

Tokai Densitometer Manual

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TOKAI DENSITOMETER MANUAL

by

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ABSTRACT

In 1979, the Tokai densitometer was installed at the Tokai Reprocessing Plant in Tokai, Japan. It uses a nondestructive active technique (K-edge absorption densitometry) to assay solutions for plutonium content. The original hardware was upgraded in 1984 and 1985. This manual describes the instrument's operation after the upgrade.

GENERAL

The Tokai densitometer is designed to non-destructively measure the plutonium concentration of plutonium in solution. The technique employed is K-edge absorption densitometry using radioisotopic transmission sources. By measuring the transmissions of the 121.1-keV gamma ray from ^{75}Se and 122.1-keV gamma ray from ^{57}Co , the plutonium concentration can be uniquely determined. The densitometer at the Tokai plant was installed in the fall of 1979 and has undergone an extended period of test and evaluation.¹ However, the original hardware supplied during 1979 was becoming obsolete and difficult to maintain. The hardware, mainly the computer and the multichannel analyzer (MCA), was replaced in 1984, and the new software was installed in the summer of 1985. This manual describes the operation of the densitometer after the upgrade and applies only to the new software.

AUDIENCE

This manual is for those who operate the densitometer for routine assays, and also for the system supervisor who is the resident expert on the densitometer. It does not explain the measurement physics¹ or the computer operating system.

OTHER DOCUMENTATION

The Livermore Isotopic Manual
IOM Company Documentation
Nuclear Data Manuals

- ND66 Analyzer
- NIM Units

Digital Equipment Corporation (DEC)

- Hardware Documentation
- RSX-11M Operating System Manuals

OTHER DOCUMENTATION

Previous documentation for the Tokai densitometer

- Tokai Densitometer Operation Manual
- In-Plant Measurements of Gamma-Ray Transmissions for Precise K-Edge and Passive Assay of Plutonium Concentration and Isotopic Fractions in Product Solutions

SYSTEM OVERVIEW

The system consists of a Nuclear Data 66 MCA with two analog-to-digital (ADC) converters. The MCA is controlled by a Digital Equipment Corporation (DEC) Micro-11/23 plus computer with 256 k bytes of memory. The software is RSX-11M from DEC. The system has two RL02 disk drives and two RX02 disk drives for data and program storage. The time-sharing nature of the software allows both the densitometer and the isotopic software to control the MCA simultaneously and to operate independently of each other. Appendix A describes the densitometer electronics.

The densitometer software consists of two programs. The main program, DENSIT, controls the MCA, the Geneva source wheel, and the digital stabilizer. The program also performs data analysis and writes (or reads) data to (or from) the disk. In addition to these operations, the program performs the measurement control function by prompting operators to perform bias or precision checks on a scheduled basis. Besides the measurement control checks, there are also diagnostic checks on the performance of the system, such as detector-resolution and peak-centroid checks.

SYSTEM OVERVIEW

(cont)

The DENSIT program uses a set of parameters, and this set is prepared and modified by the ancillary program, CDENSIT. Both of these programs are menu driven, and the menu options are similar to the isotopic system in as much as it is practical. We will first discuss the options of the DENSIT program and then the options of the CDENSIT program.

Several improvements have been made in the upgrade. Operator interaction in the revised software is much more intuitive and user friendly. Secondly, we have added a second plutonium concentration result based on extrapolation to the plutonium K-absorption edge. The extrapolation causes the result to be immune to the presence of a relatively large amount of uranium (or other heavy metal).

GENERAL

Under normal conditions, the DENSIT program running on terminal number 2 can be started by typing .DEN. A clean exit is provided with the X option described on page 45. Since the system was delivered, all necessary files are on DL0: under [200,200]. The operator can log on with the command LOGON 200,200/NID and can log off with the command LOGOFF.

If the program is busy, the last line on the terminal informs the operator what the program is currently doing.

If the program is not busy, the ENTER OPTION prompt is the last line on the terminal. The DENSIT program options available to the operator fall into two categories.

OPERATOR OPTIONS

The operator options are the routine operations used in the course of normal data acquisition and analysis. There are five options, and the menu is listed whenever H is entered in response to the ENTER OPTION question.

- A - Assay
- AU - AUTOCYCLE
- SB - Straight through - Background
- MB - Measurement control - Bias
- MP - Measurement control - Precision
- H - Help

SUPERVISOR OPTIONS

The supervisor options are listed only when HS is entered and are not intended for routine use.

SUPERVISOR OPTIONS

(cont)

They should be used only by personnel who are fully knowledgeable in the operation of the program.

- AD - Assay from Disk
- AUD - Autocycle from Disk
- SBD - Straight through - Background from Disk
- C - Calibration
- CD - Calibration from Disk
- D - Default
- LA - List Assay log
- LM - List MC log
- LR - List combined Results file
- OU - Change OUTput listing device
- R - Read data from disk
- W - Write data to disk
- X - eXit from program
- HS - Help the supervisor

Not listing supervisor options in the default choice of options is sufficient protection.

OPERATOR OPTIONS

A - Assay

This option is used to acquire data so that the plutonium concentration can be determined by the densitometry technique. Only a single concentration determination is made. The DENSIT program prompts the operator for several items before the data acquisition begins.

Operator ID

This prompt ensures that the proper operator identification (ID) gets into the output header block. If no ID is entered, the assay run aborts and the operator is returned to the ENTER OPTION question. The operator ID may be up to 8 alphanumeric characters long.

Remark

This comment (up to 80 characters) is optional and is printed in the output header block.

Sample ID

If no sample identification (ID) is entered, the assay is aborted and the operator is returned to the ENTER OPTION question. The maximum length of the sample ID is 12 alphanumeric characters. If the spectra are to be written to disk, then the first 6 characters of the sample ID are used as the file name.

Sample Check

A message appears and the program is suspended while the operator checks the sample. When the operator is ready to continue the assay, the RETURN key should be pressed.

A - Assay

(cont)

Assay Messages

Occasionally messages appear at the terminal to inform the operator of the current status of the assay. For each assay, two separate transmission measurements (with ^{57}Co and ^{75}Ce) must be made. Each time the source wheel is moved and a measurement begins, a message appears informing the operator what measurement is being made, the length of the run, and the beginning and ending time of the measurement. The count times are in clock time, not live time; thus, the operator knows exactly when each phase of the data acquisition is completed. The count times are preset and may be changed by the supervisory default option (see D - Default on page 31).

Writing Spectra to Disk

Spectra can be written on any of the disks: DL1 (hard disk), DY0, DY1, DY2, or DY3 (floppy disks). Determination of which disks, if any, records the data is made in the supervisory default option (see D - Default on p. 31). When the spectra are written to a disk, the first 6 characters of the sample ID are used as the file name. If the data are written to more than one disk, the data file in the output header block is the last file written. For each assay run, two files are created--one contains the selenium spectrum and the other contains the cobalt spectrum. These files are distinguished by the extension. For example, suppose the sample ID is PUSOL1 and the data are written to DL1.

A - Assay

(cont)

Writing Spectra to the Disk (cont)

The data file in the output header block is DL1:PUSOL1.01C. If the directory of the DL1 disk is printed, it will show the files PUSOL1.01S;1 and PUSOL1.01C;1. The number appearing after the semicolon is the version number. If another assay run is made with the same sample ID, then the files PUSOL1.01S;2 and PUSOL1.01C;2 will be created. The assay runs are logged in an assay log file. The assay result is discussed in a later chapter starting on page 47.

The following sample dialog of an assay option is a typical series of messages and operator inputs [as seen on the cathode-ray tube (CRT)] when initiating a single-pass assay. Operator responses are underlined.

02-AUG-85 14:50:15 Enter OPTION (H or HS to see Menu) -> A

This is a SINGLE pass assay

Enter operator ID (up to 8 chars) or RETURN to escape -> HSUE

Enter remark (80 char.) ->

PRINT OUT FOR SINGLE ASSAY

Enter sample ID or RETURN to escape -> PUSOL1

The following is shown during data acquisition.

Assay beginning

Moving Source Wheel to Se Position

Starting a 300. sec run at 14:51:23 (02-AUG-85) ends Today at 14:56

PUSOL1.01S written to DL1:

PUSOL1.01S written to DY2:

Moving Source Wheel to Co Position

Starting a 300. sec run at 14:58:21 (02-AUG-85) ends Today at 15:03

PUSOL1.01C written to DL1:

PUSOL1.01C written to DY2:

Moving Source Wheel to Blank Position

AU - Autocycle

This option enables the operator to repeat a measurement on the same sample a preset number of times with or without having to attend to the system between measurements. After each assay, the data are analyzed, results are printed out, and a new run is automatically initiated. A pause can be inserted between assays that allows the operator to stir the samples. The operator indicates when the sample has finished mixing, then the program will proceed. At the end of the autocycle, a summary of the results is printed, which includes the average and standard deviation of the autocycle run. Also, the test for outliers by the Grubbs method² is included in the summary. Appendix B summarizes this outlier test. In addition, a file with .RES as an extension is created on DL1: that contains the average results that with the isotopic information would give the complete assay results for that sample. Such a file is created for a single assay.

The input format of this option is very similar to that of the assay option. Additional questions are asked to determine the number of runs to be made and whether a pause between assays is desired.

If the data are to be written onto the disk, the sample ID is used as the file name. The extensions begin at .01S and .01C, and are incremented automatically (.02S, .02C; .03S, .03C; .04S, ...). Each autocycle run is logged in the Assay Log file.

AU - Autocycle
(cont)

The output for each cycle of an autocycle run is similar to the output of a single-pass assay. The only changes are that the run type is printed as autocycle, and the cycle number is printed.

At the end of the autocycle run a summary is printed. This summary includes the standard header block, which contains operator ID, the name of the constants file, both calibration constants, the date of the last SB run, and the date the constants file was written.

The results of all the cycles are listed. Both the original value and the extrapolated value are given. The Grubbs method² checks for any outlier values. A listing of the nonoutlier plutonium densities is also given. The mean, absolute sigma and fractional sigma are calculated and printed.

The following are typical inputs and displays shown on the CRT while initiating an autocycle run. The operator responses are underlined.

06-AUG-85 15:29:01 Enter OPTION (H or HS to see Menu) -> AU
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF AN AUTOCYCLE PRINT OUT
Enter sample ID or RETURN to escape -> FOIL
Enter number of cycles (1-25) -> 4

When sample is ready for assay, press RETURN ->
Pause between each assay ? (y/n) -> N

AU - Autocycle
(cont)

The following is shown for each cycle during data acquisition.

Moving Source Wheel to Se Position
Starting a 300. sec run at 15:29:43 (06-AUG-85) ends Today at 15:34
FOIL .01S written to DL1:
Moving Source Wheel to Co Position
Starting a 300. sec run at 15:36:04 (06-AUG-85) ends Today at 15:42
FOIL .01C written to DL1:
Moving Source Wheel to Blank Position

A summary of an autocycle-run with three cycles is shown below. The details of the summary will be discussed in a later chapter on page 49.

TOKAI densitometer - Run Type: Autocycle
Summary for 3 Cycles

Sample ID: FOILAU1 Current Date: 06-AUG-85 12:15:44
Operator ID: KLJUNCK St. thru Date: 06-AUG-85 08:37:58
Last Data file: DL1:FOILAU.04C
Constants File: SY:PARMTR.DEN Constants Date: 05-AUG-85 16:21:39
Delta MuX = 6.65370 Extrapolated: 6.74618

* * * * *

Pu density(raw)		Pu density(-outlier)	
(original)	(extrap.)	(original)	(extrap.)
230.580	230.573	230.580	230.573
231.932	231.862	231.932	231.862
228.192	228.208	228.192	228.208
Sigma of value :		1.894(0.823%)	1.853(0.805%) (extrp)
(Standard dev)			
Mean of Pu density (gm/L) =		230.235	230.214 (extrp)
Absolute sigma of mean =		1.094	
Fractional sigma =		0.475(%)	

**SB -
Straight through -
Background**

The straight-through background data should be measured weekly. The SB measurement consists of three runs: a background or no-source run, a run with the selenium-75 (Se) source in position, and a run with the cobalt-59 (Co) source in position. The operator should count for a long enough time to reduce the error resulting from counting statistics to a negligible level. It is recommended that the count time for each run be at least 1000 seconds long, preferably 2000 seconds. The warning message (MEASUREMENT CONTROL BACKGROUND RUN SHOULD BE MADE) is printed if the SB is not done within the specified interval (the interval is set in the CDENSIT program). The SB measurement time is set in the CDENSIT program, but it can be altered in the supervisory default option (see D - Default on page 31). A message is shown on the CRT to remind the operator to remove any sample from the measuring well before starting the data acquisitions.

The output header block reads: Sample ID: NO SAMPLE. The data are used to rewrite SY:BACKGR.DEN, the background file, which is used for each subsequent measurement. The data are also written to any disks set by the default option.

The file name used for SB runs is MCddmm.01S, where

MC implies measurement control data,
dd is the day of the month (1-31),
mm is a two-letter abbreviation of the month,
where May is MY and July is JL.

SB - 01 is the number of the run (This begins
Straight through - the day as 01 and is automatically incre-
Background mented for each SB run.), and
(cont) S denotes the type of spectra: B-blank/no
source, S-selenium, or C-cobalt.

For example, the SB measurement performed on
June 1 has the file name:

MC01JU.01B

MC01JU.01S

MC01JU.01C

The SB run is logged in the MC Log file.

The following is a typical series of messages and
operator inputs seen on the CRT when initiating
an SB run. Operator responses are underlined.

06-AUG-85 08:19:36 Enter OPTION (H or HS to see Menu) -> SB
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->

Remove any sample, then press RETURN ->

The following is displayed on the screen during
data acquisition:

```
Straight Through - Background
Moving Source Wheel to Blank Position
Starting a 1000. sec run at 08:20:07 (06-AUG-85) ends Today at 08:36
MC06AU.01B written to DLI:
Moving Source Wheel to Se Position
Starting a 1000. sec run at 08:38:01 (06-AUG-85) ends Today at 08:54
MC06AU.01S written to DLI:
Moving Source Wheel to Co Position
Starting a 1000. sec run at 08:56:01 (06-AUG-85) ends Today at 09:12
MC06AU.01C written to DLI:

Writing SY:BACKGR.DEN
SY:BACKGR.DEN Written 06-AUG-85 09:12:47
Moving Source Wheel to Blank Position
```

SB
Straight through -
Background
(cont)

The output of the SB run contains the standard header block. Under the heading of background, the peak areas collected during background runs are listed for each energy. These are used in each assay to correct for background. Next, the normalized peak areas for the straight-through runs (selenium and cobalt runs) plus their corresponding peak centroids and resolutions (in keV) are listed. Below is a sample SB output.

TOKAI densitometer -

Run Type: Sthru-Bk

Sample ID: NO SAMPLE
Operator ID: KLJUNCK
Last Data File: DL1:MC06AU.01C
Delta MuX = 6.65370
Live time (sec): 938.

Current Date: 06-AUG-85 09:12:47
St. thru Date: 06-AUG-85 08:37:58
Extrapolated: 6.74618
Clock time (sec): 1000.

Energy	Background	%err	Norm st area	%err	Centroid	FWHM
88.04	0.46220E+06	0.15	0.40657E+06	0.18	1157.1	0.521
122.06	0.46697E-04	110.40	0.48284E+01	0.19	1644.6	0.570
121.11	-0.15918E-04	255.38	0.44806E+00	0.30	1629.8	0.562
136.00	0.15948E-04	206.99	0.12467E+01	0.22	1842.4	0.586
279.53	-0.74172E-05	114.13	0.10450E+00	0.51	2893.0	0.787

**MB - Measurement
control - Bias**

This statistical check is done to monitor the validity of the calibration and to continually test for bias. This check should be performed daily. If the check is not performed within a specified time (set in the CDENSIT program), the warning message (MEASUREMENT CONTROL BIAS RUN SHOULD BE MADE) is printed informing the operator an MB run should be made. The standard foil is measured and the result is compared with the accepted value. Two limits, a warning limit and an action limit, are set at two and three times the standard deviation, which is preset in the CDENSIT program. These limits represent approximately 5% and 0.3% failure rate, respectively, assuming a normal distribution of the foil assays.

If either of these limits is exceeded, an appropriate warning message is shown and the operator is given the choice of repeating the bias run or aborting. If the last bias run failed, a message is shown to notify the operator.

In addition to the standard deviation, the foil reference value is also entered using the CDENSIT program. Because the foil value cannot be determined independently by other means (for example, chemical analysis), the foil value has to be determined by repeated assays after a careful calibration. This check, therefore, is most useful in detecting a relative change after a calibration.

MB - Measurement
control - Bias
(cont)

The following is a typical series of messages and operator inputs seen on the CRT when initiating an MB run. Operator responses are underlined.

06-AUG-85 13:36:33 Enter OPTION (H or HS to see Menu) -> MB
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF A BIAS RUN
Enter sample ID or RETURN to escape -> FOILMB1

When sample is ready for assay, press RETURN ->
PAUSE - Put Ta foil in, <CR> to continue -

Note that <CR> means press RETURN (the carriage return).

The following is printed before and during the selenium data acquisition.

Moving Source Wheel to Se Position
Starting a 500. sec run at 13:37:27 (06-AUG-85) ends Today at 13:45
FOILMB.01S written to D11:
PAUSE - Put Ta foil in, <CR> to continue

User action is required to insert a different tantalum (Ta) foil before the cobalt data acquisition.

Moving Source Wheel to Co Position
Starting a 500. sec run at 13:58:36 (06-AUG-85) ends Today at 14:06
FOILMB.01C written to D11:
Moving Source Wheel to Blank Position

The output for the MC Bias run is very similar to that of a single-pass assay. After printing the plutonium density of the standard, this value is compared with the reference value, and the difference is calculated. If the difference is too large, then the appropriate warning message is printed. A sample output of an MB run follows.

MB - Measurement
control - Bias
(cont)

TOKAI densitometer -

Run Type: MC Bias

Sample ID: FOILMB1 Current Date: 06-AUG-85 14:07:02
 Operator ID: KLJUNCK St. thru Date: 06-AUG-85 08:37:58
 Last Data file: DL1:FOILMB.01C
 Constants File: SY:PARMTR.DEN Constants Date: 05-AUG-85 16:21:39
 Delta MuX = 6.65370 Extrapolated: 6.74618
 Live time (sec): 489 Clock time (sec): 500.

EXAMPLE OF A BIAS RUN

* * * * *

Energy	Isotope	Centroid	FWHM	Norm Area	%err	Transmission	%err
88.04	CD109	1157.1	0.517	225356.359	0.22	0.00000	00.00
122.06	CO57	1644.6	0.566	0.528	0.38	0.10925	0.42
121.11	SE75	1629.9	0.559	0.225	0.54	0.50317	0.62
136.00	SE75	1842.4	0.580	0.228	0.54	0.18256	0.58
279.53	SE75	3893.1	0.798	0.073	0.83	0.70252	0.97

Pu Density(gm/l) = 229.5323 +/- 1.128 (0.5 %)
 Pu Density(gm/l) = 229.5115 +/- 1.128 (0.5 %) (Extrapolate to edge)
 This measurement = 229.53
 (Standard value = 228.70)
 (Historical SD = 1.37)
 Difference (in SD units) = 0.61

**MP - Measurement
control - Precision**

This check verifies that the random error of the instrument is adequately predicted by counting statistics. The standard foil is used for 5 or 15 repeated assays (the number of runs is set in the CDENSIT program). This check should be done on a monthly basis. If an MP run has not been made in this interval, the warning message (MEASUREMENT CONTROL PRECISION RUN SHOULD BE MADE) is printed. The check is accomplished by comparing the observed standard deviation from the repeated runs to that estimated from propagated counting statistics; when they are in perfect agreement, the reduced chi square = 1. Warning and action limits are fixed in the program corresponding to 5% and 1% failure rate, respectively. If either limit fails, an appropriate warning message is printed. If the last precision run failed, a message is shown at the beginning of any subsequent assay to inform the operator.

The following is a sample dialog to initiate an MP run. Operator responses are underlined.

07-AUG-85 08:56:41 Enter OPTION (H or HS to see Menu) -> MP
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->
TESTING FOR MANUAL
Enter sample ID or RETURN to escape -> FOIL

When sample is ready for assay: press RETURN ->

MP - Measurement The following is printed during each cycle.
 control - Precision
 (cont)

Moving Source Wheel to Se Position

Starting a 200. sec run at 08:57:18 (07-AUG-85) ends Today at 09:00

FOIL .01S written to DL1:

Moving Source Wheel to Co Position

Starting a 200. sec run at 09:01:58 (07-AUG-85) ends Today at 09:05

FOIL .01C written to DL1:

Moving Source Wheel to Blank Position

The summary of an MP run includes the standard header block, each result with a fractional sigma and an absolute sigma, the average result, the mean square sigma, the standard deviation, and the chi square. A sample summary follows.

TOKAI densitometer - Run Type: MC PRECN
 Summary for 15 Cycles

Sample ID: FOILMP Current Date: 07-AUG-85 14:09:38
 Operator ID: KLJKUNCK St. thru Date: 06-AUG-85 08:37:58
 Last Data file: DL1:FOILMP.16C
 Constants File: SY:PARMTR.DEN Constants Date: 05-AUG-85 16:21:39
 Delta MuX = 6.65370 Extrapolated: 6.74618
 * * * * *

Cycle	Result	Fract Sigma	Abs. Sigma
1	230.5308	0.0072	1.6522
2	230.2306	0.0072	1.6585
3	230.3021	0.0072	1.6648
4	228.1151	0.0073	1.6637
5	227.0323	0.0073	1.6663
6	227.5935	0.0073	1.6547
7	227.8474	0.0073	1.6558
8	229.1571	0.0072	1.6574
9	230.5973	0.0072	1.6582
10	228.4816	0.0073	1.6707
11	227.3398	0.0073	1.6686
12	226.3193	0.0073	1.6569
13	228.0303	0.0073	1.6612
14	228.2352	0.0073	1.6600
15	227.4471	0.0073	1.6626

Average result = 228.4840

Observed variance (repeated measurement) = 1.8747

Estimated variance (propagated count
 statistics) = 2.7582 (average)
 Chi square = 0.6797

SUPERVISOR OPTIONS

These options are available in the same fashion as the operator options previously discussed. They are not included in the operator menu because they are not routinely used. Only well-trained personnel should use these options because their usage can require additional input.

AD - Assay from Disk

This option analyzes data from the disk. The data are read directly into the computer, and the multichannel analyzer (MCA) is by-passed. The operator must input the entire file name except for the run-type letter on the extension. If two file names are identical, the computer uses the set of data with the highest version number. An S or C is automatically appended to the file name and then the file is opened. For example, to analyze the set of data DY0:PUSOL1.01S and DY0:PUSOL1.01C, the operator should input DY0:PUSOL1.01 when the file name is requested.

The following is a typical series of messages and operator inputs as seen on the CRT when initiating an AD run. Operator responses are underlined.

```
05-AUG-85 15:22:20 Enter OPTION (H or HS to see Menu) -> AD
  Assay from Disk
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF ASSAY FROM DISK
Enter the full filename -> DL1:PUSOL1.01
Use original (O) or most recent (R) straight through? R
```

Note that the original straight-through results are stored in the data file.

AD - Assay from Disk

(cont)

The output of an Assay from Disk is similar to the output of a single-pass assay. The run type is different, and the header block contains the input file. Below is a sample output.

TOKAI densitometer -

Run Type: Assy Dsk

Input file: DL1:PUSOL1.01 Current Date: 05-AUG-85 15:22:20
Operator ID: KLJUNCK St. thru Date: 01-AUG-85 14:58:27
Constants File: SY:PARMTR.DEN Constants Date: 19-JUL-85 11:48:59
Delta MuX = 6.65370 Extrapolated: 6.74618
Live time (sec): 291. Clock time (sec): 300.

EXAMPLE OF ASSAY FROM DISK

* * * * *

Energy	Isotope	Centroid	FWHM	Norm Area	%err	Transmission	%err
88.04	CD109	1157.1	0.517	134914.500	0.29	0.00000	00.00
122.06	CO57	1644.6	0.565	0.530	0.48	0.10133	1.27
121.11	SE75	1629.9	0.552	0.225	0.70	0.45066	1.90
136.00	SE75	1842.5	0.587	0.232	0.69	0.16810	1.49
279.53	SE75	3893.0	0.808	0.074	1.06	0.60802	3.08

Pu Density(gm/l) = 224.2845 +/- 3.431 (1.5 %)
Pu Density(gm/l) = 224.4372 +/- 3.433 (1.5 %) (Extrapolate to edge)

AUD - Autocycle
from Disk

This option is similar to the AD option just discussed. Data are read and analyzed by the computer and do not go to the MCA. The operator must input the starting file name and the number of cycles. The starting file name does not necessarily have to be the file with the extension .01. The operator must be aware of the number of cycles on the disk for a given run and cannot exceed the last cycle of the run. The List-Assay log option may be helpful.

The following are typical inputs and displays shown on the CRT while initiating an autocycle from a disk run. The user responses are underlined.

22-OCT-85 08:02:53 Enter OPTION (H or HS to see Menu) -> AUD
Enter operator ID (up to 8 chars) or RETURN to escape -> JKJS
Enter remark (80 char.) ->
TEST AUD OPTION
Enter the full filename -> DL1:PUA217.01
Enter number of cycles (1-25) -> 5
Use original (O) or most recent (R) straight through? O

AUD - Autocycle
from Disk
(cont)

The output of an autocycle from disk is similar to the output of an autocycle run. The run type is different, and the input file is included in the header block. After all the cycles have been completed, a summary of the autocycles is printed. Below is a sample summary output.

TOKAI densitometer -	Run Type: AutoDisk
Summary for	5 Cycles
Operator ID: JKSJ	St. thru Date: 06-AUG-85 08:37:58
Constants File: SY:PARMTR.DEN	Constants Date: 09-AUG-85 07:52:22
Delta MuX = 6.65370	Extrapolated: 6.74618
* * * * *	* * * * *

Pu density(raw)		Pu density(-outlier)	
(original)	(extrap.)	(original)	(extrap.)
226.648	226.510	226.648	226.510
229.289	229.244	229.289	229.244
229.605	229.472	229.605	229.472
227.649	227.659	227.649	227.659
226.353	226.213	226.353	226.213
Sigma of value :		1.489 (0.653%)	1.507 (0.662%)
(Standard dev)			
Mean of Pu density (gm/L) =		227.909	227.820(extrp)
Absolute sigma =		0.696	
Fractional sigma =		0.305(%)	

SBD - SB from Disk

The SBD option is similar to the SB option, except that the data are taken from the disk. The operator inputs the entire file name without the run-type letter on the extension, for example, DY0:MC06AU.01. In this case, the disk in the drive DY0 has to have the files MC06AU.01B, MC06AU.01S, and MC06AU.01C in order for this option to be successful. The operator is given the option to rewrite the background file SY:BACKGR.DEN based on the disk data or to retain the current background file. If the current file is retained, only the values in the computer are changed. These values remain in effect until the next SB, or SBD option is completed, or until the DENSIT program is started again.

The following is a sample dialog to initiate an SBD run.

```
08-AUG-85 08:40:22 Enter OPTION (H or HS to see Menu) -> SBD
St thru - Background from disk
Enter operator ID (up to 8 chars) or RETURN to escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF AN SBD RUN
Enter the full filename -> DL1:MC06AU.01
Do you want to write a new BACKGR.DEN file ? (y/n) -> N
```

The output of an SBD run is similar to that of an SB run. The run type is changed appropriately, and the input file is listed in the header block. A sample SBD output follows:

SBD - SB from Disk

(cont)

TOKAI densitometer -

Run Type: SthruDsk

Input file: DL1:MC06AU.01

Current Date: 08-AUG-85 08:40:22

Operator ID: KLJUNCK

St. thru Date: 06-AUG-85 08:37:58

Delta MuX = 6.65370

Extrapolated: 6.74618

Live time (sec): 0.

Clock time (sec): 0.

EXAMPLE OF AN SBD RUN

* * * * *

Energy	Background	%err	Norm st area	%err	Centroid	FWHM
88.04	0.46220E+06	0.15	0.40657E+06	0.18	1157.1	0.521
122.06	0.46697E-04	110.40	0.48284E+01	0.19	1644.6	0.570
121.11	-0.15918E-04	255.38	0.44806E+00	0.30	1629.8	0.562
136.00	0.15948E-04	206.99	0.12467E+01	0.22	1842.4	0.586
279.53	-0.74172E-05	114.13	0.10450E+00	0.51	3893.0	0.787

C - Calibration

A calibration run consists of several measurements made on a standard. The operator inputs the concentration of the standard and the number of measurements to be made. Based upon the known standard concentration, the computer calculates a new value of $\Delta\mu x$ and the extrapolated $\Delta\mu x$ for each measurement. The sample ID is used as the file name in the same manner as an assay. The calibration measurement spectra may be written to a disk by the same method as assay data are written.

The following is a sample dialog used to initiate a calibration run with three cycles. The operator responses are underlined.

```
06-AUG-85 07:19:09 Enter OPTION (H or HS to see Menu) -> C
Enter operator ID (up to 8 chars) or RETURN TO escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF A CALIBRATION RUN
Enter sample ID or RETURN to escape -> FOIL
Enter number of calibration cycles (1-25) -> 3
Enter known concentration (g/l) -> 225.00
```

The following is displayed on the screen during data acquisition.

```
When sample is ready for assay, press RETURN ->
Pause between each assay ? (y/n) -> N
```

Calibration run

```
Moving Source Wheel to Se Position
Starting a 500. sec run at 07:13:01 (06-AUG-85) ends Today at 07:21
FOIL .01S written to DL1:
Moving Source Wheel to Co Position
Starting a 500. sec run at 07:22:41 (06-AUG-85) ends Today at 07:31
FOIL .01C written to DL1:
Moving Source Wheel to Blank Position
```

C - Calibration
(cont)

The output of each calibration cycle is similar to that of an assay or autocycle run. The summary contains all of the $\Delta\mu x$ values (both original and extrapolated) and calculates the average and the standard deviations. Below is a sample of the summary of a calibration run with three cycles. The $\Delta\mu x$ values in the header are from the old calibration.

TOKAI densitometer -
Summary forRun Type: Calibrat
3 Cycles

Sample ID:	FOIL	Current Date:	06-AUG-85	08:10:19
Operator ID:	KLJUNCK	St. thru Date:	05-AUG-85	14:58:27
Last Data file	DL1:FOIL .01			
Constants File:	SY:PARMTR.DEN	Constants Date:	05-AUG-85	16:21:39
Delta MuX =	6.65370	Extrapolated:	6.74618	

* * * * *

	DelMuX(orig)	DelMuX(extrap)
	6.6359	6.7295
	6.6644	6.7594
	6.6065	6.7012
Average	6.6356	6.7300
St Dev	0.0289	0.0291
Concentration of standard =	225.000 (g/l)	

**CD - Calibration
from Disk**

This option produces a calibration run from data stored on a disk. The operator inputs the starting file name (the one-character run type is appended by the computer) and the number of cycles. The operator must be aware of the number of runs under the file name on the disk and must not exceed this number.

The following is a sample dialog to initiate a CD run. Operator inputs are underlined.

```
08-AUG-85 08:12:41 Enter OPTION (H or HS to see Menu) -> CD
Enter operator ID (up to 8 chars) or RETURN TO escape -> KLJUNCK
Enter remark (80 char.) ->
EXAMPLE OF CALIB FROM DISK
Enter the full filename -> DL1:FOIL.01
Enter number of calibration cycles (1-25) -> 3
Enter known concentration (g/l) -> 225.0
Use original (O) or most recent (R) straight through? O
```

The output of a CD run is identical to that of a calibration run.

D - Default

The default option allows the operator to change various parameters. These changes are not permanent but remain in effect until the program is terminated or the operator enters the default option again.

When this option is selected, a menu of the parameters appears, and by entering the appropriate number, a parameter may be changed. If the parameter has a True/False flag, entering its number changes the flag from True to False or vice versa.

1. Long Printout

If set to T, the output will contain the output header block; any warning messages; a table listing all five peaks, energies, centroids, FWHM, area, percent error in area, transmission, and percent error in transmission; and two results representing the plutonium density in grams/liter and the plutonium density in grams/liter after extrapolating to the K-absorption edge. The default of the long printout is T.

If set to F, the output is identical to the long printout without the table for the five peaks.

2. Write data to Disk

If set to T, data will be written to the storage disks flagged in parameters 3 through 7. If set to F, no data are saved. The default setting is T.

D - Default

(cont)

3. Write data to DL1
4. Write data to DY0
5. Write data to DY1
6. Write data to DY2
7. Write data to DY3

If flag 2 has been set to T, then data from A, AU, SB, or C options are written on each disk whose flag has been set to T. If flag 2 has been set to F, then no data are written and the parameters 3 through 7 are not listed.

The default settings for 3 and 4 are T, and for 5, 6, and 7 are F.

The hard disk DL1 is a public device that each operator can write to. The floppy diskettes must be allocated, mounted, and initialized to the appropriate (private) operator, before the operator can write to them.

8. Preset assay time

Upon entering parameter number 8, all five of the preset assay times are displayed:

AssayTim(1) - is the assay count time for the Se source data acquisition. Default value is 300 s.

D - Default
(cont)

AssayTim(2) - is the assay count time for the Co source data acquisition. Default value is 300 s.

SthruTim(1) - is the SB count time for the Se source data acquisition. Default value is 1000 s.

SthruTim(2) - is the SB count time for the Co source data acquisition. Default value is 1000 s.

StBkTim(3) - is the SB count time for the background/no source data acquisition. Default value is 1000 s.

These values are in seconds of clock time. A message asks the operator to enter Y if the times are correct and N if any one of them is incorrect. If the answer is Y, the operator is returned to the default option menu. If the answer is N, the five preset times are paged through individually. Pressing RETURN will keep the time currently set. Typing a new time and RETURN replaces that preset time. After paging through all five times, they are listed, and the correct/incorrect question is asked again. The original default time settings are determined by the CDENSIT program. Note that it is important to use longer count times for the SB acquisitions.

9. Constants file: PARMTR.DEN

The current constants file is displayed in

D - Default

(cont)

the menu. To change this file, enter 9.

Next a menu of five constants files is displayed. The operator may choose any of the listed files or use option 5 to name another file not currently in the menu. The default constants file is the first in the list and is named by the CDENSIT program. The usual constants file is SY:PARMTR.DEN.

10. Output device: TT1->TT5->Terminal

The current output device (LP) is listed in the menu--either TT1, TT5, or Terminal. Entering 10 causes a change from one device to the next. The two line printers have labels indicating which is TT1 and which is TT5.

In the following examples, all operator responses are underlined. The dialog shows the sequence of events to change the output device from TT5 to terminal.

1. Long printout = T
2. Write Data to disk = T
3. to DL1 = T
4. to DY0 = T
5. to DY1 = F
6. to DY2 = F
7. to DY3 = F
8. Preset assay time :
9. Constants file = SY:PARMTR.DEN
10. Output Device = LP ->TT5

Enter number (1-10) to change (RETURN for no change) -> 10

1. Long printout = T
2. Write data to disk = T
3. to DL1 = T
4. to DY0 = T
5. to DY1 = F
6. to DY2 = F
7. to DY3 = F
8. Preset assay time :
9. Constants file = SY:PARMTR.DEN
10. Output Device = Terminal

D - Default

(cont)

The following sequence of events changes the
write to disk flag from T to F.

02-AUG-85 12:24:56 Enter OPTION (H or HS to see Menu) -> D

1. Long printout = T
2. Write data to disk = T
3. to DL1 = T
4. to DY0 = T
5. to DY1 = F
6. to DY2 = F
7. to DY3 = F
8. Preset assay time :
9. Constants file = SY:PARMTR.DEN
10. Output Device = LP ->TT5

Enter number (1-10) to change (RETURN for no change) -> 2

1. Long printout = T
2. Write data to disk = F
8. Preset assay time :
9. Constants file = SY:PARMTR.DEN
10. Output Device = LP ->TT5

The following sequence will change the assay times
from 10 seconds and 8 seconds to 60 seconds.

Enter number (1-10) to change (RETURN for no change) -> 8

Preset time (sec)

Assay : (Se)	10.	Assay : (Co)	8.
St thru : (Se)	30.	St thru : (Co)	30.
St thru : (Bk)	60		

Are these times correct ? (y/n) -> N

Index 1 = Se Index 2 = Co

AssayTim(1) = 10.0000 -> 60.0

SthruTim (1) = 30.0000 ->

AssayTim(2) = 8.00000 -> 60.0

SthruTim(2) = 30.0000 ->

StBk Tim (3) = 60.0000 ->

Preset time (sec)

Assay : (Se)	60.	Assay : (Co)	60.
St thru : (Se)	30.	St thru : (Co)	30.
St thru : (Bk)	60.		

Are these times correct ? (y/n) -> Y

D - Default

(cont)

The following sequence changes the parameter file
from SY:PARMTR.DEN to SY:PARMTR.002.

Enter number (1-10) to change (RETURN for no change) -> 9

The constants file read was: SY:PARMTR.DEN USUAL FILE

Do you want to select another constants file? (Y/N) -> Y

The current constants files are:

1	SY:PARMTR.DEN	USUAL FILE
2	SY:PARMTR.002	SECOND FILE
3	SY:PARMTR.003	THIRD FILE
4	SY:PARMTR.004	FOURTH FILE
5	SY:PARMTR.005	FIFTH FILE

Enter constants file selected (1-5) or 6 for new file -> 2

Constants file = SY:PARMTR.002 OK? (Y/N) -> Y

SY:PARMTR.002 was written 18-JUL-85 11:13:56 by KUNO

1. Long printout = T
2. Write data to disk = T
3. to DL1 = T
4. to DY0 = T
5. to DY1 = F
6. to DY2 = F
7. to DY3 = F
8. Preset assay time :
9. Constants file = SY:PARMTR.002
10. Output Device = Terminal

LA - List Assay log

The operator can list a log file three ways: all listings in the log are printed, the most recent n entries are printed (where n is entered by the operator), or all entries within two dates are printed (beginning and ending dates are entered by the operator).

The following dialog lists the last 15 assays recorded in the assay log. Operator responses are underlined.

08-AUG-85 08:35:42 Enter OPTION (H or HS to see Menu) -> LA

Menu of Options for Listing Assay Log

1. Return to main menu
2. List entries between two dates
3. List all entries
4. List n entries

Enter option number -> 4

How many entries do you want listed ? (99 maximum) -> 15

LA - List Assay log

(cont)

Assay log as of 08-AUG-85 08:35:50

Entry	Date	Time	Sample ID	Operator	File	Cycles	Results	Err Flg
1.	07-AUG	15:49	FOIL	KLJUNCK	DL1:FOIL	.06 6/ 6	2.281939E+02	F
2.	07-AUG	15:39	FOIL	KLJUNCK	DL1:FOIL	.05 5/ 6	2.263535E+02	F
3.	07-AUG	15:29	FOIL	KLJUNCK	DL1:FOIL	.04 4/ 6	2.276487E+02	F
4.	07-AUG	15:20	FOIL	KLJUNCK	DL1:FOIL	.03 3/ 6	2.296055E+02	F
5.	07-AUG	15:10	FOIL	KLJUNCK	DL1:FOIL	.02 2/ 6	2.292893E+02	F
6.	07-AUG	15:00	FOIL	KLJUNCK	DL1:FOIL	.01 1/ 6	2.290240E+02	F
7.	07-AUG	08:54	FOIL	KLJUNCK	DL1:FOIL	.05 5/ 5	2.289203E+02	F
8.	07-AUG	08:41	FOIL	KLJUNCK	DL1:FOIL	.04 4/ 5	2.290789E+02	F
9.	07-AUG	08:28	FOIL	KLJUNCK	DL1:FOIL	.03 3/ 5	2.303179E+02	F
10.	07-AUG	08:15	FOIL	KLJUNCK	DL1:FOIL	.02 2/ 5	2.299241E+02	F
11.	07-AUG	08:03	FOIL	KLJUNCK	DL1:FOIL	.01 1/ 5	2.309624E+02	F
12.	06-AUG	16:33	FOILA2	KLJUNCK	DL1:FOILA2	.01 1/ 1	2.305954E+02	F
13.	06-AUG	16:19	FOIL	KLJUNCK	DL1:FOIL	.04 4/ 4	2.269013E+02	F
14.	06-AUG	16:06	FOIL	KLJUNCK	DL1:FOIL	.03 3/ 4	2.299297E+02	F
15.	06-AUG	15:54	FOIL	KLJUNCK	DL1:FOIL	.02 2/ 4	2.277386E+02	F

Most of the assay-log entries are self-explanatory. The error flag is for the diagnostic checks; if any of the limits has been exceeded, then the flag is = T.

The following dialog lists all assays between August 1, 1985, and August 6, 1985. Operator responses are underlined.

LA - List Assay log
(cont)

Menu of Options for Listing Assay Log

1. Return to main menu
2. List entries between two dates
3. List all entries
4. List n entries

Enter option number -> 2Enter start date (most recent) [09-AUG-84] -> 06-AUG-85Enter stop date (oldest) [02-AUG-84] -> 01-AUG-85

Assay log as of 08-AUG-85 08:36:25

Entry	Date	Time	Sample ID	Operator	File	Cycles	Results	Err Flg
1.	06-AUG	16:33	FOILA2	KLJUNCK	DL1:FOILA2.01	1/ 1	2.305954E+02	F
2.	06-AUG	16:19	FOIL	KLJUNCK	DL1:FOIL .04	4/ 4	2.269013E+02	F
3.	06-AUG	16:06	FOIL	KLJUNCK	DL1:FOIL .03	3/ 4	2.299297E+02	F
4.	06-AUG	15:54	FOIL	KLJUNCK	DL1:FOIL .02	2/ 4	2.277386E+02	F
5.	06-AUG	15:41	FOIL	KLJUNCK	DL1:FOIL .01	1/ 4	2.303994E+02	F
6.	06-AUG	15:16	FOIL	KLJUNCK	DL1:FOIL .01	1/ 1	2.307623E+02	F
7.	06-AUG	14:54	FOILA2	KLJUNCK	DL1:FOILA2.01	1/ 1	2.296412E+02	F
8.	06-AUG	12:15	FOILAU1	KLJUNCK	DL1:FOILAU.03	3/ 3	2.281919E+02	F
9.	06-AUG	11:56	FOILAU1	KLJUNCK	DL1:FOILAU.02	2/ 3	2.319319E+02	F
10.	06-AUG	11:36	FOILAU1	KLJUNCK	DL1:FOILAU.01	1/ 3	2.305804E+02	F
11.	06-AUG	11:09	FOILAU1	KLJUNCK	DL1:FOILAU.04	4/ 4	-8.253239E+00	F
12.	06-AUG	10:49	FOILAU1	KLJUNCK	DL1:FOILAU.03	3/ 4	-9.216751E+00	F
13.	06-AUG	10:30	FOILAU1	KLJUNCK	DL1:FOILAU.02	2/ 4	-6.621377E+00	F
14.	06-AUG	10:10	FOILAU1	KLJUNCK	DL1:FOILAU.01	1/ 4	-7.360284E+00	F
15.	06-AUG	09:37	KJFOIL	KLJUNCK	DL1:KJFOIL.01	1/ 1	-5.665236E+00	F
16.	06-AUG	08:10	FOIL	KLJUNCK	DL1:FOIL .01	3/ 3	2.243880E+02	F
17.	05-AUG	16:08	FOIL	KLJUNCK	DL1:FOIL .03	3/ 3	2.323264E+02	F
18.	05-AUG	16:04	FOIL	KLJUNCK	DL1:FOIL .02	2/ 3	2.249753E+02	F
19.	05-AUG	16:00	FOIL	KLJUNCK	DL1:FOIL .01	1/ 3	2.215810E+02	F
20.	02-AUG	16:02	PUSOL1	HSUE	DY2:PUSOL1.01	1/ 3	2.279363E+02	F
21.	02-AUG	15:03	PUSOL1	HSUE	DY2:PUSOL1.01	1/ 1	2.296398E+02	F
22.	01-AUG	16:07	MT	JKSJ	DY0:MT .01	1/ 1	3.364103E+02	T

LM - List MC log

Whereas data from SB runs can be recorded on a storage disk, MB and MP runs cannot. However, results from all three of these measurement control (MC) options are stored on the system disk under the MC log.

The MC log contains date and time of the entry, operator ID, run type (MB, MP, ST), result, fractional error, standard value, number of runs, and status of the error flag.

LM - List MC log
(cont)

The following dialog lists the last 20 entries in
the MC log. Operator responses are underlined.

08-AUG-85 08:36:50 Enter OPTION (H or HS to see Menu) -> LM

Menu of Options for Listing Measurement Control Log

1. Return to Main menu
2. List entries between two dates
3. List all entries
4. List n entries

Enter option number -> 4

How many entries do you want listed ? (99 maximum) -> 20

Measurement control log as of 08-AUG-85 08:37:03

Ent	Date	Time	Operator	Ty	Result	Fractional Error	Standard Value	No Run	Er Fg
1	08-AUG	07:40	KLJUNCK	MB	2.26648E+02	5.007E-03	2.250000E+02	0	F
2	07-AUG	21:18	KLJUNCK	MP	3.24396E-01	4.160E-01	1.282519E+00	15	F
3	07-AUG	14:09	KLJKUNCK	MP	6.79648E-01	1.875E+00	2.758218E+00	15	F
4	07-AUG	11:19	KLJUNCK	MP	1.45932E+00	4.033E+00	2.763580E+00	15	F
5	07-AUG	07:43	KLJUNCK	MB	2.29914E+02	6.042E-03	2.250000E+02	0	F
6	06-AUG	14:07	KLJUNCK	MB	2.29532E+02	4.916E-03	2.250000E+02	0	F
7	06-AUG	09:12	KLJUNCK	ST	1.60913E-01	1.791E+00	1.112932E+01	15	F
8	05-AUG	21:17	KLJUNCK	MP	1.60913E-01	1.791E+00	1.112932E+01	15	T
9	05-AUG	15:20	KLJUNCK	MB	2.09762E+02	3.943E-02	2.250000E+02	0	F
10	05-AUG	15:00	KLJUNCK	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F
11	05-AUG	14:45	KLJUNCK	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F
12	05-AUG	14:36	KLJUNCK	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F
13	02-AUG	15:47	HSUE	MB	2.30006E+02	6.989E-03	2.250000E+02	0	F
14	02-AUG	13:59	HSUE	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F
15	02-AUG	12:24	HSUE	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F
16	19-JUL	12:15	JKSJ	MP	1.24428E+00	3.613E+01	2.904042E+01	5	F
17	19-JUL	06:47	SPRINKLE	MP	2.40421E+02	2.479E-01	3.116085E-01	5	F
18	18-JUL	14:09	KUNO	MB	2.11882E+02	2.622E-02	2.250000E+02	0	F
19	17-JUL	11:13	KUNO	MB	2.10285E+02	2.761E-02	2.250000E+02	0	F
20	16-JUL	21:39	ITSUDA	ST	0.00000E-01	0.000E-01	0.000000E-01	0	F

LR - List combined
Results

This option lists the results of both the densitometer and isotopic systems. These results are stored in the .RES file made at the end of the autocycle (see AU - Autocycle on page 10).

This listing contains operator ID, date of autocycle, number of runs, result, extrapolated result, and a summary of any task H results on that sample. The plutonium isotopic information also is listed if it is available.

The following dialog lists all of the results with the Sample ID Foil. User responses are underlined.

08-AUG-85 08:37:53 Enter OPTION (H or HS to see Menu) -> LR
Enter Sample ID (or filename) -> FOIL

Sample I.D. : FOIL

Densitometry Results

Operator: SPRINKLE
date : 03-JUL-85
Number of runs: 5

216.70 +/- 0.20%

216.68 +/- 0.20%

**OU - Output listing
device**

With this option the operator can name TT1, TT5, or the terminal as the output device. This option is identical to the output-device parameter in the default option (see D - Default on page 31). Enter 6 for TT5, 7 for the terminal, and 8 for TT1. The default is TT5. Changing this parameter automatically changes the default listing also.

The following dialog changes the output device to the terminal. Operator responses are underlined.

```
05-AUG-85 16:17:20 Enter OPTION (H or HS to see Menu) -> OU
Enter 6 for LP ->TT5:
      7 for terminal
      8 for LP ->TT1: 7
```

R - Read data
from disk

This option retrieves one spectrum from the disk and displays it on the MCA. The operator specifies the full file name with complete extensions (that is, the file name must include S, C, or B; for example, DL1:SAMPLE.01B).

05:AUG-85 16:17:43 Enter OPTION (H or HS to see Menu) -> R

Enter full filename [SY:FILENM.EXT] -> DL1:FOIL.02C

W - Write data to disk The spectrum currently in the MCA is written to a disk under the exact file name the operator enters. The operator must enter the complete file name; for example, DL1:SAMPLE.EXT.

05-AUG-85 16:18:30 Enter OPTION (H or HS to see Menu) -> W
Enter full filename [SY:FILENM.EXT] -> DL1:TEST.01C

X - exit from program This option terminates the program. If the operator must quit in the middle of a run, the program may be aborted by holding the control key while typing C. The computer responds with DCL> (cursor). Type ABO DEN and the program will terminate.

05-AUG-85 16:19:31 Enter OPTION (H or HS to see Menu) -> X
Densitometry Program Exiting ...DEN
>

GENERAL

Three types of output are discussed in this section--the output for a routine assay, the summary output for an autocyte assay, and the calibration output.

ASSAY OUTPUT

The routine assay output consists of two portions--the header and the results portion. An example of the output is shown below.

TOKAI densitometer -

Run Type: Assay

Sample ID: PUSOL1 Current Date: 02-AUG-85 15:03:26

Operator ID: HSUE St. thru Date: 02-AUG-85 13:48:36

Last Data file: DY2:PUSOL1.01C

Constants File: SY:PARMTR.DEN Constants Date: 19-JUL-85 11:48:59

Delta MuX = 6.65370 Extrapolated: 6.74618

Live time (sec): 293. Clock time (sec): 300.

PRINT OUT FOR SINGLE ASSAY

* * * * *

Energy	Isotope	Centroid	FWHM	Norm Area	%err	Transmission	%err
88.04	CD109	1157.1	0.520	134579.937	0.29	0.00000	00.00
122.06	CO57	1644.6	0.567	0.536	0.49	0.10918	0.60
121.11	SE75	1629.8	0.570	0.232	0.69	0.50317	0.88
136.00	SE75	1842.5	0.587	0.237	0.69	0.18270	0.80
279.53	SE75	3893.1	0.805	0.075	1.07	0.70940	1.42

Pu Density(gm/l) = 229.6398 +/- 1.605 (0.7 %)

Pu Density(gm/l) = 229.6275 +/- 1.605 (0.7 %) (Extrapolate to edge)

The header includes most of the ancillary information concerning the assay. It contains the instrument name, the assay run type, the sample ID, the operator ID, and the constants file name. In addition, the header also contains the current date and time, the straight-through date, the constants date as well as the assay count time. The calibration constants, the $\Delta\mu x$ values, are also printed in the header.

ASSAY OUTPUT

(cont)

The results portion depicts the plutonium assay concentrations in grams/liter. Two results are printed. The first result, based on the identical calculation as used in the original Tokai densitometer, is based on the transmission ratio between 122.06 and 121.12 keV. The second result is obtained by extrapolating to the K-absorption edge (121.795 keV for plutonium) from the measured transmissions at 121, 122, and 136 keV. The details of the extrapolation are shown in Appendix C. The extrapolated result for plutonium concentration is less biased when a substantial amount of uranium is present.

If the long printout is selected, other information on the photopeaks is also printed. These are explained below:

Energy

This column lists the peak energy in keV.

Isotope

The isotope producing the peak is listed.

Centroid

Centroid of the peak in units of channel is listed.

FWHM

This is the full width at half maximum of each peak in units of keV. FWHM can be used to monitor resolution performance.

Norm Area

This is the peak area normalized to the 88-keV peak, except for the 88 peak, which is the net peak area.

Transmission

This is the the measured transmission except for the 88-keV cadmium peak.

If the autocycle option is selected, the printout has a summary for each cycle in addition to the regular printouts as discussed above. An example of the summary printout is shown below.

Sample ID:	FOILAU1	Current Date:	06-AUG-85	12:15:44
Operator ID:	KLJUNCK	St. thru Date:	06-AUG-85	08:37:58
Last Data file:	DL1:FOILAU.04C			
Constants File:	SY:PARMTR.DEN	Constants Date:	05-AUG-85	16:21:39
Delta MuX =	6.65370	Extrapolated:	6.74618	

★ ★

Pu density(raw)		Pu density(-outlier)	
(original)	(extrap.)	(original)	(extrap.)
230.580	230.573	230.580	230.573
231.932	231.862	231.932	231.862
228.192	228.208	228.192	228.208
Sigma of value : (Standard dev)		1.894 (0.823%)	1.853 (0.805%) (extrp)
Mean of Pu density (gm/L) =		230.235	230.214 (extrap)
Absolute sigma =		1.094	
Fractional sigma =		0.475(%)	

The first part of the summary output is the header, which is similar to the header for the assay output. After the header, the plutonium densities (both the original and the extrapolated) are listed for each of the assay runs. At the completion of autocycle, an outlier test is performed according to the Grubbs² procedure, which is briefly described in Appendix B. The plutonium densities, after the outlier test, are also tabulated. After the tabulation of the plutonium densities, several quantities are printed:

SUMMARY OUTPUT

(cont)

Sigma of value (standard deviation)

The standard deviation of the plutonium densities after the outliers have been removed.

Mean of plutonium density

The average of the plutonium densities after the outliers have been removed.

Absolute sigma

The averaged sigma as predicted by the code divided by the square root of the number of runs. This gives the sigma of the mean.

Fractional sigma

The absolute sigma divided by the average plutonium density.

CALIBRATION OUTPUT

If the calibration option is chosen, each assay output occurs as for the Au option. However, the summary output lists the new $\Delta\mu_X$ values, their average and standard deviations. An example is given below.

```
*****
TOKAI densitometer -          Run Type: Cal Disk
                          Summary for    3 Cycles
Operator ID:      JIM          St. thru Date: 05-AUG-85  14:58:27
Constants File:  SY:PARMTR.DEN  Constants Date: 26-NOV-85  11:10:00
Delta MuX =      6.65370       Extrapolated:    6.74618

      DelMuX(oris)      DelMuX(extrap)

      6.6818            6.7723
      6.7609            6.8556
      6.7704            6.8624
Average 6.7377          6.8301
St. Dev 0.0487          0.0501
Concentration of standard = 222.000 (g/l)
*****
```

If this new calibration is desired in the DENSIT program, the calibration must be entered into the parameter file with the CDENSIT program.

CDENSIT PROGRAM

The CDENSIT program is a separate program that sets various parameters used in the DENSIT program. The CDENSIT program is typically not running. First, the operator must exit the DENSIT program with the X option, then the operator can start CDENSIT by typing

.CDE

A clean exit is provided with the EX option. After running the CDENSIT program, the parameter file SY:PARMTR.DEN can be rewritten. A listing of the parameter file is shown next. In the example the following abbreviations are used:

BO - for peak 1 - net peak area from
last background data
- for other peaks - normalized net
peak area from last background data

BOSIG - fractional uncertainty in BO

AO - for peak 1 - net peak area from
last ⁵⁷Co source SB data
- for other peaks - normalized net
peak area from last SB data

AOSIG - fractional uncertainty in AO

STAB. - stabilization channel

Delta Mux(1) - for original analysis

Delta Mux(2) - for extrapolation analysis

The six diagnostic values are the centroids and FWHM is used for measurement control checks.

CDENSIT PROGRAM

(cont)

19-JUL-85 10:04:45

SY:PARMTR.DEN USUAL FILE
KUNO

Written 18-JUL-85 11:13:56 by

Peak	Isotope	Energy	Windows...
1	CD109	88.036	1139 - 1146
2	CO57	122.060	1623 - 1628
3	SE75	121.115	1614 - 1620
4	SE75	136.000	1626 - 1831
5	SE75	279.528	3865 - 3876

SY:BACKGR.DEN Written 16-JUL-85 21:39:10

Peak	Isotope	Energy	BO	BOSIG	AO	AOSIG
1	CD109	88.036	0.24229E+07	0.67842E-03	0.17021E+07	0.84460E-03
2	CO57	122.060	0.39451E-04	1.1916	12.671	0.87300E-03
3	SE75	121.115	0.28538E-04	1.2483	1.4236	0.11045E-02
4	SE75	136.000	0.84195E-05	3.7544	4.2958	0.94609E-03
5	SE75	279.528	0.10858E-04	0.90205	0.51871	0.13787E-02

E-Slope	=	0.699905E-01	E-Offset	=	7.05699
Energy keV	=	88.0360	Centroid	=	1157.50
Energy keV	=	279.528	Centroid	=	3893.50

Isotope	Indx1	Indx2	Stab.	Half Life(days)
1 SE75	3	5	3893	118.452
2 CO57	2	2	1851	271.651
3 PU	6	10	2878	693147.187
4 CD109	1	1	1157	453.000
6 BACKGR	2	5	3893	0.100

Preset time (sec)

Assay : (Se)	10.0	Assay : (Co)	8.0
St Thru: (Se)	9.0	St. Thru: (Co)	7.0
St Thru: (Bk)	6.0		
St thru - background interval (days)	=	5.0	

Calibration constants

Delta MuX (1)	=	6.65370
Delta MuX (2)	=	6.74270

Measurement Control

	Bias	Precision
Interval(day) =	3.00000	30.0000
Reference =	225.000	
Standard Dev. =	20.0000	
Cycles =		5

Diagnostic max = 6

Diagnostic Value	Diagnostic Limit
1157.50	1.00000
1644.50	1.00000
3893.50	1.00000
0.513000	0.100000
0.568000	0.114000
0.777000	0.155000

CDENSIT PROGRAM

(cont)

Any changes can be made permanent; thus, this program should only be used by authorized personnel. Very few of these options should ever be needed once the system is running.

WARNING: THIS PROGRAM SHOULD BE USED WITH CAUTION!

CODE-OPTION

HE - HElp
EN - ENergies
WI - WIndows
ST - STabilizer channels
HF - HalF lives
IS - ISotope names and indices
EC - Energy Calibration
MC - Measurement Control
PT - Preset Time
RD - Read constants from Disk
LI - LIst all constants
OU - Change listing device
CC - Calibration Constant
DD - Data Diagnostics
EX - EXit

HE - HElp

This option displays the menu of the CDENSIT program.

EN - ENergies

This option allows the operator to change the peak energies. The format of this option is used for several other options. Each energy is listed one at a time. If RETURN is pressed, the old value is kept. To replace a value, simply type in the new value when the appropriate old value is listed.

WI - Windows

This option sets the channels for the low-background window, peak window, and high-background window. The operator enters the peak number (1 through 5) to be changed. The energy and six channel numbers are displayed with a question asking whether these values should be changed. If Y, the operator enters six channel numbers separated by commas. If N, the program asks for the next peak number. If the operator enters 0, the program control is transferred back to the main menu.

ST - Stabilizer
channels

This sets the channel numbers for the peak centroid used by the stabilizer. The peak is placed in the channel number listed plus one-half channel. The format is identical to the EN option and is in units of channels.

HF - Half lives

This lists the half-life of the isotopes used in the data analysis. The format is identical to the EN option and is in units of days.

IS - ISotope names
and indices

This option defines the portions of the array where the various isotopes go. For each isotope, a beginning index number and ending index number are given. The format is identical to the EN option. The system was delivered with ^{109}Cd in index 1, ^{57}Co in index 2, and ^{75}Se in indices 3, 4, and 5.

EC - Energy
Calibration

These parameters are used by the MCA to calibrate points on the x-axis to an energy in kiloelectron volts. The format is identical to the EN option.

- MC - Measurement Control** These parameters control the MB and MP runs. BIASTIME is the maximum interval of time (in days) allowable between bias runs. If this time is exceeded, a warning message is printed informing the operator it is time for a bias run. BIASREF contains the reference value of the standard foil. HISTSTD is the standard deviation of the foil bias runs. PRCSTIME is the maximum interval of time between precision runs. NO. RUNS can be set to 5 or 15 and is the number of cycles in a precision run.
- PT - Preset Time** These parameters are the same times found in the default option's preset times of the program DENSIT. The values here are the initial values that DENSIT uses. The format is identical to the EN option and is in units of seconds. The additional parameter STINTEV is the maximum interval of time (days) between SB runs.
- RD - Read constants from Disk** This option is similar to the change of constants option in the DENSIT default option. It determines which constants file will be the default constants file used when the DENSIT program is run (see p. 32 for more information).
- LI - LIst all constants** This option provides a copy of all the current constants in the CDENSIT program. The output device is chosen in the next option.
- OU - change Output listing device** This option determines the default output device when the DENSIT program is run. Either 6 is entered for TT5, 7 for terminal, or 8 for TT1.

CC - Calibration Constant	This option contains the values of $\Delta\mu x$ and $\Delta\mu x$ extrapolated. The format is identical to the EN option.
DD - Data Diagnostics	This option contains the diagnostic parameters for centroid positioning and resolution of each of the five peaks. The format is similar to the EN option.
EX - EXit from changes	This option exits the CDENSIT program. A prompt asks if the changes should be made permanent. If Y (yes), then the constants file chosen in the RD option is written. SY:PARMTR.DEN is the default file.

GENERAL

The RSX-11M system has several types of error messages. The Executive Reference Manual lists system error messages. The FORTRAN 77 manual lists the FORTRAN error messages. The error messages built into the source code are listed below, with an occasional comment for explanation or suggested follow-up.

MESSAGES

88-KEV(CD) PEAK CENTROID PROBLEM)

88-KEV(CD) PEAK RESOLUTION PROBLEM) Data are probably defective; check the

122-KEV(CO) PEAK CENTROID PROBLEM) stabilizer, high voltage, and source

122-KEV(CO) PEAK RESOLUTION PROBLEM) position.

279-KEV(SE) PEAK CENTROID PROBLEM)

279-KEV(SE) PEAK RESOLUTION PROBLEM)

nnn-KEV PEAK IS TOO NARROW
FOR A GAUSSIAN FIT

Data are probably defective.

ADC IS STILL ON

Program expects analog-to-digital (ADC) to be finished. This problem has occurred when the ND66 clock runs at a slower rate than the DEC clock.

ALTER PRIORITY ERROR-RSX

RSX-11M system problem.

ANSWER WAS IMPROPER

Try again.

BAD ACKNOWLEDGE - HOLD/ON/RESET

Stabilizer communications error.

BIAS CHECK ACTION LIMITS EXCEEDED

Check the reference and historical standard deviation values, especially if there are new sources.

MESSAGES

(cont)

BIAS CHECK WARNING LIMITS EXCEEDED	Try again.
CANNOT USE GAUSSIAN ON nnn KEV PEAK DUE TO NONPOSITIVE VALUES	No peak was found at nnn kev.
CHECKPOINT ERROR	RSX system problem.
DATAND ERROR - ADC# nnn NFIRST = nnn NLAST = nnn	Error in calling parameters; invalid choice of windows (ROI).
DATAND - RECEIVE ERROR = nnn	Transmission error with ND66; repeat assay.
DECODE ERROR POS	RSX system error; reboot system.
DSS ERROR IN DTAOUT	Tried to set stabilizer channels and failed; is hardware all right?
ENCODE ERROR - DATAND	Transmission error; repeat assay.
ENCODE ERROR IN ACQRND	Problem trying to encode up to 5-digit preset time to send to ND66.
ENTRY NUMBER nnn WAS NOT LISTED	Invalid number; try again.
ERROR ACQRND LIVTIM = nnn CLKTIM = nnn	Transmission error with ND66; received invalid times.
ERROR ANSLOG	An error occurred in the routine that writes to the combined results file.

MESSAGES

(cont)

ERROR BUSY EF	RSX system error in reading event flag; restart DENSIT program.
ERROR BUSY WAITED nnn SEC	Expected event flag to be cleared by now; other job (isotopics) halted prematurely? Or perhaps a system problem? Try again. If that fails, try to exit and restart DENSIT code; if that fails, reboot system.
ERROR - DATAND DECODE nnn NFIRST = nnn	Received wrong number of characters in spectral data transmission. Repeat assay.
ERROR IN OPENING FILE	Does file exist? Is the device valid, mounted, and does the device contain the correct disk?.
ERROR IN POS GETMCR CALL	RSX system error; reboot system.
ERROR IN READING FILE	File is probably corrupted.
ERROR IN SLEEP CALL MARK IDS = nnn	RSX error; look up error message in RSX Executive Reference Manual.
ERROR IN SLEEP CALL WAIT,IDS = nnn - RSX error	Look up error message in RSX Executive Reference Manual.
ERROR IN WRITING FILE	Enough space on disk?
ERROR PEAKS COMON	ND66 communications error; occurs in FORTRAN subroutine COMON called by subroutine PEAKS.

MESSAGES

(cont)

EVENT FLAG ERROR	This will also print the routine calling the event flag and the flag number; probably an RSX system problem; reboot?
FILENAME IS TOO LONG	Up to nine characters allowed in file name.
FILENAME PROBLEM	May need to restart program; use a valid file name.
GET ANOTHER COPY ILLEGAL FILE FORMAT	File is probably corrupted.
INCORRECT DAY NUMBER	Check the input date.
INCORRECT MONTH NUMBER	Check the input date.
INCORRECT YEAR NUMBER	Check the input date.
INITND FAILED	Program cannot initialize ND66; reset ND66 or test communications with TESTND (especially DATAND option).
INPUT MUST BE A LETTER	Try again.
IS THE DISK ALLOCATED, MOUNTED & INITIALIZED? OR FULL?	If not, fix it.

MESSAGES

(cont)

NO COMMAND LINE IN POS CALL, ENTER 1,2, OR 3	POS is the stand-alone program that controls the Geneva mechanism (1=SE,2=CO,3=BLANK).
NO DOT IN FILENAME	Cannot find extension (that is, .01S).
PRECISION CHECK ACTION LIMITS EXCEEDED	Error is much larger than that expected from counting statistics. Find what is fluctuating.
PRECISION CHECK WARNING LIMITS EXCEEDED	Try again.
RECORD POINTER INVALID	Disk file is probably corrupted.
RESGN WINDOW > 44	Choose a smaller ROI, program array size is too small.
SPAWN (POS)	DENSIT code could not spawn pos code; is pos installed?
STABLE ERROR IZERO = nnn IGAIN = nnn	Invalid stabilization channels; zero > gain, or channel < 0 or > 4095?
START DATE IS EARLIER THAN STOP DATE	Switch start and stop dates.
SUM <=0.0 for nnn KEV PEAK CANNOT COMPUTE CENTROID FWHM	Supervisor needs to correct problem, data are defective, check signed processing electronics.

MESSAGES

(cont)

WAITFR

Error in waiting for event flag to be set.
Try again. Probably system error; reboot
may be necessary.

WRONG DLV-? ?

Hardware problem? DECNET cannot find com-
munications port for ND66.

This appendix will discuss several aspects of the hardware configuration of the upgraded Tokai densitometer. We will first discuss the NIM modules and then the computer hardware.

NIM ELECTRONICS

Figure A-1 shows a block diagram of the main NIM electronic components up to and including the ADC.

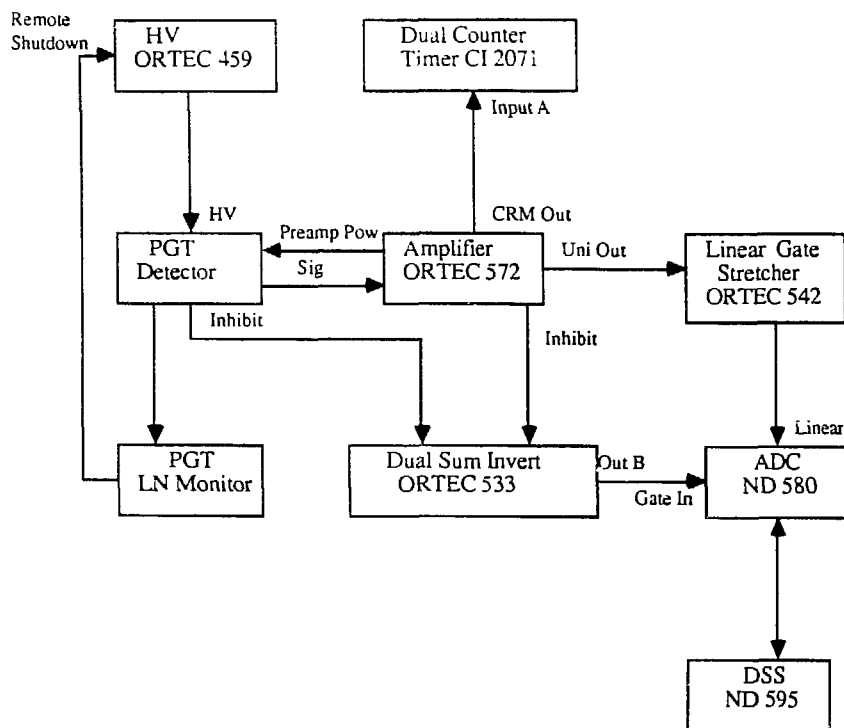


Fig. A-1. Block diagram of NIM electronics components.

Typical settings:

1. High-Voltage Power Supply (Ortec 459)
 - negative 1500 v

2. Amplifier (Ortec 572)

Coarse gain - 200
Fine gain - 243
Input - positive
BLR - P/Z adj

3. Dual Sum and Invert (Ortec 533)

Input 3 - detector inhibit
Input 4 - amplifier inhibit
Output A - Input B₁

4. Dual Counter Timer (CT 2071)

N - 1
M - 0
P - 1
Mode - recycle

Note: This module has been modified to shorten the recycle time.
[The resistor R21(220 k Ω) on drawing number B18878 was replaced with a 27-k Ω resistor.]

5. Linear Gate and Stretcher (Ortec 542)

Disc - ~0.1 V

Note: The minimum threshold level of this module has been modified from ~0.1 V to ~0.01 V to allow better rejection of the slow-rising preamplifier pulses. [A 10- Ω resistor was soldered in parallel to the R76 (38.3- Ω) resistor on drawing number 620480-S1.]

COMPUTER

The computer is a DEC LSI-11/23 plus with 256 k bytes of memory. There are two serial interface boards (DLV11-J), each of which has four serial ports. The addresses and interrupt vectors for these ports are summarized in Table A-I. The baud rates used for the various devices and the vectors and addresses for the system at Los Alamos, which were used to develop the software, are also shown in Table A-I.

The MBD interface board used for motor control has been modified to provide DMA continuity. This modification allows placement of the interface board anywhere in the Q-bus in contrast to having to place the interface board at the end of the Q-bus. (Grounds Y10 and X8 are both connected to D3.8. See motor interface card 1710 modification, drawing number 68Y-155592-D27).

TABLE A-I
ADDRESSES AND VECTORS FOR THE TOKAI UPGRADE

PNC				Los Alamos		ND Usage
Device	Interface	Address	Vector	Interface	Device	
Console (ND66)	DLV11J -ch0 (Baud 9600)	177560	60	Micro-11 port A0 (Baud 9600)	Console (ND66)	TT0
L printer	-ch1 (9600)	176500	300	Micro-11 port A1 (1200)	L printer	TT1
VT125 (Plotter)	-ch2 (2400)	176510	310	DLV11F (2400)	Terminal (Plotter)	TT2
VT125	-ch3 (9600)	176520	320			TT3
	DLV11J -ch0	176540	340	DLV11J -ch0		Reserved (ND)
Stabilizer	-ch1 (2400)	176550	350	-ch1 (2400)	Stabilizer	TT4
LA-36 printer	-ch2 (300)	176560	360	-ch2	Spare	TT5
ND communications	-ch3 (9600)	176570	370	-ch3 (9600)	ND communications	ND MCA communications
Hard disk (RL02x2)	RLV12	174400	160	RLV12	Hard disk (RL02)	
Floppy disk (RS02x2)	RXV21	177170	264	DSD440	Floppy disk (DSD440)	
Floppy disk (RX02x2)	RSV21	177150	270	DSD440	Floppy disk (DSD440)	
		172150	154	RQDX1	Winchester/ 5-in. floppy disk	
Source control	Interface	167760		Interface	Source control	

An outlier test is applied to the densitometer assay results according to the Grubbs² method. The method is summarized below. The hypothesis is that all observations in the sample come from the same normal population.

Consider n observations arranged in ascending order.

$$x_1 \leq x_2 \leq x_3 \dots \leq x_n$$

Let \bar{x} = the average of the n observations, and

s = the standard deviation of the n observations.

Then one can calculate the following test criteria:

$$T_n = (x_n - \bar{x})/s \quad \text{-- test on the high side.}$$

$$T_1 = (\bar{x} - x_1)/s \quad \text{-- test on the low side.}$$

The operator should use the criterion T_n or T_1 according to whichever is larger for the outlier either in the high or low side. If this value exceeds the critical value for T (tabulated in Table B-I), then the corresponding observation should be considered an outlier and be excluded. If the T value is smaller or equal to the critical value for the number of observations, then the observation should be retained.

TABLE B-I

TABLE OF CRITICAL VALUES FOR T (ONE-SIDED TEST)

<u>No. of Observations n</u>	<u>1% Significance Level</u>
3	1.15
4	1.49
5	1.75
6	1.94
7	2.10
8	2.22
9	2.32
10	2.41
11	2.48
12	2.55
13	2.61
14	2.66
15	2.71
16	2.75
17	2.79
18	2.82
19	2.85
20	2.88
21	2.91
22	2.94
23	2.96
24	2.99
25	3.01

To minimize the effect of the matrix to the densitometry assay result, the operator must find the transmissions immediately above and below the K-absorption edge of plutonium (121.795 keV). In addition to the transmissions at 122 and 121 keV, the measured transmission at 136 keV from the ^{75}Se source is also available with no additional measurement. The technique is, therefore, to extrapolate from 136 and 122 keV to 121.795 keV to find the transmission above the edge. For a short energy range near the K-absorption edge, μ vs E is approximately a straight line in \ln - \ln space. By assuming the same slope below the K-absorption edge, the extrapolation below the edge can also be performed. The extrapolation is reasonable because of the short distance to be extrapolated (from 121 to 121.795 keV). This extrapolation is shown in Fig. C-1.

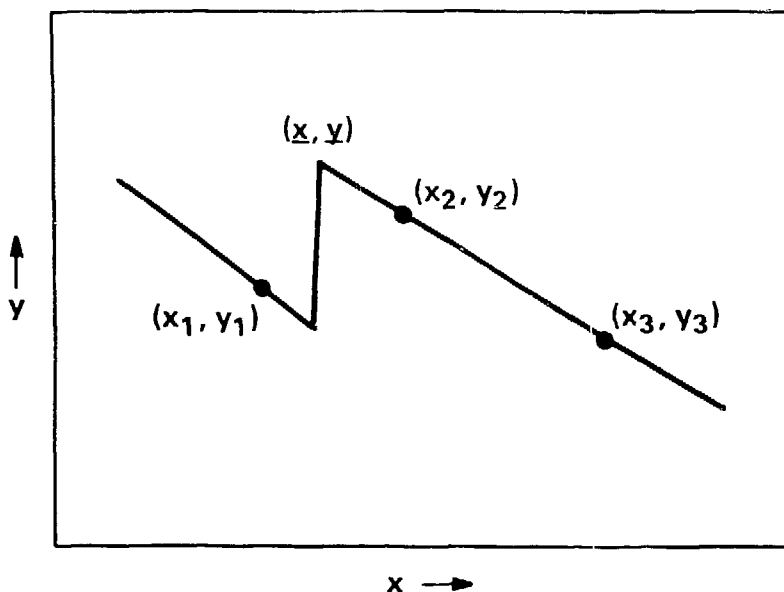


Fig. C-1. This figure illustrates the extrapolation. The x-axis is the $\ln E$ variable, and the y-axis is the $\ln \mu$ variable.

$$y = (y_2 - y_1) \left(\frac{x - x_1}{x_2 - x_1} \right) + y_1 \quad .$$

Let

$$C = \frac{x - x_1}{x_2 - x_1} \quad , \text{ then}$$

$$y = (1 - C)y_1 + Cy_2 \quad , \text{ and}$$

$$\sigma^2(y) = (1 - C)^2 \sigma^2(y_1) + C^2 \sigma^2(y_2) \quad .$$

A. Extrapolation above the edge

$$\text{Let } y = \ln [-\ln (T)],$$

$$x = \ln E, \text{ and}$$

$$\sigma(y) = \sigma\{\ln [-\ln (T)]\} = \sigma_r[-\ln (T)] = \frac{\sigma_r(T_u)}{\ln (T_u)} \quad ,$$

$$\text{where } \sigma_r(T) \text{ is defined as } \frac{\sigma(T)}{T} \quad .$$

Let $E_1 = 136.00$,

$E_2 = 122.06$, and

$\underline{E} = 121.795$.

Then $C = \frac{\ln \underline{E} - \ln E_1}{\ln E_2 - \ln E_1}$,

$\ln (-\ln T_u) = C \ln (-\ln T_{122}) + (1 - C) \ln (-\ln T_{136})$,

and

$$\sigma_r^2(T_u) = \ln(T_u)^2 \left[\frac{C^2 \sigma_r^2(T_{122})}{\ln^2 T_{122}} + (1 - C)^2 \frac{\sigma_r^2(T_{136})}{\ln^2 T_{136}} \right].$$

B. Extrapolation below the edge.

The operator assumes the same slope

$$\frac{y_3 - y}{x_3 - x} = \frac{y_2 - y_1}{x_2 - x_1}.$$

Therefore,

$$Y = (Y_2 - Y_1) \left(\frac{X - X_3}{X_2 - X_1} \right) + Y_3 \quad .$$

$$\text{Let } D = \frac{X - X_3}{X_2 - X_1} \quad ,$$

$$Y = DY_2 - DY_1 + Y_3 \quad ,$$

and

$$\sigma^2(Y) = D^2 \sigma^2(Y_2) + D^2 \sigma^2(Y_1)^2 + \sigma^2(Y_3) \quad .$$

$$\text{Let } E_3 = 121.115 \quad ,$$

then

$$D = \frac{\ln E - \ln E_3}{\ln E_2 - \ln E_1} \quad ,$$

$$\ln [-\ln (T_L)] = D[\ln (\ln T_{122}) - \ln (-\ln T_{136})] + \ln (-\ln T_{121}) \quad ,$$

and

$$\sigma_r^2(T_l) = \ln^2(T_l) \left[\frac{D^2 \sigma_r^2(T_{122})}{\ln^2 T_{122}} + \frac{D^2 \sigma_r^2(T_{136})}{\ln^2 T_{136}} + \frac{\sigma_r^2(T_{121})}{\ln^2 T_{121}} \right] .$$

The operator will find a summary of commands in the DEC RSX-11M Mini-Reference Manual. We will assume the operator is in the DCL (not the MCR) command language. The command languages and commands are explained in detail in the complete RSX-11M manuals. In addition, the system HELP facility outputs information about xxx when the operator types HELP xxx, where xxx is the command.

Devices must be allocated and mounted before they can be used. When the operator is finished with a device, the user should dismount and deassign it so that it is ready for the next operator.

ALL DY0:	Allocates drive 0 for use by program.
DEA DY0:	Deallocates drive 0; device is now available for anyone.
MOU DY0:IAEA	Mounts the diskette in drive 0 (if it is initialized correctly) for the program to use it.
DISM DY0:	Dismounts the diskette in drive 0.

Some of the operations that can be performed once a device is correctly mounted are shown below.

DIR DL1:	Lists directory on DL1.
INIT/BAD DY0:IAEA	Initializes a new floppy diskette in drive 0; this destroys the data already on the diskette.
COPY	This copies a file from one device to another. The system asks the operator to type FROM: which file, TO: which file.
DEL	Deletes the user-specified FILES: entered after the prompt.

If programs are installed with the following command

```
.INS [1,75] WMB
```

(where the program called WMB is in UIC = [1,75]), then the system remembers how to locate them. In DCL, the programs can then be accessed with this command

```
.WMB
```

Several supplemental programs are available for this system. Some of these are used on a regular basis and some are used for troubleshooting.

[1.27]DSS This is a vendor(ND)-supplied package that interacts with the stabilizer. The DENSIT program uses some of the DSS subroutines. This package reads out the present stabilizer values and allows the operator to change the ones chosen. Note 1: For proper operation of this program, the user must set up the correct terminal characteristics (an example is found in TERSET.CMD or TERSET4.CMD). Note 2: This device uses a modem (not terminal) wiring convention. See the handwritten notes in the DSS user manual.

.MCA This is the ND-supplied package that demonstrates the use of the software control of the analyzer. The Los Alamos software uses the two routines that read or write data to disk files. MCACOM is built in [1,62] by ND convention and named MCA.

[1.70]POS This software controls the Geneva mechanism (which contains the transmission sources). The software is a stand-alone program, which is spawned at the appropriate times by the DENSIT program. The operator can run this software separately to test the Geneva mechanism. InDCL:

.POS n

causes the program to move the mechanism to position n, where n = 1 is SE, n = 2 is CO, and n = 3 is the Blank position.

[1,75]TESTND This is a calling program to test the analyzer software. The program contains all of the analyzer subroutines used in the DENSIT program. If the analyzer communications break down, TESTND can help troubleshoot the communications without the overhead associated with the DENSIT program. Note: Sometimes the DATAND option must be used first if the analyzer rejects the INITND command.

WMB This is constructed in [1,75]. This is the program to Write Measurement control Bias data to a separate file. It creates the file MBOUT.DEN, which can be input to a plotting routine. WMB outputs to the user terminal the first and last date of the MB runs it finds in the log file. The format of the sequential file MBOUT.DEN consists of n lines, where n is the number of MB data points. Each line has the number of the run, the result, and the absolute uncertainty based on counting statistics. The line format is

```
1x,F6.0',',E13.6',',E13.6
```

For example, " 1., 0.123456E+00, 0.123456E+00 ".

See the WMB.FTN file for more details.

Note 1: In normal usage MCA, POS, and WMB are installed, DSS and TESTND are not installed.

Note 2: In DCL, a period preceding a three-letter name indicates that the three-letter name refers to a program the system can find under MCR.

REFERENCES

1. P. A. Russo; S. T. Hsue; J. K. Sprinkle, Jr.; S. J. Johnson; Y. Asakura; I. Kondo; J. Masui; and K. Shoji; "In-Plant Measurements of Gamma-Ray Transmissions for Precise K-Edge and Passive Assay of Plutonium Concentration and Isotopic Fractions in Product Solutions," Los Alamos National Laboratory report LA-9440-MS (PNCT 841-82-10) (August 1982).
2. F. E. Grubbs, "Procedures for Detecting Outlying Observations in Samples," *Technometrics*, 11, (1), 1-21 (1969).