 1 to 8 character file name
	ext: 0 to 3 character file name extension

3.2 PARAMETER INITIALIZATION

The AEA program uses a parameter initialization file to control certain features of program operation. The table below shows the typical contents of this file. The file is designed as a self explanatory text file. The data values are placed within the "<..>" structure. If missing, this file is initialized to default values by the program. Values may be changed by using any standard text editing utility.

File: **AEAINIT.DT**

Record	Contents	Default Value
1	Diagnostic Enable: (0=no, 1=yes)	<0>
2	Nucleus* = 1, ORTEC** = 2, LANL/ASCII = 3	
3	Vendor code: (1,2,...,9)	<1>
4	MCA model: (1,2,...,9)	<1>
5	Spool report (0=no, 1=yes)	<0>
6	LOTUS output (0=no, 1=yes)	<1>
7	Perform analysis (0=LOTUS file only)	<1>
8	Create a Los Alamos text file(1=yes)	<1>
9	Create a counts per minute and energy file (1=yes)	<0>
10	Batch default of detector and geometry	<9903>
11	Max. % err @95%C.L. for peak reporting	<20>
12	Max. % err @95%C.L. for peak detection	<30>
13	Generate line printer graph (1=yes)	<1>
14	Generate spectral printer dump(1=yes)	<0>

*Nucleus is a trademark of The Nucleus, Inc., Oak Ridge, Tennessee.
**ORTEC is a trademark of EG&G ORTEC, Oak Ridge, Tennessee.

Record 1. Diagnostic enable: An interger value of zero disables diagnostic output to file **AEADIAG.LS**; a value of one enables.

Record 2. Definitions: The valid parameter values are defined for record 3.

Record 3. Vendor code: An integer value directs the interpretation of spectral files in accordance with the noted vendor. Option 3 assumes an ASCII text file list of channel contents, one channel per record. Supported vendors are identified in Record 2.

Record 4. MCA model: An integer value indicates more than one data file structure in accordance with the vendor (i.e., analyzer dependent). Program versions to 1.4 only support a value of one.

Record 5. Spool report: The program can be directed to automatically spool the hardcopy report to the standard spooled printer port. The report is created as a disk file (<fname.REP>) and is spooled under control of this flag.

Record 6. Lotus output: The program may be directed to generate a Lotus 123* compatible text file for spreadsheet import. This output is an ASCII spectrum list preceded by spectral header information.

Record 7. Perform analysis: The program can be used as a translator of vendor internal file format to a Lotus text file by disabling the analysis code with this flag.

Record 8. Los Alamos: A spectral display program is available from Los Alamos National Laboratory for displaying successive files as slides. This flag enables the generation of compatible files named <fname.LNL>.

Record 9. Counts per minute and Energy: A set of time sequence spectra can be processed and the final peak results recorded to a summary text file. This flag enables the generation of a <fname.CPM> file.

Record 10. Geometry: This parameter defines the default user-defined instrument and geometry to be used during batch operations. The value is an integer and has the form IIGG where II is the instrument number in the range of 01 to 99, and GG is the geometry ranging from 01 to 99. The combined value is unique among the defined combinations.

Record 11. Reporting error: This integer value is the maximum percent error allowed for an isotope to be identified in the analytical report. Peaks with counting errors in excess of this value will be reported but not identified.

Record 12. Peak detection error: This integer value is the maximum percent error allowed during peak detection. Peaks detected with errors exceeding this value will not be considered for analysis.

*Lotus 123 is a trademark of Lotus Development Corporation, Cambridge, Massachusetts.

Record 13. Graph output: This parameter controls the generation of a low resolution graph for output to the line printer. The graph is enabled with a value of one and disabled with a value of zero. The graph is appended to the standard analytical report file (<fname.REP>).

Record 14. Spectral output: This parameter controls the generation of a channel-by-channel data dump appended to the analytical report (<fname.REP>). The maximum 512 channel working array is printed 10 channels per line.

3.3 REPORT AND DIAGNOSTIC FILES

The program generates a single report for each spectrum analyzed. This report contains the individual peak analyses, isotopic results, and optionally, a trailing line printer graphical rendition of the raw data spectrum overlaid with modeled peak outlines and a channel-by-channel data list. The report files are printer ready and contain only free-form text output (fname.REP).

The program will also conditionally generate a diagnostic listing of data processed during the reduction. These data include numerical listings of the spectrum at various stages of the processing, the determined regions of interest data, peak search test data, and intermediate parameter fitting data. This file (**AEADIAG.LS**) is ASCII text and is printer ready. The file is reinitialized for each spectrum as for the report file. Exact interpretation requires access to the program source listings. This file is generated based on the condition of the flag in the **AEAINIT.DT** file.

3.4 SPECTRUM FILES

The program processes prestored spectral files defined by the multichannel analyzer system used to collect the data. These data files depend upon vendor definition and may contain only multichannel analyzer data or may be augmented with additional experimental parameters. The program has been ported to several vendors and includes a direct ASCII text file input port. For example, the output of the Lotus 123 file generation mode is compatible with the ASCII input port. The available ports are implied by the definitions found in the initialization file, **AEAINIT.DT**. The ports are internal modules coded to interpret the individual vendor data specifications. Inclusion of undefined data structures requires development of the required new port (subroutine) and linking it into the main program as a new version.

3.5 ALPHA ENERGY ANALYSIS STANDARDS

The GENAEA program supports the generation and update of standards data calibration files using designated standard sources. The stored results are the individual peak fitted model results for the known standard isotopes. The program is designed to automatically address the standards isotopes ^{237}Np, $^{239/240}Pu$, ^{241}Am, and ^{244}Cm. The primary purpose of these files is to monitor the quality of the analytical system. Current values can be compared to the previously stored peak parameter results.

The names of the standards files are of the form: <fname>.STM where <fname> is a standard identification number. The standard identification number may contain up to eight characters from the character set A-Z and 0-9. This name may be different from the input spectrum name. Inclusion of the character string "STD" in <fname> of the input spectrum name or in the file name extension

triggers the program to perform standard calculations. Information contained in the STM file includes overall standard value in disintegrations per minute, individual isotopic energy, and the model fit parameters. A linear fit of energy versus peak centroid of these data will yield the instrument energy calibration in effect for peak identification.

File: <fname>.STM

Record 1	
Byte	Description
0-11	Text: "OVERALL D/M"
12-31	Standard value (F10.1)
22-77	Pad
78-79	Record terminator

File: <fname>.STM

Record 2-N	
Byte	Description
0-6	Isotope energy in MeV (F7.3)
7-18	Peak model peak height in counts (E12.6)
19-31	Peak model centroid channel number (E12.6)
32-43	Peak model resolution (FWHM) (E12.6)
44-55	Peak model tailing factor (tau) (E12.6)
56-77	Pad
78-79	Record terminator

The user may not have the default isotope standards available. The program provides for user definition of standard isotopes through the file **STDENRG.DT**. Existence of this file overrides the internal four isotope energy definition. This external energy file contains the number of expected peaks followed by a list of the peak energies in million electron volts (MeV). The file is ASCII text and the format is shown below. Any peaks used for energy and efficiency calibration must be larger than 20% of the most prominent peak. The program starts at the highest energy peak and matches to the decreasing standard energy list based on this quantity rule. This feature allows a user to calibrate an unknown spectrum using prior knowledge of the spectral peak identities in order to produce a properly identified peak report.

File: **STDENRG.DT**

Record 1	
Byte	Description
0-1	Free form integer, left justified value of the number of expected standard peaks.

Record 2-N	
Byte	Description
0-6	Free form real value with decimal point, left justified containing the peak energy of interest in MeV. Each successive record contains a lower energy value.

3.6 DETECTOR CALIBRATION

Isotopic identification and quantification is dependent on the accuracy of the detector energy dispersion and efficiency calibration. The program is designed to automatically update these calibration parameters when a standard spectrum is analyzed. The energy calibration and efficiency as derived by reference of the results to the standard data file is placed in a detector calibration file (**AEADETCL.DT**). This file has a unique entry for each detector geometry measured. A single standard may be measured at several geometries (detector to source distance), or multiple standards, one for each geometry may be elected. However, the most recent measurement for a designated geometry is updated regardless of the actual standard mount.

File: **AEADETCL.DT**

Record 1-N	
Byte	Description
0-1	Space pad
2-6	Instrument/geometry, format IIIGG where III is the three number instrument or detector number and GG is the two number geometry number.
7-16	The energy calibration intercept value for channel zero in units of MeV, format F10.4.
17-26	The energy calibration gain or slope in units of MeV per channel, format F10.4.
27-36	The calculated detector efficiency in units of counts per minute per disintegration per minute. This is obtained by dividing the integrated raw spectrum count with the overall standard value in disintegrations per minute. Format F10.4.

3.7 ISOTOPE IDENTIFICATION

The report writing phase of the program attempts to match determined peaks against an isotope library. This library, **AEAISONM.DT**, contains the isotope name, energy, half-life, and alpha decay branching ratio in percent. The energy is used to match against the found peaks, the half-life may be used for various decay corrections (not implemented), and the branching ratio is used to correct the calculated disintegrations per minute data to microcurie activity values. The program searches the library for matches within an energy window. The energy window, E_w, is derived from the resolution fit parameter of each peak,

$$E_w = \text{MAX}(\text{MIN}(\text{FWHM}, 0.1), 0.02)$$

where:

E_w = Energy window (MeV)
FWHM = Peak resolution, full width at one-half peak maximum[1]
MAX = Maximum value of list
MIN = Minimum value of list.

and

$$E_{obs} - E_w < E_{exp} < E_{obs} + E_w * 2$$

where:

E_{obs} = Observed energy
E_{exp} = Expected or actual isotope energy.

This method allows for considerable energy shift to lower values because of sample-to-sample overmass variations.

File: **AEAISONAM.DT**

Record 1-N	
Byte	Description
0-7	Isotope name (i.e., ^{212}Po) as an 8 character text spring, blank padded, format 4A2
8-16	Isotope energy in MeV, format F9.3
17-26	Half-life in units of days, format E10.3
26-36	Percent alpha branching ratio, format I6

3.8 SIMPLEX PARAMETERS

The peak fitting is performed by a set of subroutines that implement the Simplex (Caceci and Cacheria 1984) algorithm. Control and convergence criteria are specified in an external file, **SIMPAEA.DT**. The data in this file are projection constants, initial estimator multipliers, and priority control and parameter convergence criteria. The values are established through empirical testing and affect the speed of convergence as well as the accuracy.

[1]The peak model has two shape parameters, the FWHM and the quadratic tailing. The tailing parameter compensates for the low energy peak shape below the peak centroid. Therefore, manual comparisons of resolution to program FWHM should only be applied to the high energy half of the peak.

File: **SIMPAEA.DT**

Record 1-3	
Byte	Description
0-4	Simplex projection constants alpha, beta, gamma, format F5.1
Record 4	
0-5	Maximum number of Simplex iterations for nonconvergence
Record 5-8	
0-11	Initial step multiplier. This value is used to make the first projection on the initial estimates. Format E12.6. The parameters are the peak model parameters of height, centroid, resolution, and peak tailing. Successful first projections are: height = height/2 center = 0 (fixed position) resolution = resolution *1.5 tailing = tailing/10
Record 9-13	
0-11	Maximum error for each model parameter and the overall error convergence limit

4.0 OPERATING MODES

Several operating paths exist for the program based on the sample type. The pathway is determined by the character string used to define the sample units. Two specific strings are defined: STD and AIR. All other unit specifiers default to the "normal" calculation mode.

4.1 NORMAL

Under normal operation, the program accepts spectral data for general analysis. Based on the instrument/geometry designation for the sample, appropriate isotopic matching and activity calculations are performed. When a peak is discernable and no energy match in the isotope library is successful, the result is calculated for a 100% alpha yield.

4.2 AIR FILTERS

Calculation of air particulate filters is triggered by designating either the sample units to be "AIR" or by including the character string "AIR" in the file name. Air filters are analyzed in the same manner as normal samples except that a plutonium estimate is also made. The current energy calibration is used to determine a peak centroid for the 5.15 MeV alpha of $^{239/240}$Pu in the raw spectrum. Then, based on the less than calculation of LA Currie, 4.66 times the square root of the residual value after fit in this channel is used as the estimate of the peak height (Currie 1968). The peak model parameters for the first found peak (typically ^{212}Po) are used to integrate a "less-than" region of interest. The resulting disintegrations per minute value is reported as an additional estimate for the plutonium.

4.3 STANDARDS

Calculation of standards is triggered by designating the sample units to be "STD" or by including the character string "STD" in the file name. Peak analysis is performed as in the other general methods. At the completion of peak analysis, the standards mode is tested and a linear fit is performed on the peak centroids versus known peak energies. The results of the fit are the channel zero intercept and the MeV per channel gain for the system. These data along with the calculated detector efficiency are overlaid into the detector calibration file **AEADETCL.DT**. Each defined standard is expected to have a minimum of two peaks.

5.0 REFERENCES

Caceci, M. S. and W. P. Cacheria, 1984, "Fitting Curves to Data," *Byte*, May, pp. 340-362.

Currie, L. A., 1968, "Limits for Qualitative Detection and Quantitative Determination," *Anal. Chem.*, 40:586.

Troyer, G. L., 1987, *On-line Data Reduction of Stack Gas Particulate Alpha Spectra for Plutonium*, RHO-RE-SA-205P, Rockwell Hanford Operations, Richland, Washington.

APPENDIX A

PROCEDURES

PROCEDURES

Calibration. The first step in successful operation of the program is to calibrate the detector geometry for a particular mount type. The mounted standard must contain relatively equal quantities of the reference materials.

1. Prepare and characterize an alpha-emitting isotope standard mount. The overall or total disintegrations per minute value for the standard must be established. Assign a unique standard label of up to eight characters from the character set A-Z and 0-9, which does not contain embedded blank characters.

2. Collect a spectrum of the mount in the fixed geometry to be used. Assign the units of "STD" and the desired geometry code to the spectrum.

3. If a standard file exists with the name "label.STM," delete it such that a new standard value will be requested by the program.

4. Invoke the general AEA program and enter the spectrum name of the above collected and stored spectrum. Provide the standard disintegrations per minute value when requested by the program.

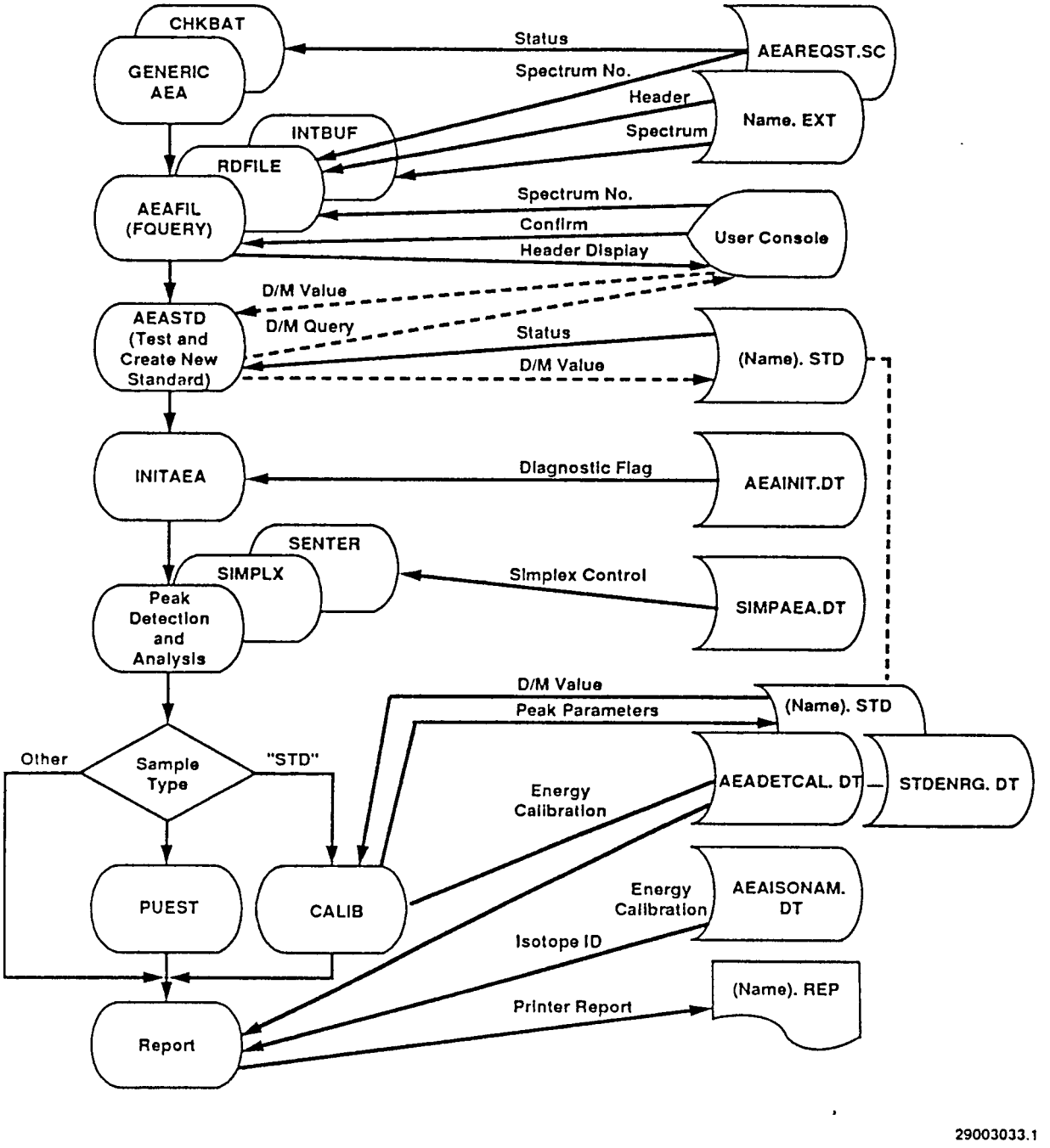
Normal. Complete routine operation is only successful if a standard has been calculated in the above procedure. Absence of a calibration will generate a report containing only the peak parameter analysis.

1. Collect a spectrum of the mounted sample in the selected and precalibrated fixed geometry position. Assign the desired geometry code to the spectrum. Assign the sample units of "AIR" to the spectrum or include the test string "AIR" in the file name if the sample is an air filter.

2. Invoke the general AEA program and enter the spectrum name of the above collected and stored spectrum.

APPENDIX B
PROGRAM FLOW CHART

Figure B-1. Program Flow Chart.



APPENDIX C
EXAMPLE REPORT

Figure C-1. Example Report. (sheet 1 of 3)

Westinghouse Hanford Co.

G E N E R A L A L P H A E N E R G Y A N A L Y S I S
Rev. 1.43

DATA REDUCTION REPORT

STANDARD
STD A
File ID: 1050.STD

Counted on: 10/23/89 @ 1:18
Detector/Geometry number: 1/ 1
Count time: 208. Sec

PEAK ANALYSIS

Peak ID	Peak height Initial	Peak height Final	Peak center Initial	Peak center Final	FWHM Initial	FWHM Final	Tau Initial	Tau Final
1	64.9	64.9	340.889	340.889	18.000	15.457	9.000	2.838
2	81.1	81.1	270.859	270.757	22.000	17.556	11.000	4.272
3	87.5	87.5	201.350	201.297	22.000	16.100	11.000	3.620
4	97.8	97.8	127.561	127.540	20.000	15.967	10.000	3.303

PEAK RESULTS
Peak Error Limit: 20%

Peak ID	Isotope	AEA Frac	Peak Centroid Exp.	Obs.	Diff.	FWHM	Count Rate c/m	%err @95	d/m	Activity uCi/ea
1	Cm243	.212	5.786	5.819	-.033	.07	570.89	4.4	8728.1	.393E-02
	Cm244		5.796	5.819	-.023				6371.5	.287E-02
2	Pu238	.235	5.499	5.482	.017	.08	630.79	4.3	9777.9	.440E-02
	Am241		5.480	5.482	-.002				7489.5	.337E-02
3	Pu239	.258	5.143	5.149	-.006	.08	693.46	4.1	7739.5	.349E-02
	Pu240		5.144	5.149	-.005				7739.5	.349E-02
4	Np237	.301	4.781	4.795	-.014	.08	808.51	3.7	10371.8	.467E-02
Totals:		1.006	<--valid peaks only-->				2703.65			

DETECTOR CALIBRATION
Energy(MEV) = 4.183 + (.0048)*Channel
Energy range (MeV): 4.183 TO 6.640
Efficiency = .0896 CPM/DPM

TOTAL COUNT DATA:

Item	Total	% Recovery
Raw spectrum	9320.0	100.000
Smoothed	9320.5	100.005
Composite fit	9372.6	100.565
Residuals	-52.6	-.565

Analyzed by: _____
GLT

Figure C-1. Example Report. (sheet 2 of 3)

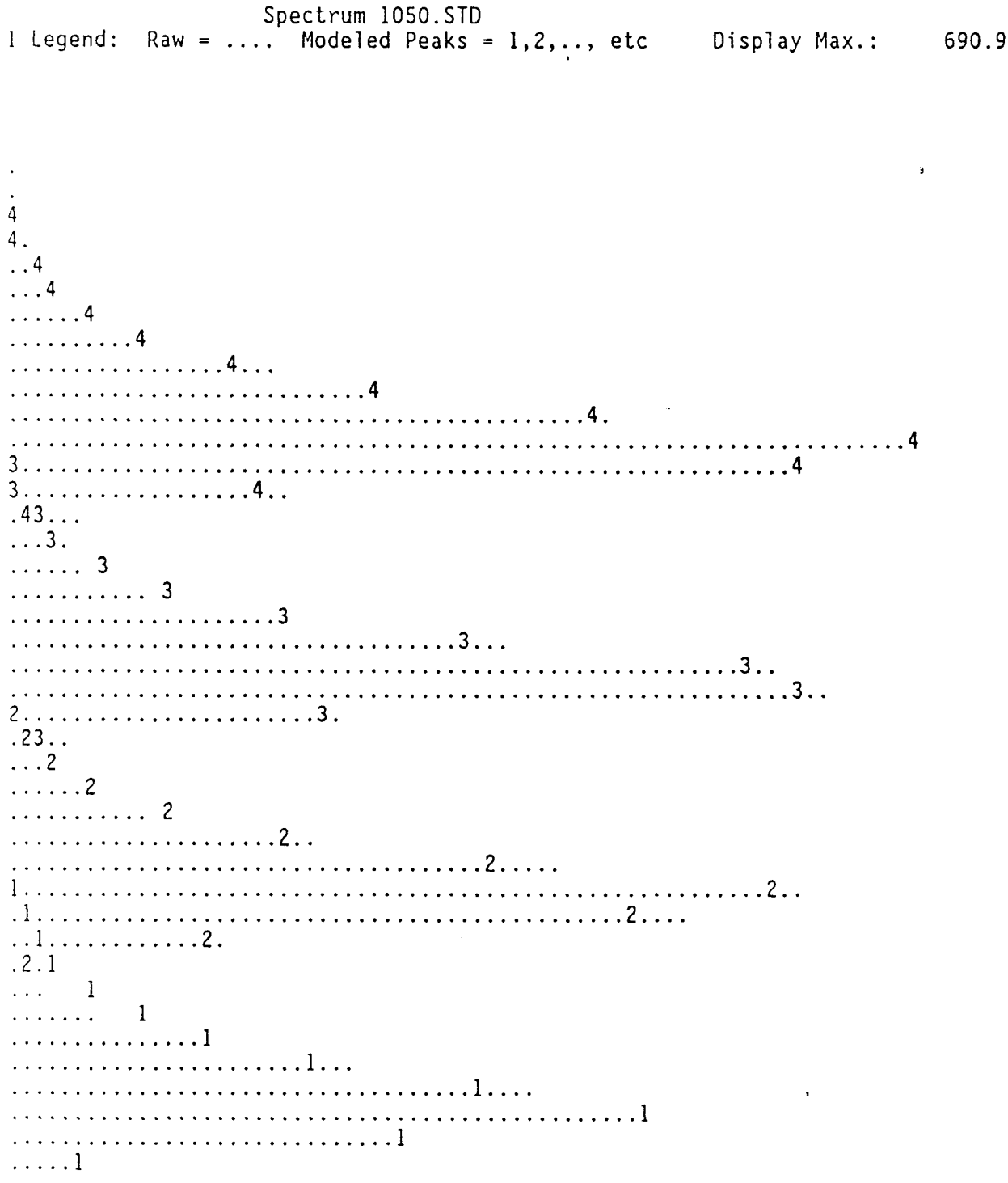


Figure C-1. Example Report. (sheet 3 of 3)

Raw Data Dump for AEA Spectrum: 1050.STD

1	1.	1.	0.	1.	0.	0.	0.	2.	2.	0.
11	2.	1.	2.	0.	2.	0.	2.	1.	0.	3.
21	2.	0.	0.	0.	1.	1.	0.	0.	3.	1.
31	1.	2.	0.	1.	4.	1.	3.	4.	4.	0.
41	2.	1.	3.	2.	1.	1.	3.	1.	4.	2.
51	3.	1.	0.	3.	1.	3.	7.	6.	4.	3.
61	1.	4.	5.	3.	2.	2.	0.	6.	2.	4.
71	5.	5.	3.	5.	6.	5.	6.	3.	5.	8.
81	11.	4.	2.	10.	9.	7.	13.	11.	10.	12.
91	11.	18.	16.	15.	15.	16.	34.	19.	21.	30.
101	33.	25.	35.	30.	28.	37.	38.	33.	33.	39.
111	44.	40.	44.	47.	58.	62.	60.	77.	77.	74.
121	69.	75.	74.	100.	74.	117.	107.	109.	95.	93.
131	89.	79.	76.	59.	58.	39.	40.	35.	16.	22.
141	17.	20.	12.	15.	11.	8.	7.	3.	4.	7.
151	5.	6.	8.	2.	7.	3.	13.	6.	8.	6.
161	7.	9.	6.	5.	11.	8.	7.	10.	11.	11.
171	9.	14.	16.	14.	27.	18.	22.	23.	27.	24.
181	31.	34.	35.	38.	57.	32.	44.	59.	48.	59.
191	52.	56.	66.	71.	74.	75.	83.	82.	96.	78.
201	97.	94.	84.	82.	81.	60.	77.	71.	52.	42.
211	30.	23.	19.	12.	12.	8.	7.	4.	3.	3.
221	2.	4.	6.	2.	4.	3.	7.	4.	5.	5.
231	5.	4.	4.	6.	10.	5.	10.	11.	5.	14.
241	7.	12.	13.	11.	12.	16.	29.	18.	23.	23.
251	16.	35.	36.	29.	49.	45.	54.	35.	54.	50.
261	56.	60.	74.	72.	66.	78.	66.	89.	87.	75.
271	91.	88.	71.	84.	66.	75.	55.	65.	51.	47.
281	22.	25.	21.	11.	15.	10.	5.	3.	7.	2.
291	6.	1.	4.	2.	4.	2.	3.	4.	4.	4.
301	4.	3.	5.	4.	4.	12.	6.	11.	10.	12.
311	13.	19.	14.	15.	8.	25.	24.	20.	26.	33.
321	18.	28.	40.	29.	39.	40.	47.	39.	38.	53.
331	48.	43.	60.	56.	60.	69.	71.	57.	59.	67.
341	61.	76.	57.	59.	51.	50.	51.	29.	33.	25.
351	17.	19.	9.	16.	1.	1.	1.	1.	0.	1.
361	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
371	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
381	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
391	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
401	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
411	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
421	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
431	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
441	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
451	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
461	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
471	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
481	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
491	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
511	0.	0.								

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