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Scientific Notebook No. 650: Evaluate the Disposal of SNF with a Variation of Degree of Burnup and Compare Pear Expected Dose with Those From the Use of an Average Representative Inventory (04/13/2004 through 06/17/2004)

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

DH
4/12/04

INITIAL ENTRIES:

SCIENTIFIC NOTEBOOK 650

LANE HOWARD DH

SOUTHWEST RESEARCH INSTITUTE

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

SAN ANTONIO, TX

APRIL 12, 2004 (4/12/04)

ACCOUNT NUMBERS: 20.06002.01.081 & 20.06002.01.112

OBJECTIVE: EVALUATE THE DISPOSAL OF SNF WITH A VARIATION IN THE DEGREE OF BURNUP, AND COMPARE PEAK EXPECTED DOSE WITH THOSE FROM THE USE OF AN AVERAGE REPRESENTATIVE INVENTORY.

DESCRIPTION: DERIVE REPRESENTATIVE INVENTORY FOR HIGH B/U SNF. PERFORM SENSITIVITY ANALYSES USING THE TPA VERSION 5.0s CODE TO QUANTIFY THE EFFECT OF HIGH B/U FUEL IN THE INVENTORY.

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ORIGEN-ARP 2.00 IS TO BE USED FOR FUEL DEPLETION & DECAY CALCULATIONS, AS WELL AS TPA VERSION 5.0s CODE AND EXCEL SPREADSHEETS FOR DATA ANALYSIS. THESE ARE INSTALLED ON THE NORFOLK MACHINE LOCATED IN A129 (NORFOLK .155), BLDG. 189.

ORIGEN-ARP INSTALLATION & TESTING WAS ACCOMPLISHED IAW THE ~~FOLLOWING~~ 4/13/04 FOLLOWING PAGES RECEIVED WITH THE CODE PACKAGE CD:

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OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Radiation Safety Information Computational Center
P.O. Box 2008
Oak Ridge, TN 37831-6171

Voice: 865-574-6176 *Fax*: 865-241-4046
email: pdc@ornl.gov
url: http://www-rsicc.ornl.gov/rsic.html

August 27, 2003

Lane Howard
Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238-5166

Dear Mr. Howard:

Thank you for your recent order. The ORIGEN-ARP2 package being sent to you is subject to the conditions written below.

Distribution Statement: The code/data package is part of the collections of the Radiation Safety Information Computational Center (RSICC) developed by various government and private organizations and contributed to RSICC for distribution. Any further distribution by any holder, unless otherwise specifically provided for is prohibited by the U.S. Dept. of Energy without the approval of RSICC, P.O. Box 2008, Oak Ridge, TN 37831-6362.

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Sincerely,

for Barbara Shaw
Hamilton T. Hunter
Director, Radiation Safety Information Computational Center

HTH:bjs

DH

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README for ORIGEN-ARP

RSICC code package C00702PC58600
May 2002

http://www.ornl.gov/origen-arp (ORIGEN-ARP Web site)
http://www-rsicc.ornl.gov/rsic.html (RSICC Web site)
http://www-rsicc.ornl.gov/ENOTE/EnotOrigen.html (ORIGEN-ARP Electronic Notebook)

Introduction

ORIGEN-ARP is an automated sequence to perform isotopic depletion / decay calculations using the ARP and ORIGEN-S codes of the SCALE system. The sequence includes the OrigenArp for Windows graphical user interface (GUI) that prepares input for ARP (Automated Rapid Processing) and ORIGEN-S. ARP automatically interpolates cross sections for the ORIGEN-S depletion/decay analysis using enrichment, burnup, and, optionally moderator density, from a set of libraries generated with the SCALE SAS2 depletion sequence. Library sets for four LWR fuel assembly designs (BWR 8x8, PWR 14x14, 15x15, 17x17) are included. The libraries span enrichments from 1.5 to 5 wt% U-235 and burnups of 0 to 60,000 MWD/MTU. Other libraries (e.g., DLC-210 CANDU libraries) are available from RSICC. SCALE users can generate their own libraries for other fuel assembly designs -see Section D1 of the SCALE Manual for details. The interpolated cross sections from ARP are passed to ORIGEN-S to perform the depletion/decay calculations. The ORIGEN-ARP sequence includes the post-processing utility module OPUS to generate ASCII plot data files and the PlotOPUS Windows GUI to plot the data.

The computer requirements for ORIGEN-ARP:
Pentium (or later) personal computer (PC)
32 MB RAM
50 MB of hard disk space
Windows 95/NT or later.

This version 2 of ORIGEN-ARP as a standalone code package contains an updated version of the SCALE 4.4a ORIGEN-S code (see "What's New in ORIGEN-S" below). It contains a subset of the modules, data libraries, and miscellaneous utilities in SCALE 4.4a. This version is intended for users who do not need the entire SCALE package. If you want to generate your own ORIGEN-ARP libraries, you need to acquire the SCALE package instead.

ATTENTION WINDOWS NT, 2000, and XP USERS!!!

YOU MUST BE LOGGED IN WITH ADMINISTRATOR PRIVILEGES ON THE PC
to install ORIGEN-ARP.

The latest news and software updates will be posted on the Web. From the ORIGEN-ARP home page, click on "Newsletter" for current and back issues of the SCALE Newsletter; click on "Download" for new utilities, verification & validation input files, and other updates.

The programs WinZip 8.0 and WinZip Self-Extractor 2.1 (Nico Mak Computing, Inc.) were used to create the self-extracting compressed files included in this package.

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What's New in ORIGEN-S

The following updates have been made to ORIGEN-S in ORIGEN-ARP 2.0 since the previous release in ORIGEN-ARP 1.0 (July 2001).

1. The neutron source and energy spectrum routines have been replaced to provide more accurate spontaneous fission and (alpha,n) neutron sources, and a delayed neutron source capability was added.

2. The printout of the fixed energy group structure photon tables was removed. Gamma sources and spectra are now printed for calculations using the Master Photon Library only.

The following updates were made to ORIGEN-S in ORIGEN-ARP 1.0 since the previous release in SCALE 4.4a (March 2000). These updates are also included in ORIGEN-ARP 2.0.

1. Debug output that routinely appeared has been redirected to a separate file to clean up the output file.

2. The precision in output print was increased from three to four digits.

3. Calls to an internal subroutine named EXIT were removed to avoid conflicts with the SCALE subroutine library.

4. The calculation of nuclide concentrations following the removal of short-lived nuclides to make a reduced transition matrix was improved.

5. The determination of the matrix norm was corrected. The value of the matrix norm is used in the determination of which short-lived nuclides are removed from the matrix, and in establishing the number of exponential terms required for series convergence. The implementation of the matrix norm calculation now matches the description in the documentation.

Installation of ORIGEN-ARP

To begin installation, open Windows Explorer, go to your CD-ROM drive, and run InstallOrigenArp.exe. The installation program will prompt you for the hard disk drive where you want the programs installed and the name of the computer. The computer name is simply a label that will appear in your ORIGEN-ARP output to identify the computer on which the calculations were performed. The name is stored in \Scale5\data\machine.nam. The name is 32 characters maximum with no embedded blanks.

The installation program offers options under "Install SCALE Components" to install ORIGEN-ARP, the ORIGEN-ARP Manual, PlotOPUS, and Programmer's File Editor (PFE) 1.01. All components selected will be installed to the same drive. Click on the "Help" button in the installation program to obtain additional information about installing ORIGEN-ARP or the other software included in the package. **Note to Windows 95 or NT 4.0 users: You must have Internet Explorer 5.0 or later installed to view the help file.** You can download it for free from http://www.microsoft.com/. A separate option is available to install Adobe Acrobat Reader with Search 5.0.5. You should uninstall any earlier version of Acrobat Reader before installing this new version.

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PlotOPUS is an interactive Visual Basic program designed for Windows PCs. PlotOPUS reads the data file produced by the ORIGEN-S post-processing utility OPUS, plots the data, and can generate Windows metafile (WMF), JPEG bitmap (JPG), or Windows bitmap (BMP) files for saving the plot images.

Acrobat Reader and PFE are freeware programs. Acrobat Reader is needed to view the ORIGEN-ARP manual on the CD (see notes on ORIGEN-ARP manual below). PFE is a versatile, easy-to-use text editor that can handle very large files and is useful for viewing, editing and printing ORIGEN-ARP input and output files. However, other text editors may be used.

An ORIGEN-ARP folder will be added to your Start Menu (you see this when you press the "Start" button) that contains shortcut icons for

- MS-DOS Prompt for ORIGEN-ARP
- OrigenArp
- PlotOPUS
- ORIGEN-ARP Manual
- PFE
- ORIGEN-ARP Web Site
- ORIGEN-ARP Users Electronic Notebook.

Attention, WINDOWS NT, 2000, and XP users: These shortcuts will only be added to your Start Menu if you are logged in with administrator privileges on your PC during installation.

Foreign Language Windows Users

Subroutine GETFILE in \SCALE5\UNIXLIB and the QAUPDATE program (\SCALE5\MISC\QAUPDATE) perform searches for keywords contained in the output from the MS-DOS "DIR" command. For non-English versions of Windows, the file containing the keywords, \SCALE5\DATA\LANGUAGE.DAT, must be modified. The modification of this file is needed (1) for the "PROGRAM VERIFICATION INFORMATION" table in the output to print correctly and (2) for the screen message "Now executing xxxxxx" (where "xxxxxx" is the module name) to be displayed. The English default keywords in \SCALE5\DATA\LANGUAGE.DAT are shown below. For non-English versions of Windows, these keywords should be replaced with appropriate correlating keywords that appear when the MS-DOS command "DIR" is used. NOTE THAT THESE KEYWORDS ARE CASE SENSITIVE!

English Defaults	Description
"Volume in drive "	16-character keyword (must appear on line prior to other keywords)
"Volume Serial Number is "	24-character keyword (must appear on any line after the above keyword)
"Directory of "	16-character keyword (precedes the drive:\dir\subdir)
":\"	2-character keyword following drive letter in drive:\dir\subdir)
exe	4-character keyword (must be lowercase - between module name and size)

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" is" 3-character keyword on same line as first keyword

Below is an example output from the English version of Windows MS-DOS "DIR" command that would be searched for keywords. This example is provided to help foreign language users in identifying the keywords that should appear in their LANGUAGE.DAT file. You can find a zip file containing LANGUAGE.DAT and QATABLE files for running SCALE on some foreign language versions of Windows on the SCALE Download Directory web page http://www.ornl.gov/scale/download.html

```
 Volume in drive C is STEVE C
 Volume Serial Number is 07CF-0619

 Directory of C:\scale5\bin

ORIGEN   EXE           576,000 06/19/2001  04:22p
             1 File(s)        576,000 bytes
             0 Dir(s)   3,301,961,728 bytes free
```

How to Run ORIGEN-ARP

To execute OrigenArp, click on the Start button, click on the ORIGEN-ARP folder, and then click on the OrigenArp icon. OrigenArp has an online help manual. Hit the F1 key or click on the "Help" button.

If you have previously created ORIGEN-ARP cases with the old MS-DOS version that was distributed with SCALE, you can import the ASCII input files (*.in or *.inp) using the OrigenArp "Import (Ctrl+R)" option under the "File" menu. Do NOT attempt to open or import the binary files from the old MS-DOS version (files with extensions of *.arp, *.cmp, *.dcy, or *.dpl).

The OrigenArp GUI can create and save an input file and execute the ARP, ORIGEN-S, and OPUS codes automatically. The ORIGEN-S output file, plots, and plot data file created by OPUS can be viewed by clicking on the "Output," "PlotOPUS," and "Plot Tables" buttons, respectively.

Running ORIGEN-ARP Manually from the DOS Prompt

The user can manually run cases without using the GUI, by clicking on the "DOS Prompt for ORIGEN-ARP" icon in the ORIGEN-ARP folder. ***Do NOT try to run ORIGEN-ARP from the standard MS-DOS "Command Prompt" icon.***

ORIGEN-ARP can be run from any directory. Therefore, you may store your input and output files in any directory on your PC.

To run ORIGEN-ARP manually from the DOS prompt, enter the following DOS command:

```
SCALE5 inputfile
```

where "inputfile" is the ORIGEN-ARP input file without the extension. The batch file works with input file names with no extension (e.g., CASE1), or extensions of .IN, .INP, or .INPUT (e.g., CASE1.IN, CASE1.INP, CASE1.INPUT). The output file will automatically be written with the .OUT extension (e.g., CASE1.OUT). If

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you include the file name extension on the command line, the .OUT extension will be appended to create the output file name (e.g., CASE1.INP.OUT). Long file names are OK, but there should be no embedded blanks.

If you want to submit multiple files to run overnight or over a weekend, set up a .BAT file as follows:

```
CALL SCALE5 inputfile1
CALL SCALE5 inputfile2
   .    .    .
   .    .    .
CALL SCALE5 inputfilen
```

Then execute the .BAT file by typing its name. For example, if you store the commands in OVERNITE.BAT and then type OVERNITE, the jobs will be executed sequentially.

How ORIGEN-ARP works on a PC

The input file is copied to a file named "SYSIN" in the \SCALE5\TMPDIR directory where the calculations are performed. The DATADIR and BINDIR files are used to point to the BIN and DATA directories without having to copy those files to \SCALE5\TMPDIR. All files written by ARP, ORIGEN-S, and OPUS (e.g., interpolated cross section libraries, restart files, scratch files) are written to \SCALE5\TMPDIR. The output and plot files are also written there and then copied back to your original directory. You may copy any of the files in \SCALE5\TMPDIR to another directory for later use. You can insert DOS commands in your input file to copy or delete files or perform other operations. The SCALE input file is delimited by the command "=MODULE" at the beginning of the module input, where MODULE is the name of the SCALE module to be executed by the driver, and the "END" terminator starting in column 1 at the end of the module input. To execute DOS commands before or after a SCALE module, you can specify "=SHELL" before or after the input of the module. The DOS commands written on the lines following "=SHELL" and before the "END" terminator will be executed from the \SCALE5\TMPDIR directory. Once the job is completed and any desired files are copied, you may delete all files in \SCALE5\TMPDIR to free disk space, if needed. Otherwise, the files may be overwritten or deleted by the next SCALE job.

OPUS/PlotOPUS Plot Files

The OPUS utility program produces an output file that can be used for making a variety of plots from output produced by the ORIGEN-S code that computes spent fuel compositions and radiological decay properties, and the corresponding photon and neutron source spectra. Tables containing individual and total nuclide or element concentrations, in 14 different units, may be generated as a function of time. Three classes of plot data may be produced by OPUS: (1) dominant or selected isotopes or elements, (2) photon and neutron source spectra, and (3) comparisons of selected quantities (totals or individual nuclides) between different ORIGEN-S cases. The input is designed for ease of use with self-explanatory parameter names, free-form input, and commonly used default values.

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The formatted output data produced by OPUS is designed to be used directly by the PlotOPUS plotting program. PlotOPUS is an interactive Visual Basic program designed for Windows 95/NT or later computers. PlotOPUS reads the formatted output data file produced by OPUS, plots the data, and can generate Windows metafile (WMF), JPEG bitmap (JPG), or Windows bitmap (BMP) files for saving the plot images. Even though it is designed to interface with PlotOPUS, the formatted OPUS output file can be easily read by other graphics packages for data visualization.

The plot files will be named "inputfile._plotxxx.plt", where "inputfile" is the input file name and "xxx" is the plot number from 000 to 999 generated by that inputfile.

ORIGEN-ARP On-line Electronic Manual

The ORIGEN-ARP manual (including the OPUS/PlotOPUS manual) is distributed in PDF format on the ORIGEN-ARP installation CD and should be installed on your PC. The Adobe Acrobat Reader with Search is required to read and print the files. Version 5.0 is included on the CD.

When you click on the ORIGEN-ARP Manual shortcut icon, the Table of Contents for the manual is opened. You may click on one of the titles to open that section of the manual. Each section of the manual has bookmarks and thumbnails to improve the ease in navigation of the document. If the bookmarks and thumbnails are not displayed when a section of the manual is opened, click on the "Show/Hide Navigation Pane" icon (immediately to the right of the printer icon).

The manual contains a searchable index. To activate the searchable index, open the ORIGEN-ARP manual. Press Ctrl+Shift+X to open the "Index Selection" window. Click on "Add." Open the INDEX subdirectory and click on the "index.pdx" file. Click on "Open" and then click "OK." You can now search the entire ORIGEN-ARP Manual for words or phrases by clicking on the "Search" toolbar button (binoculars with a page behind it). Search will return a list of all sections of the ORIGEN-ARP Manual that contain the search specification. You may then select one of these files to view. Each occurrence of the word or phrase will be highlighted. You can then move to the next occurrence or the next file by clicking on the "Next Highlight" toolbar button (right arrow with page behind it).

Contents of This Distribution

Files to Execute ORIGEN-ARP

The following files are installed in \SCALE5\CMDS to run SCALE:

COMMANDS	FUNCTION
SCALE5.BAT	Executes SCALE
SCALE_95.BAT	Called by SCALE5.BAT to execute SCALE in Windows 95
SCALE_98.BAT	Called by SCALE5.BAT to execute SCALE in Windows 98
SCALE_ME.BAT	Called by SCALE5.BAT to execute SCALE in Windows ME
SCALE_NT.BAT	Called by SCALE5.BAT to execute SCALE in Windows NT
SCALE_XP.BAT	Called by SCALE5.BAT to execute SCALE in Windows XP
SCALE_2000.BAT	Called by SCALE5.BAT to execute SCALE in Windows 2000
UPDATEQA.BAT	Updates the ORIGEN-ARP QA Table

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SCALE Modules and Executable Files

This distribution contains the SCALE modules and utilities listed below. They are the same as, or newer than, those in the SCALE 4.4a package.

These executables were compiled and linked with Version 4.0 of the Lahey F90 compiler. The executables are installed in \SCALE5\BIN and are native 32-bit Windows console applications. The SCALE5 command automatically detects the PC's operating system.

MODULE	EXECUTABLE
SCALE DRIVER	SCALE.EXE
ORIGEN-S	ORIGEN.EXE
OSBICO	OSBICO.EXE
OSBIRE	OSBIRE.EXE
ARP	ARP.EXE
OPUS	OPUS.EXE

In addition, the following files are also included in the \SCALE5\BIN directory:

ALIASES (used by SCALE driver to find modules known by different names)
BINDIR (this file is created during installation and contains the full path for this directory)
LF90.EER (Lahey run-time error message file)
SETPUSHD.EXE (stores the user input file directory for return after execution)
SHELL.EXE (opens a DOS shell and executes DOS commands)
SORTCOPY.EXE (sorts individual module output files in proper order and copies to user's output file)
QATABLE (table of modules and version numbers for verification table in output)
QATABLE.95 (version of QA table for Win95)
QATABLE.98 (version of QA table for Win98)
QATABLE.ME (version of QA table for Windows Millennium Edition(ME))
QATABLE.NT (version of QA table for Windows NT 4.0)
QATABLE.2000 (version of QA table for Windows 2000)
QATABLE.XP (version of QA table for Windows XP)
QAUPDATE.EXE (used to update QATABLE when executable modules are modified).

SCALE Data Libraries

The following data libraries are included in this distribution:

File Name	Description
ALPHAXS	Target (alpha,n) cross section library
ALPHDEC	Neutron source decay data library
ALPHYLD	Target (alpha,n) product level branching library
ARPDATA.TXT	Index of ARP libraries
FT21F001	Preliminary LWR ORIGEN-S Binary Working Library
FT22F001	Multi-burnup binary working library produced from typical PWR 33-GWd/MTU case
FT23F001	Binary Master Photon Library (no bremsstrahlung)
FT24F001	Binary Master Photon Library (with bremsstrahlung in water)
FT25F001	Basic LMFBR ORIGEN-S Binary Working Library

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FT26F001	Binary Master Photon Library (with bremsstrahlung in UO2)
FT27F001	Decay data for the light elements, actinides, and fission products
FT28F001	Nuclear data and photon-yield libraries for light elements, actinides, and fission products
FT82F001	27GROUPNDF4
FT88F001	27N-18COUPLE
LANGUAGE.DAT	Language keywords for QA Table
MACHINE.NAM	Computer name for QA Table
S114X14	ORIGEN-ARP lib 1.5 "wt%," 14x14
S115X15	ORIGEN-ARP lib 1.5 "wt%," 15x15
S117X17	ORIGEN-ARP lib 1.5 "wt%," 17x17
S18X8	ORIGEN-ARP lib 1.5 "wt%," 8x8
S214X14	ORIGEN-ARP lib 2 "wt%," 14x14
S215X15	ORIGEN-ARP lib 2 "wt%," 15x15
S217X17	ORIGEN-ARP lib 2 "wt%," 17x17
S28X8	ORIGEN-ARP lib 2 "wt%," 8x8
S314X14	ORIGEN-ARP lib 3 "wt%," 14x14
S315X15	ORIGEN-ARP lib 3 "wt%," 15x15
S317X17	ORIGEN-ARP lib 3 "wt%," 17x17
S38X8	ORIGEN-ARP lib 3 "wt%," 8x8
S414X14	ORIGEN-ARP lib 4 "wt%," 14x14
S415X15	ORIGEN-ARP lib 4 "wt%," 15x15
S417X17	ORIGEN-ARP lib 4 "wt%," 17x17
S48X8	ORIGEN-ARP lib 4 "wt%," 8x8
S514X14	ORIGEN-ARP lib 5 "wt%," 14x14
S515X15	ORIGEN-ARP lib 5 "wt%," 15x15
S517X17	ORIGEN-ARP lib 5 "wt%," 17x17
S58X8	ORIGEN-ARP lib 5 "wt%," 8x8
STCOEFF	Alpha particle stopping cross section expansion coefficients

These files are installed in \SCALE5\DATA. The ORIGEN-S libraries are described in Tables M6.8.1 and M6.8.2 of the ORIGEN-ARP manual. You may use OSBICO and OSBIRE, respectively, to convert the binary ORIGEN-S libraries to ASCII and restore them to binary.

In addition, DATADIR is contained in this directory. Like BINDIR in the \SCALE5\BIN directory, it is created during installation and contains the full path for the directory. DATADIR and BINDIR are used by SCALE to find the executables and data libraries at run-time. If you change the locations of either of these directories, re-initialize the BINDIR and DATADIR files in the appropriate directories as follows.

a) Change directories to the data directory and type the DOS command
CD> DATADIR

b) Change directories to the executable directory and type the DOS command
CD> BINDIR

c) Modify SCALE_*.BAT (depending on your Windows operating system) in \SCALE5\CMDS to copy BINDIR and/or DATADIR from the new locations instead of the default directories to \SCALE5\TMPDIR where SCALE will look for them.

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ORIGEN-ARP Sample Problems

Sample problem input files are installed in

- \OrigenArp\Sample_Problems (sample problems to be run with the OrigenArp for Windows GUI) and
- \SCALE5\SMPLPRBS (sample problems to be run in batch mode from the DOS prompt). This directory also contains a .BAT file named RUNSAMPS.BAT that will run all the sample problems.

ORIGEN-ARP Sample Problem Output Files

The corresponding output files for the sample problems are installed in

- \OrigenArp\Output and
- \scale5\output.

The sample problems were run on a Dell Pentium 4 1.7 GHz with Windows XP Pro.

Fortran Source Files

The Fortran source files are installed and may be compiled and linked using the included Makefiles. If you have the Lahey F90 compiler (version 4.0 or later) and you want to compile the SCALE modules yourself, type "MAKE" from the \SCALE5 directory (be sure that the Lahey environmental variables are set). The FORTRAN source files are installed as follows: \SCALE5\module where "module" is the SCALE module name (e.g., ORIGEN).

Uninstalling ORIGEN-ARP Components

1. PlotOPUS should be uninstalled first. Click on Start, Settings, Control Panel, Add/Remove Programs. Select PlotOPUS and click OK.

2. OrigenArp GUI, ORIGEN-ARP and ORIGEN-ARP Manual - Delete the \SCALE5 directory. If you have created any input files in a subdirectory under \SCALE5, copy to another location first, or they will be deleted. Delete the file scale5a_path.bat in the root directory of the drive where ORIGEN-ARP was installed.

3. PFE can be removed by deleting the directory \PFE.

4. Icons - Click the right mouse button on the Start button, select "Explore All Users" (Windows NT/2000/XP) or "Explore" (Windows 95/98/ME). Delete the ORIGEN-ARP folder.

ORIGEN-ARP WAS INSTALLED ON THE NORFOLK MACHINE ACCORDING TO THESE INSTRUCTIONS IN C:\SCALE5. SAMPLE PROBLEM INPUT AND OUTPUT FILES DESCRIBED ARE LOCATED IN NORFOLK C:\SCALE5\ORIGENARP\SAMPLE_PROBLEMS.

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INSTALLATION TESTING COMPLETED SATISFACTORY WITH TEST INPUT AND OUTPUT FILES (DA 4/14/04) LOCATED IN NORFOLK MACHINE C:\SCALE5\ORIGENARP\TESTS FOR COMPARISON TO THOSE DESCRIBED IN C:\SCALE5\ORIGENARP\SAMPLE_PROBLEMS. THE (DA 4/14/04) BATCH FILE TO RUN ALL SAMPLE PROBLEMS WAS USED TO CHECK THE INPUT/OUTPUT FILES LOCATED IN \SAMPLE_PROBLEMS. THESE COMPARE SATISFACTORY AND ARE LOCATED IN NORFOLK C:\SCALE5\SMPLRBS.

ORIGEN-ARP RUNS CONDUCTED TO CALCULATE REPRESENTATIVE INVENTORY AND DECAY HEAT LOADS FOR A 45 GWd/MTU BURNUP PWR FUEL & A 65 GWd/MTU HIGH BURNUP PWR FUEL. INPUT SUMMARIES ARE THE FOLLOWING 6 PAGES. INPUT AND OUTPUT FOR THESE RUNS ARE SAVED ON THE ~~NORFOLK~~ (DA 4/14/04) NORFOLK MACHINE IN C:\SCALE5\ORIGENARP\45gwdmedbudecay & \65gwdhighbudecay.

OUTPUT INVENTORIES & DECAY HEAT LOADS WERE COPIED DIRECTLY INTO MS EXCEL SPREADSHEET FOR DATA ANALYSES & GRAPHING. SPREADSHEET FILE IS SAVED ON THE NORFOLK MACHINE IN D:\High burnup\45 and 65 Gwd comparisons.xls.

CALCULATIONS COMPARE WELL WITH OTHER ANALYSES IN THE LITERATURE SUCH AS NUREG/CR-6703, PNNL-13257, "ENVIRONMENTAL EFFECTS OF EXTENDING FUEL BURNUP ABOVE 60 Gwd/MTU", U.S. NRC, NOV. 2000.


```
PlotOPUS input specified for 4 plots.

Number of Isotopes     = 13
Input Option           = Entering data using form
Input Units            = grams


Library: 15x15
Enrichment Factor (Wt%U235)    = 4.000000
Moderator Density (g/cc)       = 0.713500

Nuclide     ID          Library              Concentration
=======     ==          =======              =============
U 234       922340      Actinide              356.000000
U 235       922350      Actinide              40000.000000
U 236       922360      Actinide              184.000000
U 238       922380      Actinide              959460.000000
O           80000       Natural               136000.000000
Cr          240000      Natural               5920.000000
Mn          250000      Natural               330.000000
Fe          260000      Natural               12940.000000
Co          270000      Natural               70.000000
Ni          280000      Natural               9870.000000
Zr          400000      Natural               221440.000000
Nb          410000      Natural               700.000000
Sn          500000      Natural               3510.000000

Neutron Group      =        27GrpENDF4
Number of groups   =        27

Gamma Group        =    18GrpSCALE
Number of groups   =    18


Number of cases    = 6


Case Number #1  -- Irradiation
=====================================================

Title: Cycle 1 -45gwdmedbudecay
Basis: 1 MTU


Time units=        Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

      Light Elements
      Actinides
      Fission Products

Output units = grams
Table cutoff = 0.000010

Power                  Cumulative      Write Results
```

DA 4/14/04

MW/Basis	Time	to Dataset
3.0000000e+001	5.0000000e+001	No
3.0000000e+001	1.0000000e+002	No
3.0000000e+001	1.5000000e+002	No
3.0000000e+001	2.0000000e+002	No
3.0000000e+001	2.5000000e+002	No
3.0000000e+001	3.0000000e+002	No
3.0000000e+001	3.5000000e+002	No
3.0000000e+001	4.0000000e+002	No
3.0000000e+001	4.5000000e+002	No
3.0000000e+001	5.0000000e+002	No

Case Number #2 -- Decay

Title: Decay - 45gwdmedbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
2.6315789e+001	No	No

Case Number #3 -- Irradiation

Title: Cycle 2 -45gwdmedbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

DA 4/14/04

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	5.0000000e+001	No
3.0000000e+001	1.0000000e+002	No
3.0000000e+001	1.5000000e+002	No
3.0000000e+001	2.0000000e+002	No
3.0000000e+001	2.5000000e+002	No
3.0000000e+001	3.0000000e+002	No
3.0000000e+001	3.5000000e+002	No
3.0000000e+001	4.0000000e+002	No
3.0000000e+001	4.5000000e+002	No
3.0000000e+001	5.0000000e+002	No

Case Number #4 -- Decay

Title: Decay - 45gwdmedbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
2.6315789e+001	No	No

Case Number #5 -- Irradiation

Title: Cycle 3 -45gwdmedbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

DA 4/14/04

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	5.0000000e+001	No
3.0000000e+001	1.0000000e+002	No
3.0000000e+001	1.5000000e+002	No
3.0000000e+001	2.0000000e+002	No
3.0000000e+001	2.5000000e+002	No
3.0000000e+001	3.0000000e+002	No
3.0000000e+001	3.5000000e+002	No
3.0000000e+001	4.0000000e+002	No
3.0000000e+001	4.5000000e+002	No
3.0000000e+001	5.0000000e+002	No

Case Number #6 -- Decay

Title: Cycle 3 Down - 45gwdmedbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Years
Neutron source = UO2
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
3.0000000e-001	Yes	Yes
1.0000000e+000	Yes	Yes
3.0000000e+000	Yes	Yes
1.0000000e+001	Yes	Yes
3.0000000e+001	Yes	Yes
1.0000000e+002	Yes	Yes
3.0000000e+002	Yes	Yes
1.0000000e+003	Yes	Yes
3.0000000e+003	Yes	Yes
1.0000000e+004	Yes	Yes

DA 4/14/04

PlotOPUS input specified for 6 plots.

Number of Isotopes = 13
Input Option = Entering data using form
Input Units = grams

Library: 15x15
Enrichment Factor (Wt%U235) = 5.000000
Moderator Density (g/cc) = 0.713500

Nuclide	ID	Library	Concentration
U 234	922340	Actinide	445.000000
U 235	922350	Actinide	50000.000000
U 236	922360	Actinide	230.000000
U 238	922380	Actinide	949325.000000
O	80000	Natural	136000.000000
Cr	240000	Natural	5920.000000
Mn	250000	Natural	330.000000
Fe	260000	Natural	12940.000000
Co	270000	Natural	70.000000
Ni	280000	Natural	9870.000000
Zr	400000	Natural	221440.000000
Nb	410000	Natural	700.000000
Sn	500000	Natural	3510.000000

Neutron Group = 27GrpENDF4
Number of groups = 27

Gamma Group = 18GrpSCALE
Number of groups = 18

Number of cases = 6

Case Number #1 -- Irradiation

Title: Cycle 1 -65gwdhighbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

Power Cumulative Write Results

DA 4/14/04

MW/Basis	Time	to Dataset
3.0000000e+001	7.2222222e+001	No
3.0000000e+001	1.4444444e+002	No
3.0000000e+001	2.1666667e+002	No
3.0000000e+001	2.8888889e+002	No
3.0000000e+001	3.6111111e+002	No
3.0000000e+001	4.3333333e+002	No
3.0000000e+001	5.0555556e+002	No
3.0000000e+001	5.7777778e+002	No
3.0000000e+001	6.5000000e+002	No
3.0000000e+001	7.2222222e+002	No

Case Number #2 -- Decay

Title: Decay - 65gwdhighbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
3.0000000e+001	No	No
3.8011696e+001	No	No

Case Number #3 -- Irradiation

Title: Cycle 2 -65gwdhighbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

4/14/04

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	7.2222222e+001	No
3.0000000e+001	1.4444444e+002	No
3.0000000e+001	2.1666667e+002	No
3.0000000e+001	2.8888889e+002	No
3.0000000e+001	3.6111111e+002	No
3.0000000e+001	4.3333333e+002	No
3.0000000e+001	5.0555556e+002	No
3.0000000e+001	5.7777778e+002	No
3.0000000e+001	6.5000000e+002	No
3.0000000e+001	7.2222222e+002	No

Case Number #4 -- Decay

Title: Decay - 65gwdhighbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
3.0000000e+001	No	No
3.8011696e+001	No	No

Case Number #5 -- Irradiation

Title: Cycle 3 -65gwdhighbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

4/14/04

```
Output units = grams
Table cutoff = 0.000010

Power                Cumulative      Write Results
MW/Basis               Time           to Dataset
=======              =========       =============
3.0000000e+001       7.2222222e+001      No
3.0000000e+001       1.4444444e+002      No
3.0000000e+001       2.1666667e+002      No
3.0000000e+001       2.8888889e+002      No
3.0000000e+001       3.6111111e+002      No
3.0000000e+001       4.3333333e+002      No
3.0000000e+001       5.0555556e+002      No
3.0000000e+001       5.7777778e+002      No
3.0000000e+001       6.5000000e+002      No
3.0000000e+001       7.2222222e+002      No

Case Number #6   -- Decay
=====================================================

Title: Cycle 3 Down - 65gwdhighbudecay
Basis: 1 MTU

Beginning time      =    0.000000
Time units          =    Years
Neutron source      =    UO2
Bremsstrahlung      =    UO2
Library Type        =    Total

Output Options:
No output is requested for this case.

Cumulative Time      Source Spectra      Save Results
===============      ==============      ============
3.0000000e-001           Yes                Yes
1.0000000e+000           Yes                Yes
3.0000000e+000           Yes                Yes
1.0000000e+001           Yes                Yes
3.0000000e+001           Yes                Yes
1.0000000e+002           Yes                Yes
3.0000000e+002           Yes                Yes
1.0000000e+003           Yes                Yes
3.0000000e+003           Yes                Yes
1.0000000e+004           Yes                Yes
```

DA 4/14/04

4/16/04 DA

THE SPREADSHEET COPY OF ORIGEN-ARP OUTPUT OF RN CONCENTRATIONS FOR THE HIGH BURNUP CASE ARE SHOWN HERE- DECAY IS TO 10K YRS FROM REACTOR.

DA 4/16/04

Cycle 3 Do - 65gwdh ighbudecay

units of concentrations : curies

nuclide	time (years) 0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0	3000.0	10000.0
cs137	2.03E+05	1.99E+05	1.90E+05	1.62E+05	1.02E+05	2.02E+04	1.99E+02	1.88E-05	1.60E-25	0.00E+00
pu241	2.01E+05	1.94E+05	1.77E+05	1.26E+05	4.79E+04	1.63E+03	1.82E+00	1.62E+00	1.38E+00	7.77E-01
sr90	1.37E+05	1.35E+05	1.28E+05	1.08E+05	6.60E+04	1.18E+04	8.55E+01	2.79E-06	0.00E+00	0.00E+00
cm244	1.70E+04	1.66E+04	1.54E+04	1.18E+04	5.46E+03	3.74E+02	1.76E-01	4.02E-13	0.00E+00	0.00E+00
pu238	1.02E+04	1.04E+04	1.03E+04	9.78E+03	8.35E+03	4.81E+03	9.95E+02	4.24E+00	1.91E-05	2.11E-20
ni63	9.88E+02	9.84E+02	9.70E+02	9.24E+02	8.05E+02	4.96E+02	1.24E+02	9.74E-01	9.41E-07	0.00E+00
am241	4.11E+02	6.32E+02	1.22E+03	2.88E+03	5.33E+03	6.18E+03	4.52E+03	1.47E+03	6.12E+01	7.78E-01
pu240	7.19E+02	7.20E+02	7.23E+02	7.32E+02	7.48E+02	7.57E+02	7.42E+02	6.89E+02	5.58E+02	2.66E+02
sm151	6.38E+02	6.35E+02	6.25E+02	5.92E+02	5.08E+02	2.96E+02	6.35E+01	2.89E-01	5.89E-08	0.00E+00
pu239	3.84E+02	3.84E+02	3.84E+02	3.84E+02	3.84E+02	3.83E+02	3.81E+02	3.75E+02	3.58E+02	3.01E+02
am243	8.09E+01	8.09E+01	8.08E+01	8.08E+01	8.06E+01	8.01E+01	7.86E+01	7.36E+01	6.10E+01	3.16E+01
cm243	7.08E+01	6.96E+01	6.63E+01	5.59E+01	3.44E+01	6.27E+00	4.83E-02	1.95E-09	0.00E+00	0.00E+00
tc99	2.42E+01	2.42E+01	2.42E+01	2.42E+01	2.42E+01	2.42E+01	2.42E+01	2.41E+01	2.40E+01	2.34E+01
am242m	2.15E+01	2.14E+01	2.12E+01	2.05E+01	1.85E+01	1.31E+01	4.92E+00	1.57E-01	8.46E-06	9.60E-21
ni59	6.65E+00	6.65E+00	6.65E+00	6.65E+00	6.65E+00	6.65E+00	6.64E+00	6.59E+00	6.47E+00	6.07E+00
pu242	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.93E+00	4.91E+00	4.85E+00
sn121m	4.52E+00	4.48E+00	4.37E+00	4.00E+00	3.11E+00	1.29E+00	1.04E-01	1.53E-05	1.73E-16	0.00E+00
zr93	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.22E+00	2.21E+00
cm245	1.75E+00	1.75E+00	1.75E+00	1.75E+00	1.75E+00	1.74E+00	1.71E+00	1.62E+00	1.37E+00	7.76E-01
u234	1.14E+00	1.16E+00	1.22E+00	1.42E+00	1.93E+00	3.19E+00	4.56E+00	4.90E+00	4.88E+00	4.79E+00
cs135	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00
sn126	1.09E+00	1.09E+00	1.09E+00	1.09E+00	1.09E+00	1.09E+00	1.09E+00	1.08E+00	1.07E+00	1.02E+00
cm246	7.73E-01	7.73E-01	7.72E-01	7.72E-01	7.69E-01	7.62E-01	7.40E-01	6.67E-01	4.98E-01	1.79E-01
np237	7.22E-01	7.22E-01	7.23E-01	7.28E-01	7.56E-01	8.95E-01	1.24E+00	1.86E+00	2.14E+00	2.15E+00
u236	4.68E-01	4.68E-01	4.68E-01	4.68E-01	4.68E-01	4.70E-01	4.74E-01	4.89E-01	5.26E-01	6.08E-01
u238	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01	3.04E-01
pd107	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.43E-01	2.42E-01
se79	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.28E-01	1.28E-01	1.26E-01	1.21E-01	1.04E-01
u232	4.68E-02	5.59E-02	7.42E-02	9.40E-02	8.22E-02	4.10E-02	5.64E-03	9.21E-06	3.79E-06	3.64E-06
i129	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02
ag108m	2.87E-02	2.86E-02	2.83E-02	2.72E-02	2.44E-02	1.66E-02	5.59E-03	1.22E-04	2.22E-09	5.68E-26
u235	1.30E-02	1.30E-02	1.30E-02	1.30E-02	1.30E-02	1.30E-02	1.31E-02	1.34E-02	1.41E-02	1.64E-02
c14	2.30E-04	2.30E-04	2.30E-04	2.30E-04	2.29E-04	2.28E-04	2.22E-04	2.04E-04	1.60E-04	6.87E-05
nb94	1.68E-04	1.68E-04	1.68E-04	1.68E-04	1.68E-04	1.68E-04	1.67E-04	1.63E-04	1.52E-04	1.20E-04
pa231	9.34E-05	9.36E-05	9.41E-05	9.60E-05	1.02E-04	1.21E-04	1.75E-04	3.67E-04	9.21E-04	2.90E-03
th230	3.60E-05	4.34E-05	6.53E-05	1.50E-04	4.59E-04	2.14E-03	9.58E-03	4.06E-02	1.29E-01	4.22E-01
u233	3.37E-05	3.59E-05	4.25E-05	6.46E-05	1.29E-04	3.80E-04	1.32E-03	6.20E-03	2.40E-02	8.79E-02
ac227	9.55E-06	1.14E-05	1.65E-05	3.22E-05	6.37E-05	1.09E-04	1.67E-04	3.67E-04	9.21E-04	2.90E-03
th229	3.87E-07	3.89E-07	3.96E-07	4.29E-07	5.98E-07	2.14E-06	1.65E-05	2.32E-04	2.65E-03	2.87E-02
ra226	8.91E-08	1.01E-07	1.48E-07	4.70E-07	3.03E-06	3.99E-05	5.11E-04	7.12E-03	5.59E-02	3.29E-01
pb210	3.15E-08	3.29E-08	3.83E-08	8.82E-08	8.15E-07	2.11E-05	4.01E-04	7.11E-03	5.59E-02	3.28E-01
cl36	1.27E-29	1.27E-29	1.27E-29	1.27E-29	1.27E-29	1.27E-29	1.27E-29	1.27E-29	1.26E-29	1.24E-29
mo93	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
total	6.33E+06	3.05E+06	1.43E+06	7.33E+05	4.04E+05	7.81E+04	7.62E+03	2.75E+03	1.16E+03	6.92E+02
subtotal	5.71E+05	5.59E+05	5.25E+05	4.23E+05	2.38E+05	4.71E+04	7.25E+03	2.67E+03	1.09E+03	6.49E+02

4/16/04

THE EFFECTS OF THE HIGHER NUCLIDE CONCENTRATIONS ~~4/16/04~~ WAS ANALYZED FOR RISK SIGNIFICANCE USING THE TPA VERSION 5.0s CODE BY COMPARING A MEAN VALUE RUN CONDUCTED PREVIOUSLY TO A MEAN VALUE RUN USING A MODIFIED nuclides.dat FILE. THE nuclides.dat FILE CONTAINS A REPRESENTATIVE INVENTORY FOR USE BY THE TPA CODE. THE DATA FILE WAS MODIFIED BY CHANGING THE NUCLIDE CONCENTRATIONS TO THOSE OF THE HIGH BURNUP FUEL AT 10 YRS DECAY FROM REACTOR - CORRESPONDING TO THE DECAY AT 4/16/04 TIME OF THE DEFAULT nuclides.dat INVENTORY. A MEAN VALUE TPA RUN USING THE HIGH B/U INVENTORY WOULD SIMULATE A REPOSITORY COMPOSED OF 100% HIGH B/U FUEL. THIS IS INTENDED TO PROVIDE A BOUNDING INVENTORY SINCE THE POTENTIAL REPOSITORY IS PROJECTED TO CONTAIN 30-35% HIGH B/U FUEL (>45 GWd/MTU).

THE FOLLOWING PAGES ARE THE TPA RUNS AND THE HIGH B/U INVENTORY nuclides.dat FILE. THEY ARE STORED ON SPOCK AT /net/spock/home/lhoward/tpa50s FOR THE NOMINAL INVENTORY MEAN VALUE RUN AND /net/spock/home/lhoward/highburn/tpa50s FOR THE HIGH B/U CASE RUN.

4/16/04

```
[lhoward@spock] /net/spock/home/lhoward {1} # cd highburn/tpa50s
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {2} # vi nuclides.dat
"nuclides.dat" 84 lines, 7152 characters
TITLE: TPA5.0 nuclide data used for the invent.f module.
** TPA5.0 Colloids added as nuclides 44-57. (9-08-02)
** TPA5.0 glass waste form inventory added. (8-30-02)
** TPA5.0 glass waste form data extracted by R.Janetzke from an Excel spreadsheet
** prepared by O.Pensado in Dec 2000. This data is in the 10th column (CPMGLASS).
** The units are Ci/MTHM but are listed here as Ci/MTU to keep naming consistency
** in the TPA modules.  They can be thought as curies per equivalent MTU.
** NOTE ON PARAMETERS CPMTU@10 AND CPMGLASS:
**   For Colloids (e.g. Jc246, Jp242, ...) these parameters must be 0.00d+00.
**   If they are set to a value other than zero, they will be overwritten by
**   subroutine releasecolloids (called from module EBSREL).
** ( TPA 4.0 data extracted from invent.f - prepared by jmm)
** mas Se79 & Ag108m half-lives updated 3/17/00
** rwr added new initial inventories 3/28/00
** rwr added flag to indicate decay information received from J. Weldy
**     for groundwater protection calculations: (1) beta/gamma,
**     (2) alpha, (3) radon, and (4) uranium (9/5/00)
**      idx = Nuclide index
**      NIS = namesisotopesave
**      NES = nameselemsave
** CPMTU@10 = cipermtuat10yr
**    DECAY = decay information (see above) rwr 9/6/00
**      --- = unitless
** Number of nuclides to be read follows:
57
**idx,      NIS,     NIS2,     NIS3, NES,     wmole, halflife,    epalim,  CPMTU@10,  CPMGLASS,  DECAY
**---       ---,      ---,      ---, ---,  [g/mol],     [yr], [Ci/MTU],  [Ci/MTU],  [Ci/MTU],    ---
   01      U238     U238      U238      U   238.0d0  4.468d9      0.10  3.04d-01  6.37d-02      4
   02     Cm246    Cm246     CM246     Cm   246.0d0  4.731d3      0.10  7.72d-01  0.00          2
   03     Pu242    Pu242     PU242     Pu   242.0d0  3.869d5      0.10  4.93d+00  3.07d-03      2
   04   Am242m   Am242m    AM242M     Am   242.0d0  1.520d2      0.10  2.05d+01  0.00          1
```

4/16/04

05	Pu238	Pu238	PU238	Pu	238.0d0	8.774d1	0.10	9.78d+03	2.09d+02	2
06	U234	U234	U234	U	234.0d0	2.445d5	0.10	1.42d+00	4.79d-02	4
07	Th230	Th230	TH230	Th	230.0d0	7.700d4	0.01	1.50d-04	3.37d-05	2
08	Ra226	Ra226	RA226	Ra	226.0d0	1.600d3	0.10	4.70d-07	3.68d-06	3
09	Pb210	Pb210	PB210	Pb	210.0d0	2.230d1	1.00	8.82d-08	2.47d-06	1
10	Cm243	Cm243	CM243	Cm	243.0d0	2.850d1	0.10	5.59d+01	0.00	2
11	Am243	Am243	AM243	Am	243.0d0	7.380d3	0.10	8.08d+01	6.83d-02	2
12	Pu239	Pu239	PU239	Pu	239.0d0	2.406d4	0.10	3.84d+02	9.67d+00	2
13	U235	U235	U235	U	235.0d0	7.038d8	0.10	1.30d-02	7.66d-04	4
14	Pa231	Pa231	PA231	Pa	231.0d0	3.277d4	0.10	9.60d-05	8.61d-03	2
15	Ac227	Ac227	AC227	Ac	227.0d0	2.177d1	0.10	3.22d-05	7.74d-03	1
16	Cm245	Cm245	CM245	Cm	245.0d0	8.499d3	0.10	1.75d-00	0.00	2
17	Pu241	Pu241	PU241	Pu	241.0d0	1.440d1	1000.00	1.26d+05	0.00	1
18	Am241	Am241	AM241	Am	241.0d0	4.322d2	0.10	2.88d+03	2.22d+01	2
19	Np237	Np237	NP237	Np	237.0d0	2.140d6	0.10	7.28d-01	2.80d-02	2
20	U233	U233	U233	U	233.0d0	1.585d5	0.10	6.46d-05	2.42d-02	4
21	Th229	Th229	TH229	Th	229.0d0	7.339d3	0.10	4.29d-07	1.99d-04	2
22	Cm244	Cm244	CM244	Cm	244.0d0	1.811d1	1000.00	1.18d+04	0.00	2
23	Pu240	Pu240	PU240	Pu	240.0d0	6.537d3	0.10	7.32d+02	3.88d+00	2
24	U236	U236	U236	U	236.0d0	2.341d7	0.10	4.68d-01	5.68d-04	4
25	U232	U232	U232	U	232.0d0	7.200d1	0.10	9.40d-02	4.13d-03	4
26	Sm151	Sm151	SM151	Sm	151.0d0	8.999d1	1.00	5.92d+02	0.00	1
27	Cs137	Cs137	CS137	Cs	137.0d0	3.000d1	1.00	1.62d+05	1.98d+03	1
28	Cs135	Cs135	CS135	Cs	135.0d0	2.300d6	1.00	1.10d-00	0.00	1
29	I129	I129	I129	I	129.0d0	1.570d7	0.10	6.13d-02	1.87d-03	1
30	Sn126	Sn126	SN126	Sn	126.0d0	1.000d5	1.00	1.09d-00	0.00	1
31	Sn121m	Sn121m	SN121M	Sn	121.0d0	4.997d1	1.00	4.00d+00	0.00	1
32	Ag108m	Ag108m	AG108M	Ag	108.0d0	4.180d2	1.00	2.72d-02	0.00	1
33	Pd107	Pd107	PD107	Pd	107.0d0	6.496d6	1.00	2.43d-01	0.00	1
34	Tc99	Tc99	TC99	Tc	99.0d0	2.130d5	10.00	2.42d+01	2.79d+00	1
35	Mo93	Mo93	MO93	Mo	93.0d0	3.498d3	1.00	0.00d-00	0.00	1
36	Nb94	Nb94	NB94	Nb	94.0d0	2.030d4	1.00	1.68d-04	0.00	1
37	Zr93	Zr93	ZR93	Zr	93.0d0	1.530d6	1.00	2.22d+00	0.00	1
38	Sr90	Sr90	SR90	Sr	90.0d0	2.912d1	1.00	1.08d+05	8.14d+03	1
39	Se79	Se79	SE79	Se	79.0d0	1.100d6	1.00	1.29d-01	0.00	1
40	Ni63	Ni63	NI63	Ni	63.0d0	9.200d1	1.00	9.24d+02	4.32d+00	1
41	Ni59	Ni59	NI59	Ni	59.0d0	8.000d4	1.00	6.65d+00	0.00	1
42	Cl36	Cl36	CL36	Cl	36.0d0	3.010d5	1.00	1.27d-29	0.00	1
43	C14	C14	C14	C	14.0d0	5.729d3	0.10	2.30d-04	7.48d-03	1
44	Jc246	Jc246	JC246	Jc	246.0d0	4.731d3	0.00	0.00d+00	0.00	2
45	Jp242	Jp242	JP242	Jp	242.0d0	3.869d5	0.00	0.00d+00	0.00	2
46	Ja242m	Ja242m	JA242M	Ja	242.0d0	1.520d2	0.00	0.00d+00	0.00	1
47	Jp238	Jp238	JP238	Jp	238.0d0	8.774d1	0.00	0.00d+00	0.00	2
48	Jt230	Jt230	JT230	Jt	230.0d0	7.700d4	0.00	0.00d+00	0.00	2
49	Jc243	Jc243	JC243	Jc	243.0d0	2.850d1	0.00	0.00d+00	0.00	2
50	Jp239	Jp239	JP239	Jp	239.0d0	2.406d4	0.00	0.00d+00	0.00	2
51	Ja243	Ja243	JA243	Ja	243.0d0	7.380d3	0.00	0.00d+00	0.00	2
52	Jc245	Jc245	JC245	Jc	245.0d0	8.499d3	0.00	0.00d+00	0.00	2
53	Jp241	Jp241	JP241	Jp	241.0d0	1.440d1	0.00	0.00d+00	0.00	1
54	Ja241	Ja241	JA241	Ja	241.0d0	4.322d2	0.00	0.00d+00	0.00	2
55	Jc244	Jc244	JC244	Jc	244.0d0	1.811d1	0.00	0.00d+00	0.00	2
56	Jp240	Jp240	JP240	Jp	240.0d0	6.537d3	0.00	0.00d+00	0.00	2
57	Jt229	Jt229	JT229	Jt	229.0d0	7.339d3	0.00	0.00d+00	0.00	2

Friday, April 16, 2004 08:05:47 AM

```
** rwr added new initial inventories 3/28/00
** rwr added flag to indicate decay information received from J. Weldy
**     for groundwater protection calculations: (1) beta/gamma,
**     (2) alpha, (3) radon, and (4) uranium (9/5/00)
**      idx = Nuclide index
**      NIS = namesisotopesave
**      NES = nameselemsave
** CPMTU@10 = cipermtuat10yr
**    DECAY = decay information (see above) rwr 9/6/00
**      --- = unitless
** Number of nuclides to be read follows:
57
```

**idx,	NIS,	NIS2,	NIS3,	NES,	wmole,	halflife,	epalim,	CPMTU@10,	CPMGLASS,	DECAY
**---	---,	---,	---,	---,	[g/mol],	[yr],	[Ci/MTU],	[Ci/MTU],	[Ci/MTU],	---
01	U238	U238	U238	U	238.0d0	4.468d9	0.10	3.04d-01	6.37d-02	4
02	Cm246	Cm246	CM246	Cm	246.0d0	4.731d3	0.10	7.72d-01	0.00	2
03	Pu242	Pu242	PU242	Pu	242.0d0	3.869d5	0.10	4.93d+00	3.07d-03	2
04	Am242m	Am242m	AM242M	Am	242.0d0	1.520d2	0.10	2.05d+01	0.00	1
05	Pu238	Pu238	PU238	Pu	238.0d0	8.774d1	0.10	9.78d+03	2.09d+02	2
06	U234	U234	U234	U	234.0d0	2.445d5	0.10	1.42d+00	4.79d-02	4
07	Th230	Th230	TH230	Th	230.0d0	7.700d4	0.01	1.50d-04	3.37d-05	2
08	Ra226	Ra226	RA226	Ra	226.0d0	1.600d3	0.10	4.70d-07	3.68d-06	3
09	Pb210	Pb210	PB210	Pb	210.0d0	2.230d1	1.00	8.82d-08	2.47d-06	1
10	Cm243	Cm243	CM243	Cm	243.0d0	2.850d1	0.10	5.59d+01	0.00	2

```
:q!
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {7} # setenv TPA_TEST
/net/spock/home/lhoward/highburn/tpa50s
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {8} # setenv TPA_DATA
/net/spock/home/lhoward/highburn/tpa50s
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {9} # $TPA_TEST/tpa.e
================================================================================
          exec: Welcome to TPA Version 5.0s
        Job started: Fri Apr 16 08:01:17 2004
================================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste    Number of WP
    #       [m^2]      [MTU]
    1     723591.3    11535.2        1462
    2     784763.0    12363.6        1567
    3     390372.0     6083.2         771
    4     207581.3     3384.8         429
    5     378857.2     5980.6         758
    6     424872.5     6698.6         849
    7     163938.3     2556.4         324
    8     393468.9     6667.1         845
    9     660785.5     7708.5         977
   10     589497.1     7061.5         895

 Total Area [acre]          =      1165.7343975661
 Total Buried Waste [MTU]   =      70039.530000000
 Repository AML [MTU/acre]  =      60.081893565319

 Specified Global Parameters:

                 Compliance Period =  10000.0 (yr)
           Maximum Simulation Time =  10000.0 (yr)
            Number Of Realizations =      1
                Number Of Subareas =     10
                Volcanism scenario =      0 (yes=1, no=0)
                  Faulting scenario =      0 (yes=1, no=0)
      Mechanical failure scenarios:
                         Seismicity =      1 (yes=1, no=0)
                  Drift Degradation =      1 (yes=1, no=0)
       Distance to Receptor Group =     18.0 (km)

 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**

 The specified path for data  = $TPA_DATA/
```

tpamean.out → tpa.inp FOR MEAN VALUE RUN USING 65 Gwd/MTU HIGH B/u INV. FOR NUCLIDES.dat - 1 REALIZATION

PEAK MEAN DOSE = 0.363 mrem/yr AT 10K YRS.

```
The specified path for codes = $TPA_TEST/

**To modify global parameters or the path, stop code execution using control-C**
------------------------------------------------------------------------
    subarea   1 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 UZFLOW: Uncertainty parameter:    0.0000E+00
         Mean Annual Infiltration at Start(AAI0):    8.5000E+00
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
  *** failed WPs:   7  out of   1462 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  1
               Tc99    6.4671E-03 [Ci/yr/SA] at  1.415E+03 yr
               Am241   1.7152E-03 [Ci/yr/SA] at  1.415E+03 yr
               Cs135   1.5485E-03 [Ci/yr/SA] at  1.415E+03 yr
               Am243   6.4442E-04 [Ci/yr/SA] at  6.560E+03 yr
               Pu240   2.2906E-04 [Ci/yr/SA] at  9.769E+03 yr
               Pu239   2.2585E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
                      Highest release rates from UZ
               Tc99    4.7159E-03 [Ci/yr/SA] at  1.810E+03 yr
               I129    7.2619E-05 [Ci/yr/SA] at  1.810E+03 yr
               Ja241   4.8630E-05 [Ci/yr/SA] at  1.810E+03 yr
               Ja243   3.6871E-05 [Ci/yr/SA] at  5.564E+03 yr
               Se79    2.6139E-05 [Ci/yr/SA] at  1.000E+04 yr
               Cm245   2.1923E-05 [Ci/yr/SA] at  1.900E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                      Highest release rates from SZ
               Tc99    3.4039E-03 [Ci/yr/SA] at  2.540E+03 yr
               I129    5.2169E-05 [Ci/yr/SA] at  2.540E+03 yr
               Am243   1.1408E-05 [Ci/yr/SA] at  1.000E+04 yr
               Pu239   9.6381E-06 [Ci/yr/SA] at  1.000E+04 yr
               Pu240   9.0842E-06 [Ci/yr/SA] at  1.000E+04 yr
               Am241   4.5866E-06 [Ci/yr/SA] at  3.305E+03 yr
------------------------------------------------------------------------
    subarea   2 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      8 at time =      0.0 yr
  *** failed WPs:   8  out of   1567 ***
  *** ejected WPs:   0
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  2
               Tc99    4.1761E-03 [Ci/yr/SA] at  1.900E+03 yr
               Cs135   9.8206E-04 [Ci/yr/SA] at  1.900E+03 yr
               Am241   6.0648E-04 [Ci/yr/SA] at  1.900E+03 yr
               Am243   5.3293E-04 [Ci/yr/SA] at  1.000E+04 yr
               Pu240   1.3286E-04 [Ci/yr/SA] at  9.769E+03 yr
               Pu239   1.3221E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                      Highest release rates from UZ
```



```
               Tc99    4.1761E-03 [Ci/yr/SA] at  1.900E+03 yr
               Cs135   9.8206E-04 [Ci/yr/SA] at  1.900E+03 yr
               Am241   6.0648E-04 [Ci/yr/SA] at  1.900E+03 yr
               Am243   5.3293E-04 [Ci/yr/SA] at  1.000E+04 yr
               Pu240   1.3286E-04 [Ci/yr/SA] at  9.769E+03 yr
               Pu239   1.3221E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                      Highest release rates from SZ
               Tc99    2.9497E-03 [Ci/yr/SA] at  2.729E+03 yr
               I129    4.4546E-05 [Ci/yr/SA] at  2.729E+03 yr
               Am243   4.1619E-05 [Ci/yr/SA] at  1.000E+04 yr
               Pu239   1.2663E-05 [Ci/yr/SA] at  1.000E+04 yr
               Pu240   1.0919E-05 [Ci/yr/SA] at  1.000E+04 yr
               Am241   6.1148E-06 [Ci/yr/SA] at  3.384E+03 yr
------------------------------------------------------------------------
    subarea   3 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   771 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  3
               Tc99    2.9272E-03 [Ci/yr/SA] at  1.601E+03 yr
               Cs135   6.9189E-04 [Ci/yr/SA] at  1.601E+03 yr
               Am241   6.5373E-04 [Ci/yr/SA] at  1.601E+03 yr
               Am243   3.6346E-04 [Ci/yr/SA] at  8.897E+03 yr
               Pu240   1.0108E-04 [Ci/yr/SA] at  9.769E+03 yr
               Pu239   1.0010E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
                      Highest release rates from UZ
               Tc99    2.0373E-03 [Ci/yr/SA] at  2.145E+03 yr
               I129    3.0915E-05 [Ci/yr/SA] at  2.145E+03 yr
               Ja243   1.7450E-05 [Ci/yr/SA] at  8.897E+03 yr
               Ja241   1.3483E-05 [Ci/yr/SA] at  2.145E+03 yr
               Cm245   1.3036E-05 [Ci/yr/SA] at  2.363E+03 yr
               Cm246   6.3558E-06 [Ci/yr/SA] at  2.363E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                      Highest release rates from SZ
               Tc99    1.6442E-03 [Ci/yr/SA] at  2.863E+03 yr
               I129    2.4828E-05 [Ci/yr/SA] at  2.863E+03 yr
               Am243   1.4736E-05 [Ci/yr/SA] at  1.000E+04 yr
               Pu239   4.7112E-06 [Ci/yr/SA] at  1.000E+04 yr
               Pu240   3.9677E-06 [Ci/yr/SA] at  1.000E+04 yr
               Am241   1.6635E-06 [Ci/yr/SA] at  3.549E+03 yr
------------------------------------------------------------------------
    subarea   4 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
  *** failed WPs:   2  out of   429 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
```

```
                Highest release rates from Sub Area  4
            Tc99    7.5351E-04 [Ci/yr/SA] at  2.307E+03 yr
            Cs135   1.7722E-04 [Ci/yr/SA] at  2.307E+03 yr
            Am243   9.4724E-05 [Ci/yr/SA] at  1.000E+04 yr
            Am241   6.5182E-05 [Ci/yr/SA] at  2.307E+03 yr
            Pu240   2.3593E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   2.3506E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    5.7400E-04 [Ci/yr/SA] at  3.227E+03 yr
            I129    8.6469E-06 [Ci/yr/SA] at  3.227E+03 yr
            Ja243   4.4450E-06 [Ci/yr/SA] at  1.000E+04 yr
            Cm245   3.7841E-06 [Ci/yr/SA] at  3.227E+03 yr
            Cm246   1.7469E-06 [Ci/yr/SA] at  3.227E+03 yr
            Jp240   1.3014E-06 [Ci/yr/SA] at  5.971E+03 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
            Tc99    5.2795E-04 [Ci/yr/SA] at  3.812E+03 yr
            I129    7.9780E-06 [Ci/yr/SA] at  3.812E+03 yr
            Am243   3.3950E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu239   1.0917E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   9.0729E-07 [Ci/yr/SA] at  1.000E+04 yr
            Am241   2.3683E-07 [Ci/yr/SA] at  4.607E+03 yr
--------------------------------------------------------------------------
    subarea   5 of  10          realization    1 of    1
--------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 *** failed WPs:   4  out of   758 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  5
            Tc99    2.6061E-03 [Ci/yr/SA] at  1.682E+03 yr
            Cs135   6.2428E-04 [Ci/yr/SA] at  1.682E+03 yr
            Am241   5.1723E-04 [Ci/yr/SA] at  1.682E+03 yr
            Am243   2.4100E-04 [Ci/yr/SA] at  6.113E+03 yr
            Pu240   8.8375E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   8.7167E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    1.6245E-03 [Ci/yr/SA] at  2.307E+03 yr
            I129    2.5139E-05 [Ci/yr/SA] at  2.307E+03 yr
            Ja243   1.4845E-05 [Ci/yr/SA] at  5.971E+03 yr
            Cm245   7.9070E-06 [Ci/yr/SA] at  2.602E+03 yr
            Ja241   7.7130E-06 [Ci/yr/SA] at  2.307E+03 yr
            Jp240   4.7796E-06 [Ci/yr/SA] at  5.971E+03 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
            Tc99    1.4465E-03 [Ci/yr/SA] at  3.151E+03 yr
            I129    2.2271E-05 [Ci/yr/SA] at  3.151E+03 yr
            Am243   4.3354E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu239   3.6393E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   3.4085E-06 [Ci/yr/SA] at  1.000E+04 yr
            Am241   1.0264E-06 [Ci/yr/SA] at  3.812E+03 yr
--------------------------------------------------------------------------
    subarea   6 of  10          realization    1 of    1
--------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
```



```
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 *** failed WPs:   4  out of   849 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  6
            Tc99    1.8051E-03 [Ci/yr/SA] at  2.094E+03 yr
            Cs135   4.2184E-04 [Ci/yr/SA] at  2.094E+03 yr
            Am243   2.2427E-04 [Ci/yr/SA] at  1.000E+04 yr
            Am241   2.0494E-04 [Ci/yr/SA] at  2.094E+03 yr
            Pu240   5.5880E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   5.5641E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    1.0591E-03 [Ci/yr/SA] at  3.151E+03 yr
            I129    1.5937E-05 [Ci/yr/SA] at  3.151E+03 yr
            Ja243   9.9610E-06 [Ci/yr/SA] at  1.000E+04 yr
            Cm245   9.0358E-06 [Ci/yr/SA] at  3.722E+03 yr
            Cm246   4.0413E-06 [Ci/yr/SA] at  3.722E+03 yr
            Jp240   2.8926E-06 [Ci/yr/SA] at  5.971E+03 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
            Tc99    1.0298E-03 [Ci/yr/SA] at  4.191E+03 yr
            I129    1.5283E-05 [Ci/yr/SA] at  4.093E+03 yr
            Am243   7.5850E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu239   2.5393E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   2.0568E-06 [Ci/yr/SA] at  1.000E+04 yr
            Am241   4.9946E-07 [Ci/yr/SA] at  4.945E+03 yr
--------------------------------------------------------------------------
    subarea   7 of  10          realization    1 of    1
--------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
 *** failed WPs:   2  out of   324 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  7
            Tc99    8.3711E-04 [Ci/yr/SA] at  2.145E+03 yr
            Cs135   2.0093E-04 [Ci/yr/SA] at  2.145E+03 yr
            Am241   9.2038E-05 [Ci/yr/SA] at  2.145E+03 yr
            Am243   8.0007E-05 [Ci/yr/SA] at  7.038E+03 yr
            Pu240   2.7084E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   2.6796E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    4.5034E-04 [Ci/yr/SA] at  3.549E+03 yr
            I129    6.9702E-06 [Ci/yr/SA] at  3.549E+03 yr
            Ja243   4.0094E-06 [Ci/yr/SA] at  5.971E+03 yr
            Cm245   2.2043E-06 [Ci/yr/SA] at  4.093E+03 yr
            Jp240   1.3246E-06 [Ci/yr/SA] at  5.971E+03 yr
            Jp239   1.2344E-06 [Ci/yr/SA] at  1.000E+04 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
            Tc99    4.4058E-04 [Ci/yr/SA] at  4.499E+03 yr
            I129    6.7900E-06 [Ci/yr/SA] at  4.499E+03 yr
```

```
            Am243   2.3786E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu239   1.1380E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   9.7296E-07 [Ci/yr/SA] at  1.000E+04 yr
            Am241   1.2974E-07 [Ci/yr/SA] at  5.184E+03 yr
------------------------------------------------------------------------
    subarea   8 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   845 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  8
            Tc99    2.8475E-03 [Ci/yr/SA] at  1.601E+03 yr
            Cs135   6.7097E-04 [Ci/yr/SA] at  1.601E+03 yr
            Am241   5.9821E-04 [Ci/yr/SA] at  1.601E+03 yr
            Am243   3.8313E-04 [Ci/yr/SA] at  9.769E+03 yr
            Pu240   9.5737E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   9.5029E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                  Highest release rates from UZ
            Tc99    2.8475E-03 [Ci/yr/SA] at  1.601E+03 yr
            Cs135   6.7097E-04 [Ci/yr/SA] at  1.601E+03 yr
            Am241   5.9821E-04 [Ci/yr/SA] at  1.601E+03 yr
            Am243   3.8313E-04 [Ci/yr/SA] at  9.769E+03 yr
            Pu240   9.5737E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   9.5029E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                  Highest release rates from SZ
            Tc99    1.7390E-03 [Ci/yr/SA] at  2.479E+03 yr
            Am243   2.9444E-05 [Ci/yr/SA] at  1.000E+04 yr
            I129    2.6166E-05 [Ci/yr/SA] at  2.479E+03 yr
            Pu239   9.0702E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   7.7707E-06 [Ci/yr/SA] at  1.000E+04 yr
            Am241   4.8608E-06 [Ci/yr/SA] at  3.227E+03 yr
------------------------------------------------------------------------
    subarea   9 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   977 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  9
            Tc99    2.9733E-03 [Ci/yr/SA] at  1.766E+03 yr
            Cs135   7.0530E-04 [Ci/yr/SA] at  1.766E+03 yr
            Am241   5.3258E-04 [Ci/yr/SA] at  1.766E+03 yr
            Am243   3.2377E-04 [Ci/yr/SA] at  7.730E+03 yr
            Pu240   1.0147E-04 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   1.0031E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                  Highest release rates from UZ
```



```
            Tc99    2.9733E-03 [Ci/yr/SA] at  1.766E+03 yr
            Cs135   7.0530E-04 [Ci/yr/SA] at  1.766E+03 yr
            Am241   5.3258E-04 [Ci/yr/SA] at  1.766E+03 yr
            Am243   3.2377E-04 [Ci/yr/SA] at  7.730E+03 yr
            Pu240   1.0147E-04 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   1.0031E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
                  Highest release rates from SZ
            Tc99    1.6949E-03 [Ci/yr/SA] at  2.796E+03 yr
            I129    2.5790E-05 [Ci/yr/SA] at  2.796E+03 yr
            Am243   2.5494E-05 [Ci/yr/SA] at  8.897E+03 yr
            Pu239   8.8749E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   7.8368E-06 [Ci/yr/SA] at  1.000E+04 yr
            Am241   2.8168E-06 [Ci/yr/SA] at  3.549E+03 yr
------------------------------------------------------------------------
    subarea  10 of  10          realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   895 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  10
            Tc99    2.6093E-03 [Ci/yr/SA] at  1.854E+03 yr
            Cs135   6.1903E-04 [Ci/yr/SA] at  1.854E+03 yr
            Am241   4.0248E-04 [Ci/yr/SA] at  1.854E+03 yr
            Am243   2.9776E-04 [Ci/yr/SA] at  8.490E+03 yr
            Pu240   8.7992E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   8.7135E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                  Highest release rates from UZ
            Tc99    2.6093E-03 [Ci/yr/SA] at  1.854E+03 yr
            Cs135   6.1903E-04 [Ci/yr/SA] at  1.854E+03 yr
            Am241   4.0248E-04 [Ci/yr/SA] at  1.854E+03 yr
            Am243   2.9776E-04 [Ci/yr/SA] at  8.490E+03 yr
            Pu240   8.7992E-05 [Ci/yr/SA] at  9.769E+03 yr
            Pu239   8.7135E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
                  Highest release rates from SZ
            Tc99    1.6212E-03 [Ci/yr/SA] at  2.863E+03 yr
            I129    2.4698E-05 [Ci/yr/SA] at  2.863E+03 yr
            Am243   2.4198E-05 [Ci/yr/SA] at  9.543E+03 yr
            Pu239   8.0542E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   6.8849E-06 [Ci/yr/SA] at  1.000E+04 yr
            Am241   2.5213E-06 [Ci/yr/SA] at  3.635E+03 yr
 exec: calling dcagw
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
                  Highest annual dose GW pathway
            Am243   2.0697E-01 [mrem/yr]  at  1.000E+04 yr
            Pu239   7.8046E-02 [mrem/yr]  at  1.000E+04 yr
            Pu240   6.8378E-02 [mrem/yr]  at  1.000E+04 yr
            Am241   2.9414E-02 [mrem/yr]  at  3.466E+03 yr
            I129    2.2745E-02 [mrem/yr]  at  2.729E+03 yr
            Cm245   9.0014E-03 [mrem/yr]  at  4.191E+03 yr
          At end of TPI, annual dose GW pathway
            Am243   2.0697E-01 [mrem/yr]
```

Friday, April 16, 2004 08:05:48 AM

```
              Pu239    7.8046E-02 [mrem/yr]
              Pu240    6.8378E-02 [mrem/yr]
              Cm245    3.7463E-03 [mrem/yr]
              Am241    3.7090E-03 [mrem/yr]
              Cm246    1.0949E-03 [mrem/yr]
                 sum   3.6275E-01 [mrem/yr]
 exec: end realizations

 exec: Peak Mean Dose is 3.62750E-04 rem/yr at  10000.0 yr, based on      1 realizations.

 exec:  Run Successfully Completed

[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {10} #
```

4/16/04 DKI

MEAN VALUE BASE CASE RUN USING tpameans.out AS NEW tpa.inp & NOMINAL nuclides.dat INVENTORY - 1 REALIZATION.

GIVES PEAK MEAN DOSE = 0.162 mrem/yr AT 10K YRS.

spock - default - SSH Secure Shell

Tuesday, April 06, 2004 10:46:32 AM

```
Your use of the CNWRA computer system constitutes consent to monitoring.
Unauthorized use is strictly prohibited. (Ref. Administrative Procedure -014)
-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-

Last login: Tue Apr  6 10:27:48 2004 from norfolk.cnwra.s
      _______
     /_____/\     Sun Enterprise 450(4 X UltraSPARC-II @ 480MHz), Keyboard present
    /_____ \\ \   OpenBoot 3.26, 4096MB memory installed, Serial# 16704178
   /_____\ \\ /   Ethernet 8:0:20:fe:e2:b2, 129.162.200.172, HostID: 80fee2b2
  /_____/ \/ / / SunOS spock 5.9 Generic_112233-11 sun4u sparc SUNW,Ultra-4
 /_____/ /    \//\
 \_____\//\    / /              Welcome to Spock!!
  \_____/ / /\ /
   \_____/ \\ \
    \_____\ \\
     \_____\/
Copyright 2002 Sun Microsystems, Inc.                    All Rights Reserved.
On-line Since 21aug2001.                      Upgraded to Solaris 9 05jan2004.

You have mail.
[lhoward@spock] /net/spock/home/lhoward {1} # cd /tpa50s
/tpa50s: No such file or directory
[lhoward@spock] /net/spock/home/lhoward {2} # cd tpa50s
[lhoward@spock] /net/spock/home/lhoward/tpa50s {3} # setenv TPA_TEST
/net/spock/home/lhoward/tpa50s
[lhoward@spock] /net/spock/home/lhoward/tpa50s {4} # setenv TPA_DATA
/net/spock/home/lhoward/tpa50s
[lhoward@spock] /net/spock/home/lhoward/tpa50s {5} # $TPA_TEST/tpa.e >tpa.out
tpa.out: File exists
[lhoward@spock] /net/spock/home/lhoward/tpa50s {6} # $TPA_TEST/tpa.e
================================================================================
         exec: Welcome to TPA Version 5.0s
       Job started: Tue Apr  6 10:41:12 2004
================================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste    Number of WP
    #       [m^2]      [MTU]
    1     723591.3    11535.2        1462
    2     784763.0    12363.6        1567
    3     390372.0     6083.2         771
    4     207581.3     3384.8         429
    5     378857.2     5980.6         758
    6     424872.5     6698.6         849
    7     163938.3     2556.4         324
    8     393468.9     6667.1         845
    9     660785.5     7708.5         977
   10     589497.1     7061.5         895

 Total Area [acre]          =      1165.7343975661
 Total Buried Waste [MTU]   =      70039.530000000
 Repository AML [MTU/acre]  =      60.081893565319

 Specified Global Parameters:

                 Compliance Period =  10000.0 (yr)
           Maximum Simulation Time =  10000.0 (yr)
            Number Of Realizations =      1
                Number Of Subareas =     10
                Volcanism scenario =      0 (yes=1, no=0)
                  Faulting scenario =      0 (yes=1, no=0)
      Mechanical failure scenarios:
                        Seismicity =      1 (yes=1, no=0)
                  Drift Degradation =      1 (yes=1, no=0)
       Distance to Receptor Group =     18.0 (km)

 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**

 The specified path for data  = $TPA_DATA/
```

4/16/04 DA


```
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C**
------------------------------------------------------------------------
    subarea   1 of  10           realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 UZFLOW: Uncertainty parameter:    0.0000E+00
        Mean Annual Infiltration at Start(AAI0):    8.5000E+00
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      7 at time =      0.0 yr
  *** failed WPs:   7  out of   1462 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  1
              Tc99    3.9889E-03 [Ci/yr/SA] at  1.415E+03 yr
              Am241   3.4523E-03 [Ci/yr/SA] at  1.415E+03 yr
              C14     3.2377E-03 [Ci/yr/SA] at  1.415E+03 yr
              Cs135   8.5990E-04 [Ci/yr/SA] at  1.415E+03 yr
              Ja241   3.4523E-04 [Ci/yr/SA] at  1.415E+03 yr
              Am243   2.4465E-04 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling uzft
                  Highest release rates from UZ
              Tc99    2.8979E-03 [Ci/yr/SA] at  1.810E+03 yr
              Ja241   1.0046E-04 [Ci/yr/SA] at  1.810E+03 yr
              I129    4.1292E-05 [Ci/yr/SA] at  1.810E+03 yr
              C136    2.6378E-05 [Ci/yr/SA] at  1.810E+03 yr
              Jp239   1.2024E-05 [Ci/yr/SA] at  1.000E+04 yr
              Ja243   1.1414E-05 [Ci/yr/SA] at  1.947E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                  Highest release rates from SZ
              Tc99    2.0916E-03 [Ci/yr/SA] at  2.540E+03 yr
              I129    2.9662E-05 [Ci/yr/SA] at  2.540E+03 yr
              C136    1.8903E-05 [Ci/yr/SA] at  2.540E+03 yr
              Pu239   9.9408E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am241   7.6649E-06 [Ci/yr/SA] at  3.227E+03 yr
              Pu240   6.7059E-06 [Ci/yr/SA] at  1.000E+04 yr
------------------------------------------------------------------------
    subarea   2 of  10           realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      8 at time =      0.0 yr
  *** failed WPs:   8  out of   1567 ***
  *** ejected WPs:   0
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  2
              Tc99    2.5657E-03 [Ci/yr/SA] at  1.900E+03 yr
              C14     1.9275E-03 [Ci/yr/SA] at  1.900E+03 yr
              Am241   1.4186E-03 [Ci/yr/SA] at  1.900E+03 yr
              Cs135   5.4325E-04 [Ci/yr/SA] at  1.900E+03 yr
              Am243   2.3500E-04 [Ci/yr/SA] at  2.602E+03 yr
              Ja241   1.4186E-04 [Ci/yr/SA] at  1.900E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                  Highest release rates from UZ
```

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```
              Tc99    2.5657E-03 [Ci/yr/SA] at  1.900E+03 yr
              Am241   1.4186E-03 [Ci/yr/SA] at  1.900E+03 yr
              Cs135   5.4325E-04 [Ci/yr/SA] at  1.900E+03 yr
              Am243   2.3500E-04 [Ci/yr/SA] at  2.602E+03 yr
              Ja241   1.4186E-04 [Ci/yr/SA] at  1.900E+03 yr
              Pu239   1.4153E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                  Highest release rates from SZ
              Tc99    1.8122E-03 [Ci/yr/SA] at  2.729E+03 yr
              I129    2.5325E-05 [Ci/yr/SA] at  2.729E+03 yr
              Am243   1.8620E-05 [Ci/yr/SA] at  4.093E+03 yr
              C136    1.6106E-05 [Ci/yr/SA] at  2.729E+03 yr
              Pu239   1.2141E-05 [Ci/yr/SA] at  1.000E+04 yr
              Am241   1.1892E-05 [Ci/yr/SA] at  3.384E+03 yr
------------------------------------------------------------------------
    subarea   3 of  10           realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   771 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  3
              Tc99    1.7985E-03 [Ci/yr/SA] at  1.601E+03 yr
              C14     1.4080E-03 [Ci/yr/SA] at  1.601E+03 yr
              Am241   1.3984E-03 [Ci/yr/SA] at  1.601E+03 yr
              Cs135   3.8273E-04 [Ci/yr/SA] at  1.601E+03 yr
              Am243   1.4738E-04 [Ci/yr/SA] at  2.145E+03 yr
              Ja241   1.3984E-04 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling uzft
                  Highest release rates from UZ
              Tc99    1.2518E-03 [Ci/yr/SA] at  2.145E+03 yr
              Ja241   2.9816E-05 [Ci/yr/SA] at  2.145E+03 yr
              I129    1.7576E-05 [Ci/yr/SA] at  2.145E+03 yr
              C136    1.1201E-05 [Ci/yr/SA] at  2.145E+03 yr
              Ja243   6.7481E-06 [Ci/yr/SA] at  2.602E+03 yr
              Jp239   5.2743E-06 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                  Highest release rates from SZ
              Tc99    1.0102E-03 [Ci/yr/SA] at  2.863E+03 yr
              I129    1.4115E-05 [Ci/yr/SA] at  2.863E+03 yr
              C136    8.9736E-06 [Ci/yr/SA] at  2.863E+03 yr
              Pu239   4.3893E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240   2.9398E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am241   2.8856E-06 [Ci/yr/SA] at  3.549E+03 yr
------------------------------------------------------------------------
    subarea   4 of  10           realization    1 of    1
------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
  *** failed WPs:   2  out of   429 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
```

```
                Highest release rates from Sub Area  4
              Tc99     4.6296E-04 [Ci/yr/SA] at  2.307E+03 yr
              C14      3.3133E-04 [Ci/yr/SA] at  2.307E+03 yr
              Am241    1.6639E-04 [Ci/yr/SA] at  2.307E+03 yr
              Cs135    9.8032E-05 [Ci/yr/SA] at  2.307E+03 yr
              Am243    4.1701E-05 [Ci/yr/SA] at  2.602E+03 yr
              Pu239    2.5159E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
              Tc99     3.5266E-04 [Ci/yr/SA] at  3.227E+03 yr
              I129     4.9158E-06 [Ci/yr/SA] at  3.227E+03 yr
              Cl36     3.1217E-06 [Ci/yr/SA] at  3.227E+03 yr
              Ja241    2.6746E-06 [Ci/yr/SA] at  2.933E+03 yr
              Ja243    1.9067E-06 [Ci/yr/SA] at  3.227E+03 yr
              Jp239    1.2098E-06 [Ci/yr/SA] at  1.000E+04 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
              Tc99     3.2438E-04 [Ci/yr/SA] at  3.812E+03 yr
              I129     4.5357E-06 [Ci/yr/SA] at  3.812E+03 yr
              Cl36     2.8769E-06 [Ci/yr/SA] at  3.812E+03 yr
              Pu239    1.0250E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am243    7.2027E-07 [Ci/yr/SA] at  1.000E+04 yr
              Pu240    6.7431E-07 [Ci/yr/SA] at  1.000E+04 yr
--------------------------------------------------------------------------------
    subarea   5 of  10          realization    1 of    1
--------------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 *** failed WPs:   4  out of   758 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  5
              Tc99     1.6011E-03 [Ci/yr/SA] at  1.682E+03 yr
              C14      1.2596E-03 [Ci/yr/SA] at  1.682E+03 yr
              Am241    1.1001E-03 [Ci/yr/SA] at  1.682E+03 yr
              Cs135    3.4533E-04 [Ci/yr/SA] at  1.682E+03 yr
              Ja241    1.1001E-04 [Ci/yr/SA] at  1.682E+03 yr
              Am243    9.7357E-05 [Ci/yr/SA] at  1.682E+03 yr
exec: calling uzft
                Highest release rates from UZ
              Tc99     9.9822E-04 [Ci/yr/SA] at  2.307E+03 yr
              Ja241    1.4637E-05 [Ci/yr/SA] at  2.307E+03 yr
              I129     1.4294E-05 [Ci/yr/SA] at  2.307E+03 yr
              Cl36     9.1233E-06 [Ci/yr/SA] at  2.307E+03 yr
              Jp239    4.4345E-06 [Ci/yr/SA] at  1.000E+04 yr
              Ja243    4.0133E-06 [Ci/yr/SA] at  2.602E+03 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
              Tc99     8.8879E-04 [Ci/yr/SA] at  3.151E+03 yr
              I129     1.2661E-05 [Ci/yr/SA] at  3.151E+03 yr
              Cl36     8.0603E-06 [Ci/yr/SA] at  3.151E+03 yr
              Pu239    3.7376E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240    2.5178E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am241    1.3839E-06 [Ci/yr/SA] at  3.722E+03 yr
--------------------------------------------------------------------------------
    subarea   6 of  10          realization    1 of    1
--------------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
```



```
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
 *** failed WPs:   4  out of   849 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  6
              Tc99     1.1091E-03 [Ci/yr/SA] at  2.094E+03 yr
              C14      8.0855E-04 [Ci/yr/SA] at  2.094E+03 yr
              Am241    5.0222E-04 [Ci/yr/SA] at  2.094E+03 yr
              Cs135    2.3335E-04 [Ci/yr/SA] at  2.094E+03 yr
              Am243    1.0616E-04 [Ci/yr/SA] at  3.004E+03 yr
              Pu239    5.9559E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
              Tc99     6.4984E-04 [Ci/yr/SA] at  3.151E+03 yr
              I129     9.0487E-06 [Ci/yr/SA] at  3.151E+03 yr
              Cl36     5.7460E-06 [Ci/yr/SA] at  3.151E+03 yr
              Ja243    4.4542E-06 [Ci/yr/SA] at  3.722E+03 yr
              Ja241    3.5626E-06 [Ci/yr/SA] at  3.151E+03 yr
              Jp239    2.7721E-06 [Ci/yr/SA] at  1.000E+04 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
              Tc99     6.3243E-04 [Ci/yr/SA] at  4.191E+03 yr
              I129     8.6831E-06 [Ci/yr/SA] at  4.093E+03 yr
              Cl36     5.4945E-06 [Ci/yr/SA] at  4.093E+03 yr
              Pu239    2.3337E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240    1.5299E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am243    1.5276E-06 [Ci/yr/SA] at  1.000E+04 yr
--------------------------------------------------------------------------------
    subarea   7 of  10          realization    1 of    1
--------------------------------------------------------------------------------
exec: calling uzflow
exec: calling nfenv
exec: calling dsfail
exec: calling seismo
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No Corrosion WP Failure ***
exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
 *** failed WPs:   2  out of   324 ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  7
              Tc99     5.1430E-04 [Ci/yr/SA] at  2.145E+03 yr
              C14      3.8362E-04 [Ci/yr/SA] at  2.145E+03 yr
              Am241    1.6651E-04 [Ci/yr/SA] at  2.145E+03 yr
              Cs135    1.1115E-04 [Ci/yr/SA] at  2.145E+03 yr
              Am243    2.9392E-05 [Ci/yr/SA] at  2.145E+03 yr
              Pu239    2.8723E-05 [Ci/yr/SA] at  1.000E+04 yr
exec: calling uzft
                Highest release rates from UZ
              Tc99     2.7674E-04 [Ci/yr/SA] at  3.549E+03 yr
              I129     3.9634E-06 [Ci/yr/SA] at  3.549E+03 yr
              Cl36     2.5217E-06 [Ci/yr/SA] at  3.549E+03 yr
              Jp239    1.2902E-06 [Ci/yr/SA] at  1.000E+04 yr
              Ja243    1.0982E-06 [Ci/yr/SA] at  4.093E+03 yr
              Jp240    9.9230E-07 [Ci/yr/SA] at  5.971E+03 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
              Tc99     2.7068E-04 [Ci/yr/SA] at  4.499E+03 yr
              I129     3.8602E-06 [Ci/yr/SA] at  4.499E+03 yr
```

```
                C136    2.4492E-06 [Ci/yr/SA] at  4.499E+03 yr
                Pu239   1.0850E-06 [Ci/yr/SA] at  1.000E+04 yr
                Pu240   7.2118E-07 [Ci/yr/SA] at  1.000E+04 yr
                Am243   4.4937E-07 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   8 of  10           realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   845 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  8
                Tc99    1.7611E-03 [Ci/yr/SA] at  1.601E+03 yr
                C14     1.3740E-03 [Ci/yr/SA] at  1.601E+03 yr
                Am241   1.2884E-03 [Ci/yr/SA] at  1.601E+03 yr
                Cs135   3.7364E-04 [Ci/yr/SA] at  1.601E+03 yr
                Am243   1.5739E-04 [Ci/yr/SA] at  2.479E+03 yr
                Ja241   1.2884E-04 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                   Highest release rates from UZ
                Tc99    1.7611E-03 [Ci/yr/SA] at  1.601E+03 yr
                Am241   1.2884E-03 [Ci/yr/SA] at  1.601E+03 yr
                Cs135   3.7364E-04 [Ci/yr/SA] at  1.601E+03 yr
                Am243   1.5739E-04 [Ci/yr/SA] at  2.479E+03 yr
                Ja241   1.2884E-04 [Ci/yr/SA] at  1.601E+03 yr
                Pu239   1.0178E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                   Highest release rates from SZ
                Tc99    1.0687E-03 [Ci/yr/SA] at  2.479E+03 yr
                I129    1.4879E-05 [Ci/yr/SA] at  2.479E+03 yr
                Am243   1.1915E-05 [Ci/yr/SA] at  3.903E+03 yr
                C136    9.4653E-06 [Ci/yr/SA] at  2.479E+03 yr
                Am241   9.3925E-06 [Ci/yr/SA] at  3.227E+03 yr
                Pu239   8.6002E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   9 of  10           realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   977 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  9
                Tc99    1.8268E-03 [Ci/yr/SA] at  1.766E+03 yr
                C14     1.4077E-03 [Ci/yr/SA] at  1.766E+03 yr
                Am241   1.1998E-03 [Ci/yr/SA] at  1.766E+03 yr
                Cs135   3.9015E-04 [Ci/yr/SA] at  1.766E+03 yr
                Am243   1.3843E-04 [Ci/yr/SA] at  2.044E+03 yr
                Ja241   1.1998E-04 [Ci/yr/SA] at  1.766E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                   Highest release rates from UZ
```



```
                Tc99    1.8268E-03 [Ci/yr/SA] at  1.766E+03 yr
                Am241   1.1998E-03 [Ci/yr/SA] at  1.766E+03 yr
                Cs135   3.9015E-04 [Ci/yr/SA] at  1.766E+03 yr
                Am243   1.3843E-04 [Ci/yr/SA] at  2.044E+03 yr
                Ja241   1.1998E-04 [Ci/yr/SA] at  1.766E+03 yr
                Pu239   1.0753E-04 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
                   Highest release rates from SZ
                Tc99    1.0416E-03 [Ci/yr/SA] at  2.796E+03 yr
                I129    1.4666E-05 [Ci/yr/SA] at  2.796E+03 yr
                C136    9.3333E-06 [Ci/yr/SA] at  2.796E+03 yr
                Pu239   8.6475E-06 [Ci/yr/SA] at  1.000E+04 yr
                Am243   8.4681E-06 [Ci/yr/SA] at  4.191E+03 yr
                Pu240   5.8008E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea  10 of  10           realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   895 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  10
                Tc99    1.6016E-03 [Ci/yr/SA] at  1.854E+03 yr
                C14     1.2212E-03 [Ci/yr/SA] at  1.854E+03 yr
                Am241   9.2919E-04 [Ci/yr/SA] at  1.854E+03 yr
                Cs135   3.4211E-04 [Ci/yr/SA] at  1.854E+03 yr
                Am243   1.2642E-04 [Ci/yr/SA] at  2.094E+03 yr
                Pu239   9.3377E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                   Highest release rates from UZ
                Tc99    1.6016E-03 [Ci/yr/SA] at  1.854E+03 yr
                Am241   9.2919E-04 [Ci/yr/SA] at  1.854E+03 yr
                Cs135   3.4211E-04 [Ci/yr/SA] at  1.854E+03 yr
                Am243   1.2642E-04 [Ci/yr/SA] at  2.094E+03 yr
                Pu239   9.3377E-05 [Ci/yr/SA] at  1.000E+04 yr
                Ja241   9.2919E-05 [Ci/yr/SA] at  1.854E+03 yr
 exec: calling szft
                   Highest release rates from SZ
                Tc99    9.9606E-04 [Ci/yr/SA] at  2.863E+03 yr
                I129    1.4041E-05 [Ci/yr/SA] at  2.863E+03 yr
                C136    8.9347E-06 [Ci/yr/SA] at  2.863E+03 yr
                Am243   8.1399E-06 [Ci/yr/SA] at  4.191E+03 yr
                Pu239   7.6146E-06 [Ci/yr/SA] at  1.000E+04 yr
                Pu240   5.0999E-06 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling dcagw
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
                   Highest annual dose GW pathway
                Pu239   7.5625E-02 [mrem/yr]  at  1.000E+04 yr
                Am243   6.2723E-02 [mrem/yr]  at  4.093E+03 yr
                Am241   5.3165E-02 [mrem/yr]  at  3.384E+03 yr
                Pu240   5.0644E-02 [mrem/yr]  at  1.000E+04 yr
                I129    1.2932E-02 [mrem/yr]  at  2.729E+03 yr
                Tc99    4.7035E-03 [mrem/yr]  at  2.796E+03 yr
              At end of TPI, annual dose GW pathway
                Pu239   7.5625E-02 [mrem/yr]
```

4/16/04 DA


```
                Pu240    5.0644E-02 [mrem/yr]
                Am243    3.4133E-02 [mrem/yr]
                Am241    5.5808E-04 [mrem/yr]
                Cm245    5.4401E-04 [mrem/yr]
                Tc99     2.5918E-04 [mrem/yr]
                   sum   1.6209E-01 [mrem/yr]
 exec: end realizations

 exec: Peak Mean Dose is 1.62090E-04 rem/yr at  10000.0 yr, based on      1 realizations.

 exec:  Run Successfully Completed

[lhoward@spock] /net/spock/home/lhoward/tpa50s {7} #
```

5/3/04 DA

FURTHER ORIGEN-ARP 2.00 ANALYSIS CONDUCTED TO REFINE THE FUEL ASSEMBLY MATERIALS & ADD C, Cl, & N IMPURITIES AT TYPICAL INDUSTRY LEVELS. THE INPUT DATA AND RN INVENTORY GENERATED ARE SHOWN IN THE FOLLOWING PAGES & STORED ON THE NORFOLK MACHINE AS INDICATED PREVIOUSLY.


```
PlotOPUS input specified for 6 plots.

Number of Isotopes     = 16
Input Option           = Entering data using form
Input Units            = grams


Library: 15x15
Enrichment Factor (Wt%U235)    = 5.000000
Moderator Density (g/cc)       = 0.713500

Nuclide     ID          Library              Concentration
=======     ==          =======              =============
U 234       922340      Actinide              445.000000
U 235       922350      Actinide              50000.000000
U 236       922360      Actinide              230.000000
U 238       922380      Actinide              949325.000000
O           80000       Natural               136000.000000
Cr          240000      Natural               5920.000000
Mn          250000      Natural               330.000000
Fe          260000      Natural               12940.000000
Co          270000      Natural               70.000000
Ni          280000      Natural               9870.000000
Zr          400000      Natural               221440.000000
Nb          410000      Natural               700.000000
Sn          500000      Natural               3510.000000
C           60000       Natural               195.000000
Cl          170000      Natural               10.000000
N           70000       Natural               60.000000

Neutron Group      =        27GrpENDF4
Number of groups   =        27


Gamma Group        =    18GrpSCALE
Number of groups   =    18


Number of cases    = 6


Case Number #1  -- Irradiation
=================================================


Title: Cycle 1 -65gwdhighbudecay
Basis: 1 MTU


Time units=        Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

       Light Elements
       Actinides
       Fission Products

Output units = grams
```

DA 5/3/04

Table cutoff = 0.000010

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	7.2222222e+001	No
3.0000000e+001	1.4444444e+002	No
3.0000000e+001	2.1666667e+002	No
3.0000000e+001	2.8888889e+002	No
3.0000000e+001	3.6111111e+002	No
3.0000000e+001	4.3333333e+002	No
3.0000000e+001	5.0555556e+002	No
3.0000000e+001	5.7777778e+002	No
3.0000000e+001	6.5000000e+002	No
3.0000000e+001	7.2222222e+002	No

Case Number #2 -- Decay

Title: Decay - 65gwdhighbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
3.0000000e+001	No	No
3.8011696e+001	No	No

Case Number #3 -- Irradiation

Title: Cycle 2 -65gwdhighbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements
Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	7.2222222e+001	No
3.0000000e+001	1.4444444e+002	No
3.0000000e+001	2.1666667e+002	No
3.0000000e+001	2.8888889e+002	No
3.0000000e+001	3.6111111e+002	No
3.0000000e+001	4.3333333e+002	No
3.0000000e+001	5.0555556e+002	No
3.0000000e+001	5.7777778e+002	No
3.0000000e+001	6.5000000e+002	No
3.0000000e+001	7.2222222e+002	No

Case Number #4 -- Decay

Title: Decay - 65gwdhighbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Days
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
1.0000000e-002	No	No
3.0000000e-002	No	No
1.0000000e-001	No	No
3.0000000e-001	No	No
1.0000000e+000	No	No
3.0000000e+000	No	No
1.0000000e+001	No	No
3.0000000e+001	No	No
3.8011696e+001	No	No

Case Number #5 -- Irradiation

Title: Cycle 3 -65gwdhighbudecay
Basis: 1 MTU

Time units= Days

OUTPUT OPTIONS

Tables = Nuclides

Output:

Light Elements

Actinides
Fission Products

Output units = grams
Table cutoff = 0.000010

Power MW/Basis	Cumulative Time	Write Results to Dataset
3.0000000e+001	7.2222222e+001	No
3.0000000e+001	1.4444444e+002	No
3.0000000e+001	2.1666667e+002	No
3.0000000e+001	2.8888889e+002	No
3.0000000e+001	3.6111111e+002	No
3.0000000e+001	4.3333333e+002	No
3.0000000e+001	5.0555556e+002	No
3.0000000e+001	5.7777778e+002	No
3.0000000e+001	6.5000000e+002	No
3.0000000e+001	7.2222222e+002	No

Case Number #6 -- Decay

Title: Cycle 3 Down - 65gwdhighbudecay
Basis: 1 MTU

Beginning time = 0.000000
Time units = Years
Neutron source = U02
Bremsstrahlung = UO2
Library Type = Total

Output Options:
No output is requested for this case.

Cumulative Time	Source Spectra	Save Results
3.0000000e-001	Yes	Yes
1.0000000e+000	Yes	Yes
3.0000000e+000	Yes	Yes
1.0000000e+001	Yes	Yes
3.0000000e+001	Yes	Yes
1.0000000e+002	Yes	Yes
3.0000000e+002	Yes	Yes
1.0000000e+003	Yes	Yes
3.0000000e+003	Yes	Yes
1.0000000e+004	Yes	Yes

5/3/04

Inventory Comparison

65gwd/M : curies/MTU
TU

nuclide	(years) TPA code nuclides.dat 0.3	1.0	10.0	**10.0**	100.0	1000.0	3000.0	10000.0
cs137	2.03E+05	1.99E+05	1.62E+05	**9.15E+04**	2.02E+04	1.88E-05	1.60E-25	0.00E+00
pu241	2.01E+05	1.94E+05	1.26E+05	**9.22E+04**	1.63E+03	1.62E+00	1.38E+00	7.77E-01
sr90	1.37E+05	1.35E+05	1.08E+05	**6.25E+04**	1.18E+04	2.79E-06	0.00E+00	0.00E+00
cm244	1.70E+04	1.66E+04	1.18E+04	**2.68E+03**	3.74E+02	4.02E-13	0.00E+00	0.00E+00
pu238	1.02E+04	1.04E+04	9.78E+03	**3.77E+03**	4.81E+03	4.24E+00	1.91E-05	2.11E-20
ni63	9.88E+02	9.84E+02	9.24E+02	**3.72E+02**	4.96E+02	9.74E-01	9.41E-07	0.00E+00
am241	4.11E+02	6.32E+02	2.88E+03	**2.08E+03**	6.18E+03	1.47E+03	6.12E+01	7.78E-01
pu240	7.19E+02	7.20E+02	7.32E+02	**5.44E+02**	7.57E+02	6.89E+02	5.58E+02	2.66E+02
sm151	6.38E+02	6.35E+02	5.92E+02	**4.28E+02**	2.96E+02	2.89E-01	5.89E-08	0.00E+00
pu239	3.84E+02	3.84E+02	3.84E+02	**3.69E+02**	3.83E+02	3.75E+02	3.58E+02	3.01E+02
am243	8.09E+01	8.09E+01	8.08E+01	**2.64E+01**	8.01E+01	7.36E+01	6.10E+01	3.16E+01
cm243	7.08E+01	6.96E+01	5.59E+01	**2.55E+01**	6.27E+00	1.95E-09	0.00E+00	0.00E+00
tc99	2.42E+01	2.42E+01	2.42E+01	**1.45E+01**	2.42E+01	2.41E+01	2.40E+01	2.34E+01
am242m	2.15E+01	2.14E+01	2.05E+01	**2.48E+01**	1.31E+01	1.57E-01	8.46E-06	9.60E-21
ni59	6.65E+00	6.65E+00	6.65E+00	**2.44E+00**	6.65E+00	6.59E+00	6.47E+00	6.07E+00
pu242	4.93E+00	4.93E+00	4.93E+00	**2.10E+00**	4.93E+00	4.93E+00	4.91E+00	4.85E+00
sn121m	4.52E+00	4.48E+00	4.00E+00	**1.04E+00**	1.29E+00	1.53E-05	1.73E-16	0.00E+00
zr93	2.22E+00	2.22E+00	2.22E+00	**2.47E+00**	2.22E+00	2.22E+00	2.22E+00	2.21E+00
cm245	1.75E+00	1.75E+00	1.75E+00	**3.66E-01**	1.74E+00	1.62E+00	1.37E+00	7.76E-01
u234	1.14E+00	1.16E+00	1.42E+00	**1.18E+00**	3.19E+00	4.90E+00	4.88E+00	4.79E+00
cs135	1.10E+00	1.10E+00	1.10E+00	**5.36E-01**	1.10E+00	1.10E+00	1.10E+00	1.10E+00
sn126	1.09E+00	1.09E+00	1.09E+00	**8.85E-01**	1.09E+00	1.08E+00	1.07E+00	1.02E+00
cm246	7.73E-01	7.73E-01	7.72E-01	**7.62E-02**	7.62E-01	6.67E-01	4.98E-01	1.79E-01
np237	7.22E-01	7.22E-01	7.28E-01	**4.34E-01**	8.95E-01	1.86E+00	2.14E+00	2.15E+00
u236	4.68E-01	4.68E-01	4.68E-01	**2.81E-01**	4.70E-01	4.89E-01	5.26E-01	6.08E-01
u238	3.04E-01	3.04E-01	3.04E-01	**3.15E-01**	3.04E-01	3.04E-01	3.04E-01	3.04E-01
pd107	2.43E-01	2.43E-01	2.43E-01	**1.31E-01**	2.43E-01	2.43E-01	2.43E-01	2.42E-01
se79	1.29E-01	1.29E-01	1.29E-01	**4.58E-01**	1.28E-01	1.26E-01	1.21E-01	1.04E-01
u232	4.68E-02	5.59E-02	9.40E-02	**3.93E-02**	4.10E-02	9.21E-06	3.79E-06	3.64E-06
i129	6.13E-02	6.13E-02	6.13E-02	**3.57E-02**	6.13E-02	6.13E-02	6.13E-02	6.13E-02
cl36	3.30E-02	3.30E-02	3.30E-02	**1.15E-02**	3.30E-02	3.30E-02	3.28E-02	3.23E-02
ag108m	2.87E-02	2.86E-02	2.72E-02	**1.26E-02**	1.66E-02	1.22E-04	2.22E-09	5.68E-26
u235	1.30E-02	1.30E-02	1.30E-02	**1.71E-02**	1.30E-02	1.34E-02	1.41E-02	1.64E-02
* c14	2.30E-04	2.30E-04	2.30E-04	**1.44E+00**	2.28E-04	2.04E-04	1.60E-04	6.87E-05
* nb94	1.68E-04	1.68E-04	1.68E-04	**8.48E-01**	1.68E-04	1.63E-04	1.52E-04	1.20E-04
pa231	9.34E-05	9.36E-05	9.60E-05	**2.69E-05**	1.21E-04	3.67E-04	9.21E-04	2.90E-03
th230	3.60E-05	4.34E-05	1.50E-04	**1.37E-04**	2.14E-03	4.06E-02	1.29E-01	4.22E-01
u233	3.37E-05	3.59E-05	6.46E-05	**3.44E-05**	3.80E-04	6.20E-03	2.40E-02	8.79E-02
ac227	9.55E-06	1.14E-05	3.22E-05	**7.51E-06**	1.09E-04	3.67E-04	9.21E-04	2.90E-03
th229	3.87E-07	3.89E-07	4.29E-07	**2.75E-07**	2.14E-06	2.32E-04	2.65E-03	2.87E-02
ra226	8.91E-08	1.01E-07	4.70E-07	**4.11E-07**	3.99E-05	7.12E-03	5.59E-02	3.29E-01
pb210	3.15E-08	3.29E-08	8.82E-08	**5.67E-08**	2.11E-05	7.11E-03	5.59E-02	3.28E-01
mo93	0.00E+00	0.00E+00	0.00E+00	**1.51E-02**	0.00E+00	0.00E+00	0.00E+00	0.00E+00
total	5.71E+05	5.59E+05	4.23E+05	**2.57E+05**	4.71E+04	2.67E+03	1.09E+03	6.49E+02

- NOT FP
- (p,n) FROM NB 93
NATURAL NIOBIUM

5/3/04

5/4/04

UPDATED THE NUCLIDES.DAT FILE FOR TPA 5.0s RUN AS DISCUSSED PREVIOUSLY TO PROVIDE ANALYSIS TO BE PRESENTED IN CLST REPORT "A REVIEW REPORT ON HIGH BURNUP SPENT NUCLEAR FUEL - DISPOSAL ISSUES" (~~20.06002.081~~ 20.06002.01.081 5/4/04) AND THE RISK ANALYSIS FOR RISK INSIGHTS TSPAI REPORT (20.06002.01.112). TPA 5.0s FILE LOCATIONS & OUTPUT RUN ARE INCLUDED IN THE FOLLOWING 5/4/04 PAGES.

5/4/04


```
copylinesgs.h                gsanwpglass.h          mve.i                  samplerp.i
zportderf.t1
copylinesgs.t                gsanwpglass.t          mvf.i                  samplerq.i
zportderf.t2
corrode.out                  gsarea.h               nameelem.h             samplerr.i
zportfdate.h
cp.tpa                       gsarea.t               nameelem.t1            samplers.i
zportfdate.t
cumfail.h                    gsaxy.h                nameelem.t2            samplert.i
zportfdatefun.h
cumfail.t                    gsaxy.t                nameiso.h              sampleru.i
zportfdatefun.t1
cumrel.res                   gsaxym.h               nameiso.t1             samplerv.i
zportfdatefun.t2
cumrel_c.res                 gsaxym.t               nameiso.t2             samplerw.i
zportieee_flags.h
cumrelse.out                 gsccdf.res             nearfld.res            samplerx.i
zportieee_flags.t1
data                         gsccdf_c.res           nefii.dis              samplery.i
zportieee_flags.t2
dcags.f                      gw_cb_ad.dat           nefii.inp              samplerz.i
zportieee_handler.h
dcags.h                      gw_cb_ci.dat           nefii.out              samplpar.abb
zportieee_handler.t1
dcags.o                      gw_pb_ad.dat           nefii.rel              samplpar.hdr
zportieee_handler.t2
dcags.t                      gw_pb_ci.dat           nefiisz.dis            samplpar.res
zportparseunixcmdtodos.t
dcagw.f                      gwccdf.res             nefiisz.inp            scale.h
zportparseunixfilenametodos.h
dcagw.h                      gwccdf_c.res           nefiisz.out            scale.t
zportparseunixfilenametodos.t
dcagw.o                      gwork.buf              nefiisz.src            scopy.h
zportsh.h
decay43mol.h                 gwpkdos.res            nefiisz.vel            scopy.t
zportsh.t1
decay43mol.t                 gwpkds_c.res           nefiiuz.dis            seisadj.i
zportsh.t2
decay43molglass.h            gwttuzsz.res           nefiiuz.inp            seisbs1.dis
zporttime.h
decay43molglass.t            halflifeperiso.h       nefiiuz.out            seisbs2.dis
zporttime.t1
decayremove43mol.h           halflifeperiso.t1      nefiiuz.src            seismo2.f
zporttime.t2
decayremove43mol.t           halflifeperiso.t2      nefiiuz.vel            seismo2.o
zportunx.f
deltaec.inp                  ia.i                   nefmks.e               set_iouzflow.h
zportunx.o
demij_to_m.h                 ia1.i                  nefmks.log             set_iouzflow.t
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {9} # setenv TPA_TEST
/net/spock/home/lhoward/highburn/tpa50s
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {10} # setenv TPA_DATA
/net/spock/home/lhoward/highburn/tpa50s
[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {11} # $TPA_TEST/tpa.e
================================================================================
         exec: Welcome to TPA Version 5.0s
       Job started: Tue May  4 17:08:48 2004
================================================================================
 REPOSITORY DESIGN INFORMATION
 Subarea    Area       Waste    Number of WP
    #       [m^2]      [MTU]
    1     723591.3    11535.2         1462
    2     784763.0    12363.6         1567
    3     390372.0     6083.2          771
    4     207581.3     3384.8          429
    5     378857.2     5980.6          758
    6     424872.5     6698.6          849
    7     163938.3     2556.4          324
    8     393468.9     6667.1          845
    9     660785.5     7708.5          977
   10     589497.1     7061.5          895
```

```
 Total Area [acre]          =      1165.7343975661
 Total Buried Waste [MTU]   =      70039.530000000
 Repository AML [MTU/acre]  =      60.081893565319

 Specified Global Parameters:

                Compliance Period =  10000.0 (yr)
          Maximum Simulation Time =  10000.0 (yr)
           Number Of Realizations =      1
               Number Of Subareas =     10
               Volcanism scenario =      0 (yes=1, no=0)
                Faulting scenario =      0 (yes=1, no=0)
      Mechanical failure scenarios:
                        Seismicity =      1 (yes=1, no=0)
                 Drift Degradation =      1 (yes=1, no=0)
       Distance to Receptor Group =     18.0 (km)

 **>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
 **>>> You may not be using the standard chains specified   <<<**
 **>>> in the invent module.                                <<<**
 **>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**

 The specified path for data  = $TPA_DATA/
 The specified path for codes = $TPA_TEST/

 **To modify global parameters or the path, stop code execution using control-C**
-------------------------------------------------------------------------
     subarea   1 of  10           realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 UZFLOW: Uncertainty parameter:     0.0000E+00
         Mean Annual Infiltration at Start(AAI0):     8.5000E+00
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL    event =       7 at time =       0.0 yr
  *** failed WPs:    7  out of    1462 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  1
              Tc99     6.6113E-03 [Ci/yr/SA] at  1.415E+03 yr
              Am241    2.1205E-03 [Ci/yr/SA] at  1.415E+03 yr
              Cs135    1.7528E-03 [Ci/yr/SA] at  1.415E+03 yr
              Am243    5.5124E-04 [Ci/yr/SA] at  4.945E+03 yr
              Pu239    2.3176E-04 [Ci/yr/SA] at  1.000E+04 yr
              Ja241    2.1205E-04 [Ci/yr/SA] at  1.415E+03 yr
 exec: calling uzft
                   Highest release rates from UZ
              Tc99     4.8343E-03 [Ci/yr/SA] at  1.810E+03 yr
              Cl36     7.5685E-05 [Ci/yr/SA] at  1.810E+03 yr
              I129     7.0881E-05 [Ci/yr/SA] at  1.810E+03 yr
              Ja241    6.0837E-05 [Ci/yr/SA] at  1.810E+03 yr
              Ja243    2.9884E-05 [Ci/yr/SA] at  5.434E+03 yr
              Se79     2.6763E-05 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                   Highest release rates from SZ
              Tc99     3.4894E-03 [Ci/yr/SA] at  2.540E+03 yr
              Cl36     5.4243E-05 [Ci/yr/SA] at  2.540E+03 yr
              I129     5.0922E-05 [Ci/yr/SA] at  2.540E+03 yr
              Pu239    9.7605E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am243    8.7153E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240    8.2304E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   2 of  10           realization    1 of    1
```



```
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL    event =       8 at time =       0.0 yr
  *** failed WPs:    8  out of    1567 ***
  *** ejected WPs:   0
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  2
              Tc99     4.2815E-03 [Ci/yr/SA] at  1.900E+03 yr
              Cs135    1.1149E-03 [Ci/yr/SA] at  1.900E+03 yr
              Am241    7.7783E-04 [Ci/yr/SA] at  1.900E+03 yr
              Am243    4.9732E-04 [Ci/yr/SA] at  9.323E+03 yr
              Pu239    1.3555E-04 [Ci/yr/SA] at  1.000E+04 yr
              Se79     1.3069E-04 [Ci/yr/SA] at  1.900E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                   Highest release rates from UZ
              Tc99     4.2815E-03 [Ci/yr/SA] at  1.900E+03 yr
              Cs135    1.1149E-03 [Ci/yr/SA] at  1.900E+03 yr
              Am241    7.7783E-04 [Ci/yr/SA] at  1.900E+03 yr
              Am243    4.9732E-04 [Ci/yr/SA] at  9.323E+03 yr
              Pu239    1.3555E-04 [Ci/yr/SA] at  1.000E+04 yr
              Se79     1.3069E-04 [Ci/yr/SA] at  1.900E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                   Highest release rates from SZ
              Tc99     3.0244E-03 [Ci/yr/SA] at  2.729E+03 yr
              Cl36     4.6230E-05 [Ci/yr/SA] at  2.729E+03 yr
              I129     4.3489E-05 [Ci/yr/SA] at  2.729E+03 yr
              Am243    4.1601E-05 [Ci/yr/SA] at  1.000E+04 yr
              Pu239    1.2967E-05 [Ci/yr/SA] at  1.000E+04 yr
              Pu240    9.9095E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   3 of  10           realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL    event =       4 at time =       0.0 yr
  *** failed WPs:    4  out of    771 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                   Highest release rates from Sub Area  3
              Tc99     3.0011E-03 [Ci/yr/SA] at  1.601E+03 yr
              Am241    8.2263E-04 [Ci/yr/SA] at  1.601E+03 yr
              Cs135    7.8547E-04 [Ci/yr/SA] at  1.601E+03 yr
              Am243    3.0745E-04 [Ci/yr/SA] at  7.205E+03 yr
              Pu239    1.0267E-04 [Ci/yr/SA] at  1.000E+04 yr
              Se79     9.2084E-05 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling uzft
                   Highest release rates from UZ
              Tc99     2.0887E-03 [Ci/yr/SA] at  2.145E+03 yr
              Cl36     3.2145E-05 [Ci/yr/SA] at  2.145E+03 yr
              I129     3.0178E-05 [Ci/yr/SA] at  2.145E+03 yr
              Ja241    1.6995E-05 [Ci/yr/SA] at  2.145E+03 yr
              Ja243    1.6697E-05 [Ci/yr/SA] at  5.434E+03 yr
              Cm245    9.0519E-06 [Ci/yr/SA] at  2.363E+03 yr
 exec: calling szft
```

```
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                    Highest release rates from SZ
              Tc99    1.6856E-03 [Ci/yr/SA] at  2.863E+03 yr
              Cl36    2.5754E-05 [Ci/yr/SA] at  2.863E+03 yr
              I129    2.4235E-05 [Ci/yr/SA] at  2.863E+03 yr
              Am243   6.3362E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu239   4.4292E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240   3.6007E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   4 of  10          realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
  *** failed WPs:   2  out of   429 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  4
              Tc99    7.7251E-04 [Ci/yr/SA] at  2.307E+03 yr
              Cs135   2.0118E-04 [Ci/yr/SA] at  2.307E+03 yr
              Am243   9.2046E-05 [Ci/yr/SA] at  9.543E+03 yr
              Am241   8.4984E-05 [Ci/yr/SA] at  2.307E+03 yr
              Pu239   2.4098E-05 [Ci/yr/SA] at  1.000E+04 yr
              Se79    2.3580E-05 [Ci/yr/SA] at  2.307E+03 yr
 exec: calling uzft
                    Highest release rates from UZ
              Tc99    5.8838E-04 [Ci/yr/SA] at  3.227E+03 yr
              Cl36    8.9578E-06 [Ci/yr/SA] at  3.227E+03 yr
              I129    8.4393E-06 [Ci/yr/SA] at  3.227E+03 yr
              Ja243   4.3508E-06 [Ci/yr/SA] at  1.000E+04 yr
              Cm245   2.6276E-06 [Ci/yr/SA] at  3.227E+03 yr
              Ja241   1.4006E-06 [Ci/yr/SA] at  2.933E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                    Highest release rates from SZ
              Tc99    5.4138E-04 [Ci/yr/SA] at  3.812E+03 yr
              Cl36    8.2582E-06 [Ci/yr/SA] at  3.812E+03 yr
              I129    7.7895E-06 [Ci/yr/SA] at  3.812E+03 yr
              Am243   3.3946E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu239   1.1178E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240   8.2369E-07 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   5 of  10          realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   758 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  5
              Tc99    2.6719E-03 [Ci/yr/SA] at  1.682E+03 yr
              Cs135   7.0872E-04 [Ci/yr/SA] at  1.682E+03 yr
              Am241   6.5460E-04 [Ci/yr/SA] at  1.682E+03 yr
              Am243   2.1000E-04 [Ci/yr/SA] at  4.607E+03 yr
              Pu239   8.9448E-05 [Ci/yr/SA] at  1.000E+04 yr
              Se79    8.3083E-05 [Ci/yr/SA] at  1.682E+03 yr
```



```
 exec: calling uzft
                    Highest release rates from UZ
              Tc99    1.6658E-03 [Ci/yr/SA] at  2.307E+03 yr
              Cl36    2.6185E-05 [Ci/yr/SA] at  2.307E+03 yr
              I129    2.4543E-05 [Ci/yr/SA] at  2.307E+03 yr
              Ja243   9.7762E-06 [Ci/yr/SA] at  5.063E+03 yr
              Ja241   9.7442E-06 [Ci/yr/SA] at  2.307E+03 yr
              Cm245   5.4903E-06 [Ci/yr/SA] at  2.602E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                    Highest release rates from SZ
              Tc99    1.4831E-03 [Ci/yr/SA] at  3.151E+03 yr
              Cl36    2.3134E-05 [Ci/yr/SA] at  3.151E+03 yr
              I129    2.1741E-05 [Ci/yr/SA] at  3.151E+03 yr
              Pu239   3.6796E-06 [Ci/yr/SA] at  1.000E+04 yr
              Am243   3.2865E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240   3.0886E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   6 of  10          realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   849 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                  Highest release rates from Sub Area  6
              Tc99    1.8507E-03 [Ci/yr/SA] at  2.094E+03 yr
              Cs135   4.7889E-04 [Ci/yr/SA] at  2.094E+03 yr
              Am241   2.6524E-04 [Ci/yr/SA] at  2.094E+03 yr
              Am243   2.1297E-04 [Ci/yr/SA] at  9.323E+03 yr
              Pu239   5.7045E-05 [Ci/yr/SA] at  1.000E+04 yr
              Se79    5.6133E-05 [Ci/yr/SA] at  2.094E+03 yr
 exec: calling uzft
                    Highest release rates from UZ
              Tc99    1.0853E-03 [Ci/yr/SA] at  3.151E+03 yr
              Cl36    1.6505E-05 [Ci/yr/SA] at  3.151E+03 yr
              I129    1.5550E-05 [Ci/yr/SA] at  3.151E+03 yr
              Ja243   9.7762E-06 [Ci/yr/SA] at  1.000E+04 yr
              Cm245   6.2736E-06 [Ci/yr/SA] at  3.722E+03 yr
              Jp239   2.8226E-06 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                    Highest release rates from SZ
              Tc99    1.0557E-03 [Ci/yr/SA] at  4.191E+03 yr
              Cl36    1.5776E-05 [Ci/yr/SA] at  4.093E+03 yr
              I129    1.4916E-05 [Ci/yr/SA] at  4.093E+03 yr
              Am243   7.5843E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu239   2.5995E-06 [Ci/yr/SA] at  1.000E+04 yr
              Pu240   1.8677E-06 [Ci/yr/SA] at  1.000E+04 yr
-------------------------------------------------------------------------
     subarea   7 of  10          realization    1 of    1
-------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      2 at time =      0.0 yr
  *** failed WPs:   2  out of   324 ***
```

```
exec: calling ebsrel
      ebsrel: running spent fuel waste form
                Highest release rates from Sub Area  7
            Tc99    8.5822E-04 [Ci/yr/SA] at  2.145E+03 yr
            Cs135   2.2810E-04 [Ci/yr/SA] at  2.145E+03 yr
            Am241   1.1937E-04 [Ci/yr/SA] at  2.145E+03 yr
            Am243   6.7665E-05 [Ci/yr/SA] at  5.308E+03 yr
            Pu239   2.7490E-05 [Ci/yr/SA] at  1.000E+04 yr
            Se79    2.6736E-05 [Ci/yr/SA] at  2.145E+03 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    4.6182E-04 [Ci/yr/SA] at  3.549E+03 yr
            Cl36    7.2378E-06 [Ci/yr/SA] at  3.549E+03 yr
            I129    6.8060E-06 [Ci/yr/SA] at  3.549E+03 yr
            Ja243   3.9785E-06 [Ci/yr/SA] at  5.971E+03 yr
            Cm245   1.5306E-06 [Ci/yr/SA] at  4.093E+03 yr
            Jp239   1.2548E-06 [Ci/yr/SA] at  1.000E+04 yr
exec: calling szft
Note: IEEE floating-point exception flags raised:
   Inexact;  Underflow;
See the Numerical Computation Guide, ieee_flags(3M)
                Highest release rates from SZ
            Tc99    4.5170E-04 [Ci/yr/SA] at  4.499E+03 yr
            Cl36    7.0291E-06 [Ci/yr/SA] at  4.499E+03 yr
            I129    6.6282E-06 [Ci/yr/SA] at  4.499E+03 yr
            Am243   1.4223E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu239   1.0997E-06 [Ci/yr/SA] at  1.000E+04 yr
            Pu240   8.8290E-07 [Ci/yr/SA] at  1.000E+04 yr
--------------------------------------------------------------------------
    subarea   8 of  10          realization    1 of    1
--------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      4 at time =      0.0 yr
  *** failed WPs:   4  out of   845 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  8
             Tc99    2.9102E-03 [Ci/yr/SA] at  1.601E+03 yr
             Cs135   7.5933E-04 [Ci/yr/SA] at  1.601E+03 yr
             Am241   7.5045E-04 [Ci/yr/SA] at  1.601E+03 yr
             Am243   3.2443E-04 [Ci/yr/SA] at  8.293E+03 yr
             Pu239   9.7445E-05 [Ci/yr/SA] at  1.000E+04 yr
             Se79    8.9018E-05 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                 Highest release rates from UZ
             Tc99    2.9102E-03 [Ci/yr/SA] at  1.601E+03 yr
             Cs135   7.5933E-04 [Ci/yr/SA] at  1.601E+03 yr
             Am241   7.5045E-04 [Ci/yr/SA] at  1.601E+03 yr
             Am243   3.2443E-04 [Ci/yr/SA] at  8.293E+03 yr
             Pu239   9.7445E-05 [Ci/yr/SA] at  1.000E+04 yr
             Se79    8.9018E-05 [Ci/yr/SA] at  1.601E+03 yr
 exec: calling szft
 Note: IEEE floating-point exception flags raised:
    Inexact;  Underflow;
 See the Numerical Computation Guide, ieee_flags(3M)
                 Highest release rates from SZ
             Tc99    1.7827E-03 [Ci/yr/SA] at  2.479E+03 yr
             Cl36    2.7157E-05 [Ci/yr/SA] at  2.479E+03 yr
             Am243   2.6957E-05 [Ci/yr/SA] at  9.323E+03 yr
             I129    2.5541E-05 [Ci/yr/SA] at  2.479E+03 yr
             Pu239   8.9776E-06 [Ci/yr/SA] at  1.000E+04 yr
             Pu240   7.0521E-06 [Ci/yr/SA] at  1.000E+04 yr
--------------------------------------------------------------------------
```



```
    subarea   9 of  10          realization    1 of    1
--------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   977 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  9
             Tc99    3.0483E-03 [Ci/yr/SA] at  1.766E+03 yr
             Cs135   8.0068E-04 [Ci/yr/SA] at  1.766E+03 yr
             Am241   6.7775E-04 [Ci/yr/SA] at  1.766E+03 yr
             Am243   2.7645E-04 [Ci/yr/SA] at  6.113E+03 yr
             Pu239   1.0291E-04 [Ci/yr/SA] at  1.000E+04 yr
             Se79    9.3860E-05 [Ci/yr/SA] at  1.766E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                 Highest release rates from UZ
             Tc99    3.0483E-03 [Ci/yr/SA] at  1.766E+03 yr
             Cs135   8.0068E-04 [Ci/yr/SA] at  1.766E+03 yr
             Am241   6.7775E-04 [Ci/yr/SA] at  1.766E+03 yr
             Am243   2.7645E-04 [Ci/yr/SA] at  6.113E+03 yr
             Pu239   1.0291E-04 [Ci/yr/SA] at  1.000E+04 yr
             Se79    9.3860E-05 [Ci/yr/SA] at  1.766E+03 yr
 exec: calling szft
                 Highest release rates from SZ
             Tc99    1.7382E-03 [Ci/yr/SA] at  2.796E+03 yr
             Cl36    2.6787E-05 [Ci/yr/SA] at  2.796E+03 yr
             I129    2.5183E-05 [Ci/yr/SA] at  2.796E+03 yr
             Am243   2.1878E-05 [Ci/yr/SA] at  7.376E+03 yr
             Pu239   8.6331E-06 [Ci/yr/SA] at  1.000E+04 yr
             Pu240   7.1086E-06 [Ci/yr/SA] at  1.000E+04 yr
--------------------------------------------------------------------------
    subarea  10 of  10          realization    1 of    1
--------------------------------------------------------------------------
 exec: calling uzflow
 exec: calling nfenv
 exec: calling dsfail
 exec: calling seismo
 exec: calling ebsfail
      ebsfail: No Weld Failure
      *** No Corrosion WP Failure ***
 exec: failed WPs from INITIAL   event =      5 at time =      0.0 yr
  *** failed WPs:   5  out of   895 ***
 exec: calling ebsrel
       ebsrel: running spent fuel waste form
                 Highest release rates from Sub Area  10
             Tc99    2.6698E-03 [Ci/yr/SA] at  1.854E+03 yr
             Cs135   7.0135E-04 [Ci/yr/SA] at  1.854E+03 yr
             Am241   5.1388E-04 [Ci/yr/SA] at  1.854E+03 yr
             Am243   2.5332E-04 [Ci/yr/SA] at  6.715E+03 yr
             Pu239   8.9375E-05 [Ci/yr/SA] at  1.000E+04 yr
             Se79    8.2215E-05 [Ci/yr/SA] at  1.854E+03 yr
 exec: calling uzft
       *** NEFTRAN is skipped for this UZ path since no layers have significant ground water
travel time. ***
                 Highest release rates from UZ
             Tc99    2.6698E-03 [Ci/yr/SA] at  1.854E+03 yr
             Cs135   7.0135E-04 [Ci/yr/SA] at  1.854E+03 yr
             Am241   5.1388E-04 [Ci/yr/SA] at  1.854E+03 yr
             Am243   2.5332E-04 [Ci/yr/SA] at  6.715E+03 yr
             Pu239   8.9375E-05 [Ci/yr/SA] at  1.000E+04 yr
             Se79    8.2215E-05 [Ci/yr/SA] at  1.854E+03 yr
 exec: calling szft
                 Highest release rates from SZ
```

```
                Tc99    1.6621E-03 [Ci/yr/SA] at  2.863E+03 yr
                Cl36    2.5643E-05 [Ci/yr/SA] at  2.863E+03 yr
                I129    2.4108E-05 [Ci/yr/SA] at  2.863E+03 yr
                Am243   2.0477E-05 [Ci/yr/SA] at  7.914E+03 yr
                Pu239   7.6673E-06 [Ci/yr/SA] at  1.000E+04 yr
                Pu240   6.2471E-06 [Ci/yr/SA] at  1.000E+04 yr
 exec: calling dcagw
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
Computing time differences using the 2 digit year from subroutine date is not safe after year
2000.
                        Highest annual dose GW pathway
                Am243   1.5093E-01 [mrem/yr]  at  1.000E+04 yr
                Pu239   7.7425E-02 [mrem/yr]  at  1.000E+04 yr
                Pu240   6.2027E-02 [mrem/yr]  at  1.000E+04 yr
                Am241   3.3996E-02 [mrem/yr]  at  3.466E+03 yr
                I129    2.2206E-02 [mrem/yr]  at  2.729E+03 yr
                Tc99    7.8494E-03 [mrem/yr]  at  2.796E+03 yr
              At end of TPI, annual dose GW pathway
                Am243   1.5093E-01 [mrem/yr]
                Pu239   7.7425E-02 [mrem/yr]
                Pu240   6.2027E-02 [mrem/yr]
                Am241   2.6463E-03 [mrem/yr]
                Cm245   2.6013E-03 [mrem/yr]
                Cm246   5.9091E-04 [mrem/yr]
                   sum  2.9707E-01 [mrem/yr]
 exec: end realizations

 exec: Peak Mean Dose is 2.97070E-04 rem/yr at  10000.0 yr, based on      1 realizations.

 exec:  Run Successfully Completed

[lhoward@spock] /net/spock/home/lhoward/highburn/tpa50s {12} #
```


6/17/04 DA RARI WRITEUP INPUTS PROVIDED FOR SUMMATION OF WORK FOR THE SCIENTIFIC NOTEBOOK ENTRIES.

Task Title

DA 6/17/04

Task #16, High Burnup Spent Nuclear Fuel

Author

L. Howard

Background and Purpose

Commercial nuclear power plants use a variety of fuels and fuel configurations in the reactor core to generate power. Each fuel assembly, depending on the reactor configuration, initial fuel enrichment, burnup, and age of the waste, will have a unique isotopic composition. Approximately 97 percent of the 1998 commercial spent nuclear fuel inventory in the United States is classified as low burnup (less than 45-GWd/MTU). High burnup spent nuclear fuel (greater than 45-GWd/MTU) is expected to substantially increase in the coming years and could account for as much as 30 percent of the total projected inventory to be placed at the potential high-level waste repository at Yucca Mountain. This task is intended to evaluate the disposal of high burnup spent nuclear fuel and compare the risk significance with estimates from a representative inventory.

INVENT is the utility module of the Total-System Performance Assessment (TPA) code that centralizes the computation and storage of radionuclide-specific information and inventory data (Mohanty, et al., 2002). The initial inventories and thermal outputs modeled in the TPA version 5.0 code are read by the INVENT utility module from the data files *nuclides.dat* and *burnup.dat*. The data file *nucildes.dat* provides the inventory in curies per metric tonne uranium (Ci/MTU) at the assumed age of emplacement - 10 years out of reactor core. The data file *burnup.dat* provides the time history of the thermal output of the average waste (MTU weighted average of boiling water reactor (BWR) and pressurized water reactor (PWR) spent nuclear fuel).

The analysis that follows studies the risk significance of high burnup fuels by evaluating the inventory and thermal output of spent nuclear fuel waste in comparison to the values currently used in the TPA version 5.0s code. This comparison will be made to the values of the data files as well as comparison to peak expected dose of a high burnup fuel inventory to that of the representative inventory provided by the TPA code.

Methodology

Radionuclide inventories for high burnup fuels were calculated using ORIGEN-ARP 2.00 code (Bowman and Leal, 2000). ORIGEN-ARP 2.00 code performs burnup calculations using libraries (files of radionuclide characteristics such as decay parameters and neutron cross sections) defined for different types of assemblies and uranium enrichments. The library for the 15 × 15 pressurized water reactor assembly was used because the relative increase in radionuclide inventory with burnup does not change significantly with fuel design. Because the principal purposes of this study were to evaluate the effects of the increase in radionuclide inventory and assess the impact on the source term for postclosure, the 15 × 15 pressurized water reactor library was used for a 5.0-wt% enriched U-235 fuel at 65 GWd/MTU burnup. The results were compared to a 15 × 15 pressurized water reactor with a 4.0-wt% enriched U-235 fuel at 45 GWd/MTU burnup and to literature values and total-system performance assessment (TPA) Version 5.0s code inventory values. Cross sections used in the calculations were

obtained by interpolation between the cross sections in the libraries for various fuel exposures.

Pressurized water reactor fuel was analyzed because it has a higher inventory of most radionuclides and generally has a higher range of burnup than boiling water reactor fuel. The radionuclide inventories were calculated based on a typical three depletion case (irradiation) in the reactor with a 10,000-year decay case in which the cooling time is assumed to be 10 years prior to emplacement in the potential repository. This calculation provides radionuclide inventories for direct comparison to the inventory used in the TPA Version 5.0s code in Ci/MTU at 10 years from the reactor and important radionuclide concentrations as the waste decays during the 10,000-year regulatory period for the potential repository.

The ORIGEN-ARP calculated source term was compared to a number of source term analyses in the literature to ensure correct calculations were made. These calculations include those used in this report such as Ramsdell, et al. (2001) and Sanders and Gauld (2003). Significant work has also been accomplished in bench marking and validation of the ORIGEN code calculations against isotopic analyses of high burnup fuels, such as Sanders and Gauld (2003), and a number of references included in Bowman and Leal (2000). Although most of the radionuclide concentrations important to risk increase with increasing burnup, as shown in Table

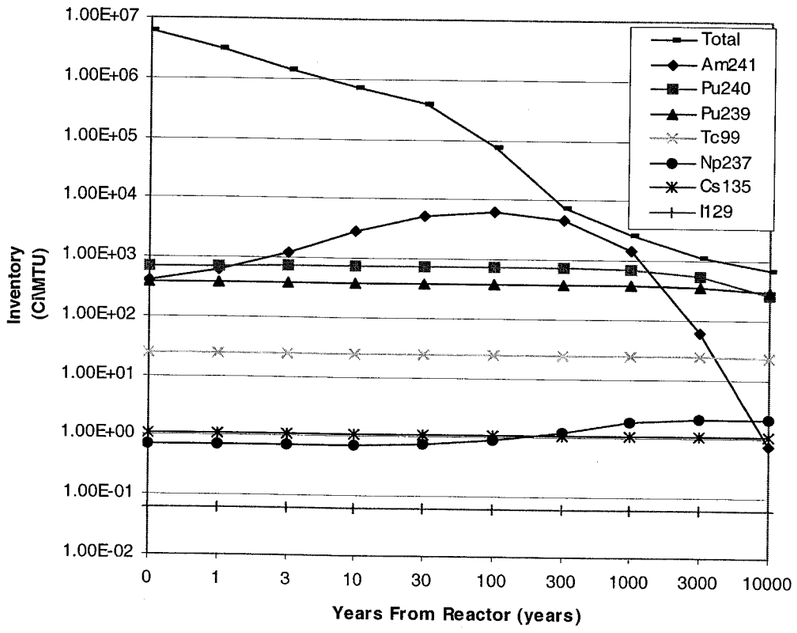

Figure #-1. ORIGEN-ARP Radionuclide Inventory and Decay—65 GWd/MTU Fuel

#-1 and Figure #-1 for the 65-GWd/MTU case inventory, the increase in the source term is not large in magnitude when comparing inventories in Table #-1 from the low end of the high burnup

fuel range (45-GWd/MTU) to those at a high end of the high burnup fuel range (65-GWd/MTU). In terms of the source term, the bounding performance assessment inventory would be entirely made up of high burnup spent nuclear fuel. As previously discussed, the potential repository inventory could be as much as 30-percent high burnup spent nuclear fuel, significantly less than the 100 percent high burnup inventory analyzed here.

Table #-1. Comparison of Calculated High Burnup Inventory to TPA Version 5.0s Code Inventory (*nuclides.dat*) for Nuclides Important to Long-Term Performance

Nuclide	ORIGEN-ARP 65 GWd/MTU Inventory at 10 Years Decay (Ci/MTU)	TPA Version 5.0s Code Initial (at 10 Years) Inventory (Ci/MTU)	Difference to TPA Version 5.0s Code Inventory (%)	ORIGEN-ARP 45 GWd/MTU Inventory at 10 Years Decay (Ci/MTU)	Difference to TPA Version 5.0s Code Inventory (%)
Am-241	2.88E+03	2.08E+03	40	2.35E+03	14
Pu-240	7.32E+02	5.44E+02	35	6.11E+02	12
Pu-239	3.84E+02	3.69E+02	4	3.57E+02	-3
Tc-99	2.42E+01	1.45E+01	67	1.78E+01	23
Np-237	7.28E-01	4.34E-01	68	4.69E-01	8
Cs-135	1.10E+00	5.36E-01	105	6.91E-01	29
I-129	6.13E-02	3.57E-02	72	4.30E-02	20
Total: 43 Nuclide TPA Version 5.0 Code Inventory	4.23E+05	2.57E+05	65		

To provide risk insight into the source term effects of a wide variation in high burnup fuel, the inventory of the 43 radionuclides tracked in the *nuclides.dat* data file were changed to the high burnup 65-GWd/MTU fuel inventory calculated using ORIGEN-ARP. This change of the initial radionuclide inventory values provides a conservative calculation of the source term effects on the dose calculation of the TPA Version 5.0s code. This change to the *nuclides.dat* inventory values provides a TPA calculation that assumes 100 percent of the inventory of the potential repository commercial spent nuclear fuel is a high burnup fuel inventory. Mean value TPA code runs were used to compare the change in dose due to the change in inventory by holding the sampled parameters of the *tpa.inp* input file at constant mean values. This is accomplished by a single realization run of the TPA version 5.0s code to generate the output file *tpameans.out*. This file is an output file of the mean values of the sampled parameters of the *tpa.inp* input file and is saved as a new *tpa.inp* input file so that further code runs using the new *tpa.inp* are mean value, constant parameter runs. This allows analysis of the changes in inventory made in the *nuclides.dat* data file discussed above to affect the change in dose instead of the various sampled parameters used in the code.

Assumptions

The following assumptions were incorporated in the analysis:

1. The ORIGEN-ARP inventory calculation uses a typical 15 x 15 pressurized water reactor (PWR) fuel assembly with a 5-wt% enriched U235 fuel irradiated at 65-GWd/MTU burnup.

2. The high burnup fuel inventory calculated using the ORIGEN-ARP 2.00 computer code provides a bounding repository inventory due to approximately 70% of the potential repository inventory being made up of low burnup spent fuel.

3. Decay heat values provided in the *burnup.dat* data file provide representative decay heat values over the life of the potential repository. This is primarily due to the heat load limits imposed in the potential repository and the blending of waste that will be required to meet those limits and prevent areas that could significantly exceed the representative heat load values.

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Results

Table #-1 provides a comparison between important long-lived radionuclides in the source term calculated for the 65-GWd/MTU high burnup fuel, the 45-GWd/MTU burnup fuel, and the representative repository inventory used in the TPA Version 5.0s code. The TPA code uses the INVENT utility module to centralize the computation and storage of radionuclide-specific information and inventory, accounting for the chain decay and ingrowth of daughters (Mohanty, et al., 2002). The data file *nuclides.dat* provides the inventory in Ci/MTU of 43 radionuclides at 10 years out-of-reactor decay age. Using a mean value, single realization TPA Version 5.0s code run to highlight the change in dose caused by the source term change, the peak dose at 10,000 years increases from the nominal basecase of 0.162 to 0.297 mrem/yr [1.62 to 2.97 μSV/yr], an increase of 1.8 times but still within the same order of magnitude for the risk calculation. This result is indicative of low risk significance due to the small change in dose resulting from analysis using a radionuclide inventory of high burnup fuel to represent the entire potential repository inventory.

The decay heat load in Watts/MTU for the two spent nuclear fuel burnup cases discussed above was calculated to analyze the impact of higher burnup fuel. The 45 GWd/MTU and 65 GWd/MTU cases are compared to literature values from Ramsdell, et al. (2001) in Figure #-2. The Ramsdell, et al. literature values only encompass 1 to 30 years decay. The recommended TPA Version 5.0s code pressurized water reactor decay heat profile (*burnup.dat* file) for pressurized water reactor spent nuclear fuel is also presented in Figure #-2 for comparison. This is the currently recommended profile for the TPA code and uses an average burnup fuel profile of 48-GWd/MTU.

The range of thermal output from the various burnup levels presented here is relatively small and shows good agreement with the calculated profiles for this report. Because most (approximately 70 percent) of the potential repository spent nuclear fuel will have been irradiated at burnups of less than 45 GWd/MTU and, thus, have lower magnitude decay heat profiles than those presented in Figure #-2, the repository decay heat load as a whole is bounded well by the recommended profile from the TPA Version 5.0s code used to assess performance of the potential repository. The thermal output used for performance assessment is a weighted average of the pressurized water reactor and boiling water reactor waste packages and weighted average fuel enrichment and burnup values taken from the literature. As can be seen from this example, the percentage of waste packages in the potential repository at higher burnup would increase the thermal output assuming the same decay time. The potential repository however, will have significant numbers of waste packages at lower thermal outputs than those shown here because of lower enrichments and burnup and longer decay times from the reactor

prior to emplacement in the potential repository.

Conclusions

Literature review and analysis indicate increasing fuel burnup changes the radionuclide inventory in spent nuclear fuels. The activities of short-lived fission products tend to remain constant or

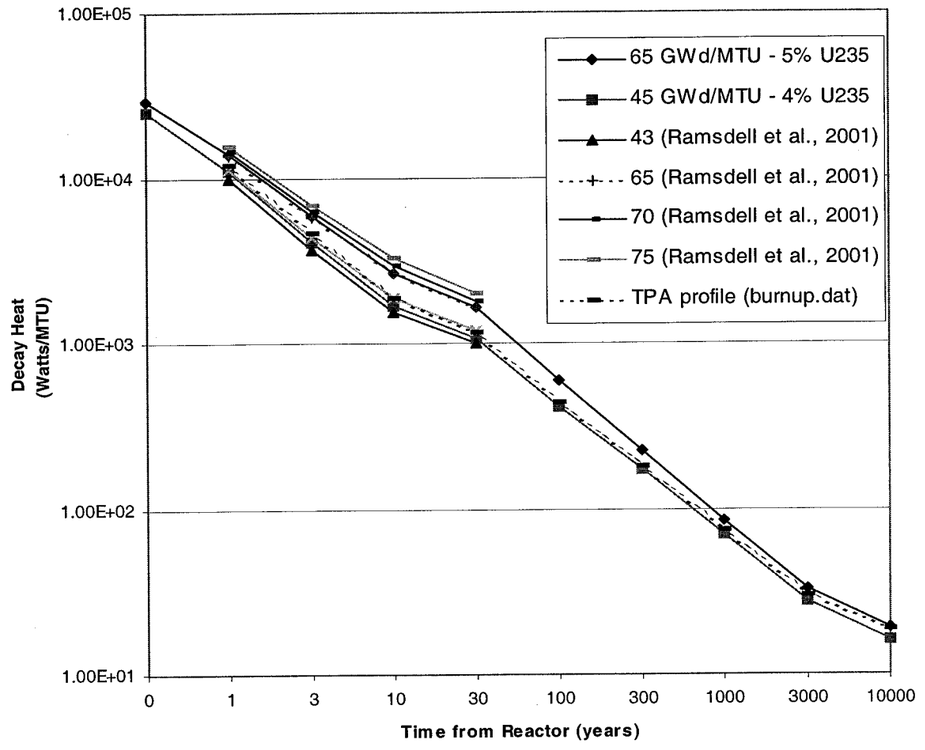

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Figure #-2. Decay Heat Comparison

decrease slightly, while activities of activation products and actinides tend to increase with increasing burnup, thus also increasing the amount of decay heat the waste will generate at a given point in time from the reactor. For use in performance assessment calculations, the source term and thermal load values are weighted averages that are used to model the potential repository inventory as a whole. An analysis using a calculated source term as a nonweighted,

100-percent high burnup fuel inventory demonstrates low risk significance in the performance assessment calculation.

The U.S. Department of Energy (DOE) source term calculations can be reviewed in two primary references, the Preclosure Safety Analysis Guide (DOE, 2002) for the preclosure source term and the Inventory Abstraction Analysis Model Report (DOE, 2001) for the postclosure source term. Both references calculate the source term using a weighted average method in which the pressurized water reactor and boiling water reactor commercial spent nuclear fuel waste inventories are determined using weighted averages of the reported enrichments, burnup, and ages from the reactor. The weighting terms are provided based on the number of fuel assemblies with a given value of each characteristic in the waste stream. Characteristics of the bounding pressurized water reactor and boiling water reactor waste forms are the maximum reported burnup, maximum reported enrichment, and the minimum reported age in the waste stream for each fuel type (DOE, 2001). DOE presents the radionuclide source terms in a curies (and grams) per fuel assembly basis vice the curies per metric tonne of uranium presented this report and used in the TPA Version 5.0s code inventory abstraction.

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I have reviewed this scientific notebook. This notebook is in compliance with QAP 001. However, if any shortcomings are identified in the future, necessary corrective action will be taken immediately.

Sitakanta Mohanty
4/15/2005