30011-2002 Rev 01
March 1997
QA: N L 03/24/97

Civilian Radioactive Waste Management System
Management and Operating Contractor

SOFTWARE QUALIFICATION REPORT
for
THE SCALE
Modular Code System Version 4.3

CSCI: 30011 V4.3
DI: 30011-2002 Rev. 01
MI: 30011-M03-001

Prepared by: Alan R Wells for Date 3/20/97
T. L. Lotz
Waste Package Development

Reviewed by: D A Thomas Date 03/20/97
D. A. Thomas
Waste Package Development

Concurrence by: D J Richards Date 3/20/97
Nevada QA Manager

Approved by: Hugh A. Benton Date 3/20/97
H. Benton, Manager
Waste Package Development

Table of Contents

1.0 INTRODUCTION

The Software Qualification Report (SQR) for SCALE 4.3 is to be revised for two reasons. The first is the addition of two new computer CPUs which differ from those used for revision 00 of the SQR and will operate with a more recent version of the operating system than the computers on which the original installation was qualified. The second is that the installation of SCALE 4.3 will be installed in a new location which is located on the new computer platform. The new installation along with the new operating system requires that a full SQR revision be performed in order to ensure that SCALE 4.3 performs properly on both the new and existing computers. Since the SCALE 4.3 code, manuals, and instillation procedures will not change, the only baseline element which is required to be updated is the SQR.

1.1 Purpose

This SQR documents the verification process for the installation of the SAS2H (burnup and isotopic decay) and CSAS25 (criticality) sequences of the SCALE modular code software package[1] for licensing evaluations. Other selected sequences of the system are to be validated as they are needed. The SAS2H sequence performs both a Light Water Reactor fuel depletion and a one-dimensional radiation shielding analysis. The CSAS25 sequence prepares appropriate cross-section data and performs a criticality analysis. These sequences are needed to support current analyses for the waste package/engineered barrier system of the Mined Geologic Disposal System. If additional sequences and/or computer platforms are required in the future, validation will be documented in revisions/addenda to this SQR.

1.2 Software Description

The source code for SCALE is developed and maintained by the Computing Applications Division of Oak Ridge National Laboratory (ORNL). It is distributed by the Radiation Safety Information Computational Center (RSICC, formerly known as the Radiation Shielding Information Center, RSIC) at ORNL as RSICC Code Package CCC-545. The system is the latest version of the NRC approved code system for licensing analyses that was originally distributed in 1980 (SCALE-0). Since that time, this system, or components of the system, have become an industry accepted standard for criticality safety analyses. The recent versions have greatly expanded the capabilities and usefulness of the system. The current version was developed under a Nuclear Regulatory Commission contract and is extensively used by the various NRC branches for verification of licensing submittals. Approval of license requests based on results provided by this system indicates that it is accepted by the NRC for licensing calculations. Since no modifications are needed for implementation by the Waste Package Development Department (WPDD) of the Las Vegas Office of Civilian Radioactive Waste Management System (OCRWMS) Management and Operating Contractor (M&O) this software is classified as acquired engineering software.

---

[1] "SCALE 4.3, Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation," Prepared for the Nuclear Regulatory Commission (NRC) by the Computing Applications Division at Oak Ridge National Laboratory (ORNL), Distributed by the Radiation Safety Information Computational Center at ORNL as code package CCC-545.

1.2.1 SAS2H Description

The SAS2H sequence of SCALE 4.3 generates radiation source terms for spent fuel and can subsequently use the source terms in a one-dimensional (1-D) shielding analysis of a shipping cask. For the analysis required for the waste package/engineered barrier system the primary use will be fuel depletion and decay analyses to obtain radiation sources, decay heat, and spent fuel isotopics. This information will be used as input for shielding, thermal-hydraulic, structural, and criticality analyses. The radiation source terms support the shielding analyses. The decay heat data is used both as the heat source term for thermal-hydraulic analyses and as input to structural analyses for material stress calculations. The spent fuel isotopics are a significant aspect of burnup credit application in the criticality analyses. In addition, these isotopic data will serve as the basis for radioactive release terms for consequence analyses of breaches to the containment system. Thus, the SAS2H sequence provides input data for all aspects of the waste package/engineered barrier system design.

The principle modules of the SAS2H sequence are BONAMI, NITAWL, XSDRNPM, ORIGEN-S, and XSDOSE. The BONAMI and NITAWL modules provide resonance processing of the cross-section data for the fuel configuration being analyzed. XSDRNPM is primarily used for homogenization of cross-sections for use in ORIGEN-S. However, it is also used for 1-D shielding analyses interior to the fuel container. ORIGEN-S depletes LWR fuel to determine radiation sources, decay heat, and spent fuel isotopics both at the end of the irradiation period and for a user specified decay interval. XSDOSE provides a point kernel shielding analysis based upon the leakage fluxes obtained from the 1-D XSDRNPM case. The sample cases accompanying the code package exercise all of these modules to ensure that they are all functioning correctly. These sample cases are used to validate the operation of the SCALE 4.3 package.

1.2.2 CSAS25 Description

The CSAS25 sequence prepares adjusted resonance cross sections as appropriate for the fuel which is being evaluated. CSAS25 is configured to accept geometric and isotopic data for both PWR and BWR fuel assemblies. The adjusted cross section data are input to the KENO-V.a Monte Carlo criticality code, along with geometric description data for the fuel and surrounding structure, such as the shells of a waste package. The principal results of a CSAS25 calculation are the k-effective of the system and the statistical uncertainty associated with the calculation.

The principal modules of the CSAS25 sequence are BONAMI, NITAWL, and KENO-V.a. As with the SAS2H sequence, the BONAMI and NITAWL modules provide resonance processing of the cross-section data for the fuel configuration being analyzed. The KENO-V.a module performs the time-independent, three-dimensional Monte Carlo simulation of neutron creation in fissile material and transport through the materials and geometry of the system. The sample cases accompanying the code package exercise all of these modules to ensure that they are all functioning correctly. These sample cases are used to validate the operation of the SCALE 4.3 package.

1.3 Functional Requirements

The SCALE 4.3 system has the capability to perform criticality, shielding, and light water reactor (LWR) fuel depletion calculations. It accomplishes these calculations with well established functional modules and data libraries. They are linked into an analysis sequence with a control module to perform the analysis desired by the user. Selected sequences from this system are required for the performance of waste package activities and will be implemented on an as-need basis.

1.3.1 General Requirements

The SCALE 4.3 system generates data to support waste package performance activities (WBS 1.2.2) related to criticality, shielding, structural, and thermal analyses. The system can perform the following analyses: 1) criticality analyses with the CSAS sequences; 2) one dimensional shielding analyses can be done with the SAS1 sequence and three dimensional analyses with the SAS3 sequence; and 3) depletion of LWR fuel to generate radiation sources, decay heat sources, and fuel isotopic distributions to support criticality, shielding, structural, and thermal analyses with the SAS2H sequence.

Examples of analyses that can be supported by the SCALE system are:

1) Evaluation of the criticality safety of various waste package designs with the range of acceptable fuel type with the SAS2H isotopic generation and CSAS criticality modules

2) Evaluation of the neutron and gamma-ray fluence and dose rate on the waste container materials and environment with SAS2H source generation and SAS1 or SAS3 shielding modules

3) Evaluation of corrosion and structural effects due to heating of the waste package with decay heat source rates generated by the SAS2H module

4) Evaluation of heating effects in the waste package contents and storage environment using SAS2H generated decay heat sources.

The complete SCALE 4.3 code package is obtained from the Radiation Safety Information Computational Center. Selected modules from this package will be implemented as they are needed. Only the modules that are implemented shall be required to be qualified. However, when the need arises for other sequences and/or computer platforms, the SQR shall be revised to include the required test cases and the SQR shall be submitted to the Software Configuration Manager (SCM) per QAP-SI-0 requirements.

1.3.2 Input/Output Requirements

Input to the SCALE modules is provided by keyboard text entry. The required input parameters vary with the different modular sequences. However, some of the parameters are:

- SCALE sequence and module specification
- Cross section library specification
- Model geometry based on radial and axial dimensions
- Material specifications for the regions in the geometrical model.

The SCALE modules provide a hard copy listing in ASCII format of the output that contains a listing of the input file, the calculational sequence, and the calculational results. In addition, binary data files are available and can be saved as necessary. Both forms of output are available for archiving.

1.3.3 Hardware/Software Platform Requirements

The current package, SCALE 4.3, is distributed for implementation in a version for an HP 9000 series workstation. The WPDD utilizes HP 9000/700 and HP 9000/C160 series computers for SCALE 4.3 evaluations. Software modifications were not necessary to install SCALE 4.3 on the HP 9000 series (i.e., 700's and C160's) platforms in the WPDD. Compiler options appropriate to the HP 9000/700 were selected for the installation and are equally applicable for the HP 9000/C160 platforms.

1.3.4 Computational Methods/Algorithm Requirements

The software will at a minimum be required to perform the following tasks, as necessary, and have the appropriate computational algorithms included in the source code:

- Determine the system k_{eff} for complex geometries using Monte Carlo methods
- Provide appropriate resonance treatment for internal cross section libraries
- Provide a 1-D discrete ordinates capability for shielding and cross-section weighting
- Provide the capability for LWR fuel depletion and isotopic generation for spent fuel
- Generate neutron and gamma-ray source terms
- Ability to generate decay heat rates for specified decay intervals
- Provide a three dimensional shielding analysis capability.

The SCALE package meets these requirements through a series of functional modules and sequences. Sections of the package will be implemented on an as need basis and an appropriately revised SQR submitted to the SCM.

1.3.5 Other Requirements

There are no additional user requirements or code requirements (internal, external, or user) because the inputs are all provided by an analyst and the SCALE system does not interface with other codes.

The user is responsible for independently collecting any materials or geometry information the SCALE 4.3 module may require. For configuration control, the users shall have only a read/execute privilege to the code.

1.4 Description of Validation

The SCALE 4.3 system SAS2H and CSAS25 sequences are first verified by performing the installation test cases provided with the software, followed by validation testing which consists of performing test cases from published sources, which address the accuracy of the sequences for specific problem types. The burnup and decay calculations included in the SAS2H sequence are evaluated for their validity in ORNL/TM-12667, *Validation of the SCALE System for PWR Spent Fuel Isotopic Composition Analyses*[2]. This report presents the results of a series of calculations of isotopic concentrations of important isotopes in spent fuel and their comparison to measurements of the actual fuel isotopics which were made via radiochemical assays. The criticality calculations included in the CSAS25 sequence are evaluated by comparison of a series of benchmark critical experiments versus calculations performed with CSAS25. These comparisons of CSAS25 calculations against benchmark critical experiments are presented in ORNL/TM-12460 (NUREG/CR-6102), *Validation of the SCALE Broad Structure 44-Group ENDF/B-V Cross-Section Library for Use in Criticality Safety Analyses*[3].

The input and significant results of the SAS2H and CSAS25 validation cases are provided in this SQR. Complete results of the computer calculations are not presented here due to the large volume of data printed in the computer outputs but not relevant to the validation effort. The complete results of the computer calculations are available on electronic media in the WPDD.

1.5 Additional Documentation

No additional documentation other than this SQR is required to be generated for the qualification of the SCALE software system.

---

[2]"Validation of the SCALE System for PWR Spent Fuel Isotopic Composition Analyses", ORNL/TM-12667, O.W. Hermann, et. al., March 1995.

[3]"Validation of the SCALE Broad Structure 44-Group ENDF/B-V Cross-Section Library for Use in Criticality Safety Analyses, NUREG/CR-6102, ORNL/TM-12460, by M.D. DeHart and S.M. Bowman, September 1994.

2.0 INSTALLATION

2.1 Installation Procedure

The current version of the SCALE system, SCALE 4.3, was obtained from the RSICC at ORNL, see Attachment I. The user information for the code package[1] is contained in four volumes, Volumes 0, I, II, & III.

Volume 0 provides an overview of the complete system, a description of PC preprocessor codes for the criticality and depletion sequences which are not currently used by the Waste Package Development Department, and installation procedures. The system, as originally received and qualified in revision 00 of this SQR, is coded and compiled on an HP 9000 based workstation. The installation is thus ready for installation on any of the HP 9000 series workstation, either the 700's or the C160's, in the WPDD. Additional information on the electronic format of the code package was provided in the cover letter accompanying the package (see Attachment I). The installation media for this revision was obtained from the SCM in compliance with QAP-SI-3 Section 5.5.3.

Volumes I, II, and III describe the various sequences of the system, individual modules of the sequences, and the data libraries used for the sequences. These descriptions include the theory, input and output specifications, and error messages for the sequences and modules. The SAS2H sequence is discussed in Volume I, Section S2, and the CSAS25 sequence is discussed in Volume I, Section C4. The primary modules supporting these sequences are: BONAMI (Vol II, Part 1, F1), NITAWL-II (Vol II, Part 1, F2), XSDRNPM-S (Vol II, Part 1, F3), XSDOSE (Vol II, Part 1, F4), COUPLE (Vol II, Part 1, F6), and ORIGEN-S (Vol II, Part 1, F7). Included in both the sequence and module sections of the manual are sample problem descriptions that include input listings and an abbreviated output listing. It should be noted that the electronic code package includes complete input and output files for each sample case. Thus the abbreviated output listing in the manual can be augmented at the user's convenience with the electronic output listing. The data libraries used with the SAS2H sequence are discussed in Volume III Sections M6 (the ORIGEN-S libraries), M7 (Material Information) and, M8 (Standard Composition Library). These sections describe the structure of the data, the source of the data, and the range of applicability of the data.

The SCALE 4.3 electronic code package was transmitted by RSICC to the WPDD on a DC 6150 tape cartridge (150MB) and a DOS formatted diskette. The instructions for removal of the code files from the tape is described in the cover letter accompanying the package (see Attachment I). The DOS formatted diskette contains a file named 'README.NOW' that provides instructions for installation of the package on the HP machine. It is noted that this file is essentially an electronic copy of the instructions listed in Volume 0 of the user's manual. The SCALE 4.3 media was submitted to the SCM as part of the revision 00 SQR and the original SCALE 4.3 baseline element. The installation media and instructions for the revision 01 SQR were obtained from the SCM in compliance with QAP-SI-3 Section 5.5.3 and are identical to the original baseline element since the SCALE 4.3 software has not changed.

Based upon the review of the installation procedure provided with the code, a comparison with the files loaded onto the HP and the installation procedure, and the results of the verification cases described in the following section, it is concluded that the complete SCALE 4.3 system has been installed on the QUICHE HP 9000 series workstation as directed by the supplier, tested on the other WPDD HP 9000 series workstations (OPUS, HODGE, PORTNOY, MILO, ROSEBUD, OLIVER, DALLAS), and that the SAS2H and CSAS25 sequences are functioning correctly on these workstations. Verification of other sequences can be accomplished, as needed, with execution of the software qualification test cases. A reference to this description of the installation verification in the SQR revision for the desired sequence is all that is necessary to satisfy the installation verification requirement.

The software testing is described below. The sample cases used for this testing generally utilize a single cross-section data library, 44group. However, based upon SAS2H regression testing with the 27burnuplib for the validation tests, which provide very similar results, the 27burnuplib library is also correctly installed, and will function properly for both SAS2H and CSAS25 sequences.

2.2 SAS2H Installation Verification

Four vendor supplied SAS2H installation test cases are included with the SCALE 4.3 package. They are described in the SCALE 4.3 manual[4] and electronic copies of both the input and output files are included in the code package. Since an electronic copy of the output is provided with the code package, verification of results is simplified by use of the 'diff' command on the UNIX operating system. This is a system command that compares two files and lists those lines that are different. A review of the list produced by this command will provide an accurate and complete validation of the SCALE 4.3 system based on the comparison of sample case results. Finally, since the WPDD HP 9000 computer platforms include six HP 9000/700's using the HP9.X operation system and two HP9000/C160's using the HP10.X operating system, all of the installation test cases will be executed, compared, and reported for both the HP 9000/700 and the HP9000/C160 computer platforms. Thus, the installation verification procedure will provide an accurate and complete validation for both each CPU type and UNIX operating system version. Additionally, selected intallation test cases will be performed on each of the like computers in the WPDD HP computer system to ensure that they indeed are identical for code calcualtion.

The sample problems exercise all the modules of the SAS2H sequence. Based upon the number of modules in the system, these sample problems provide a considerable amount of output, about 225 to 470 pages each, even with conservative printout requests. Thus, the output listings for these cases will not be included in this document. Since, the source tape is permanently stored and contains the output for each sample problem, if a review of the comparison is required, the output on the source tape can be retrieved and compared with the results from a new execution of the test cases on the QUICHE system. In addition, any and all significant differences noted in the 'diff' file will be included and discussed.

---

[4]"SCALE 4.3, Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation," RSIC- CCC-545, Volume I, Section S2.6, pages S2.6.1 to S2.6.39.

2.2.1 Sample Case 1

Only a summary description of sample case 1 is provide here since a complete description is provided in Section S2.61 beginning on page S2.6.1 of Volume 1 of the SCALE 4.3 manual. The model describes a shipping cask designed with a stainless steel basket, a B_4C neutron poison for criticality control, a depleted uranium shield for absorbing photons, and a water shield for reducing the neutron dose. The cask is to contain PWR fuel assemblies having a 33-MWd/kgU burnup. The assemblies had been coupled with control rods while within the reactor. For the sample case a 17x17 assembly (assumed a Westinghouse design) with a fuel mass of 462.4 kg U per assembly, 3.2 wt% U235 enrichment, 33 MWD/kgU burnup, and 5 year decay is considered. Addition fuel and cask parameters are provided in the problem description. A listing of the input file is provided in Table 1.

This case tests the Material Information Processor module which prepares material and cross-section library specifications, BONAMI, NITAWL, XSDRNPM, ORIGEN-S, and XSDOSE. Only one pass is made through the BONAMI to ORIGEN-S loop to generate the isotopics for the XSDOSE dose rate calculation. This case has a relatively coarse mesh interval for the XSDRNPM cases to speed execution time, however, as is noted in the manual, results are affected by this coarseness. This is a relatively typical case that will be used for the Waste Package/Engineered Barrier System Design analysis. Thus, this case will provide a good validation of the code for the desired analyses.

This test case was successfully completed on the WPDD computers, and a diff comparison of the Oak Ridge output file and the WPDD output files showed that only creation date and elapsed time differences occurred. No differences were found regarding calculated numbers. Thus, Sample Case 1 confirms that the SAS2H sequence was properly installed and correctly executes on the WPDD computer platforms.

Table 1. Sample Case 1 Input File Listing

(Computer file name: sas2a.iput)

```
=sas2h    parm='skipcellwt'
sas2 sample case 1: 33 mwd/kgu, 17*17 pin, pwr, 1 cyc, dry-fuel cask
27groupndf4    latticecell
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  this part of input:  mixtures of fuel-pin-unit-cell
'
uo2 1 0.9018 811 92234 0.028 92235 3.2 92236 0.015 92238 96.757 end
'   ....above method uses wt %'s of uranium isotopes
zircalloy 2  1           620 end
h2o       3 den=0.733 1  570 end
arbm-bormod  0.733 1 1 0 0 5000 100 3 550.0e-6  570  end
'   ....above is 550 ppm boron in moderator
co-59     3  1-20         570 end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  mixtures of shipping cask:
'
ss304       4              2.1375-2  end
n           4 den=1.22-3   0.553     end
ss304       5              2.1375-2  end
n           5 den=1.22-3   0.553     end
ss304       6              2.1712-2  end
b4c         6              7.7066-2  end
n           7              1-20      end
ss304       8                        end
u(.27)metal 9                        end
h2o        12              0.944     end
end comp
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  fuel-pin-cell geometry:
'
squarepitch  1.25984 0.83566 1 3 0.94996 2  end
more data  szf=1.2  end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  assembly and cycle parameters:
'
npin/assm=264 fuelngth=365.76 ncycles=1 nlib/cyc=1
printlevel=5
lightel=16  inplevel=1
numins= 1  ortube= 0.61214  srtube=0.5715 facmesh=1.4  end
'   ....above is larger-unit-cell geometry additions
power=17.3025  burn=880  down=1826.25 end
 c     0.05999  n    0.03377  o  62.14      al  0.04569
 si    0.06586  p    0.1422   ti  0.04983   cr  2.340
 mn    0.1096   fe   4.599    co  0.03344   ni  4.402
 zr 100.8       nb   0.3275   mo  0.1816    sn  1.652
'   ....above data are light elements (kg) per assembly
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  zone description of cask:
'
27n-18couple  tempcask(k)=325 numzones=9 detect=0 dryfuel=yes  end
4 12.75  6 21.72  5 38.05  7 47.63  8 48.90
9 57.40  8 61.35 12 72.78  8 73.22
zone=1  fuelbndl=1  zone=3  fuelbndl=6
  szfcask=2  isns=8  epss=1-3  ptcs=1-3 end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
end
```

2.2.2 Sample Case 2

Sample case 2 is a variation on case 1 by applying default values for mesh interval sizes. The default generally provided a better representation of the case with finer intervals than used in case 1. Thus, better results are to be expected from this case. A description of the changes is provided on page S2.6.8 of the manual. A listing of the input file is provided in Table 2.

This test case was successfully completed on the WPDD computers, and a diff comparison of the Oak Ridge output file and the WPDD output files showed that only creation date and elapsed time differences occurred. No differences were found regarding calculated numbers. Thus, Sample Case 2 confirms that the SAS2H sequence was properly installed and correctly executes on the WPDD computer platforms.

Table 2. Sample Case 2 Input File Listing
(Computer file name: sas2b.iput)

```
=sas2h    parm='skipcellwt'
sas2 sample case 2: 33 mwd/kgu, 17*17 pin, pwr, 1 cyc, dry-fuel cask
27groupndf4    latticecell
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  this part of input:  mixtures of fuel-pin-unit-cell
'
uo2 1 0.9018 811 92234 0.028 92235 3.2 92236 0.015 92238 96.757 end
'  ....above method uses wt %'s of uranium isotopes
zircalloy 2  1           620 end
h2o       3 den=0.733 1  570 end
arbm-bormod  0.733 1 1 0 0 5000 100 3 550.0e-6  570  end
'  ....above is 550 ppm boron in moderator
co-59     3  1-20        570 end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  mixtures of shipping cask:
'
ss304        4              2.1375-2  end
n            4 den=1.22-3   0.553     end
ss304        5              2.1375-2  end
n            5 den=1.22-3   0.553     end
ss304        6              2.1712-2  end
b4c          6              7.7066-2  end
n            7              1-20      end
ss304        8                        end
u(.27)metal  9                        end
h2o         12              0.944     end
end comp
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  fuel-pin-cell geometry:
'
squarepitch  1.25984 0.83566 1 3 0.94996 2  end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  assembly and cycle parameters:
'
npin/assm=264 fuelngth=365.76 ncycles=1 nlib/cyc=1
printlevel=5
lightel=16
'  ....above shows no larger-unit-cell geometry additions, defaults used
power=17.3025  burn=880  down=1826.25 end
 c    0.05999  n   0.03377  o  62.14     al  0.04569
 si   0.06586  p   0.1422   ti  0.04983  cr  2.340
 mn   0.1096   fe  4.599    co  0.03344  ni  4.402
 zr 100.8      nb  0.3275   mo  0.1816   sn  1.652
'  ....above data are light elements (kg) per assembly
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'  zone description of cask:
'
27n-18couple  tempcask(k)=325 numzones=9 detect=0 dryfuel=yes  end
4 12.75  6 21.72  5 38.05  7 47.63  8 48.90
9 57.40  8 61.35 12 72.78  8 73.22
zone=1  fuelbndl=1  zone=3  fuelbndl=6
 end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
end
```

2.2.3 Sample Case 3

Sample case 3 provides a further variation of cases 1 and 2. It illustrates the use of the 'halt' and 'restart' features of the system and provides a more detailed irradiation history. This is the type of case that will be used for the repository analyses. Of particular interest is the use of three cycles of irradiation with cross-sections generated for each cycle for the ORIGEN-S calculation. This will provide the best representation of the spent fuel isotopics of the three cases. Such generation of cross-section sets over the irradiation interval is recommended for the repository analyses. A detailed description of the changes are provided on pages S2.6.10 and S2.6.11 of the manual. A listing of the input file for this case is given in Table 3.

This test case was successfully completed on the WPDD computers, and a diff comparison of the Oak Ridge output file and the WPDD output files showed that only creation date and elapsed time differences occurred. No differences were found regarding calculated numbers. Thus, Sample Case 3 confirms that the SAS2H sequence was properly installed and correctly executes on the WPDD computer platforms.

Table 3. Sample Case 3 Input File Listing
(Computer file name: sas2c.iput)

```
=sas2h    parm='halt03,skipcellwt'
sas2 sample case 3: 33 mwd/kgu, 17*17 pin, pwr, 3 cyc, dry-fuel cask
27groupndf4    latticecell
uo2 1 0.9018 811 92234 0.028 92235 3.2 92236 0.015 92238 96.757 end
zircalloy 2  1          620 end
h2o       3 den=0.733 1  570 end
arbm-bormod  0.733 1 1 0 0 5000 100 3 550.0e-6  570  end
co-59     3  1-20        570 end
ss304       4             2.1375-2  end
n           4 den=1.22-3  0.553     end
ss304       5             2.1375-2  end
n           5 den=1.22-3  0.553     end
ss304       6             2.1712-2  end
b4c         6             7.7066-2  end
n           7             1-20      end
ss304       8                       end
u(.27)metal 9                       end
h2o        12             0.944     end
end comp
squarepitch  1.25984 0.83566 1 3 0.94996 2  end
npin/assm=264 fuelngth=365.76 ncycles=3 nlib/cyc=1
printlevel=4
lightel=16
power=18.3025  burn=290  down=30 end
power=17.3025  burn=300  down=60  bfrac=0.95 end
power=16.3025  burn=290  down=1826.25  bfrac=0.92 end
 c    0.05999  n   0.03377  o  62.14     al  0.04569
 si   0.06586  p   0.1422   ti  0.04983  cr  2.340
 mn   0.1096   fe  4.599    co  0.03344  ni  4.402
 zr 100.8      nb  0.3275   mo  0.1816   sn  1.652
27n-18couple  tempcask(k)=325 numzones=9 detect=0 dryfuel=yes  end
4 12.75  6 21.72  5 38.05  7 47.63  8 48.90
9 57.40  8 61.35 12 72.78  8 73.22
zone=1  fuelbndl=1  zone=3  fuelbndl=6
 end
end
=sas2h    parm='restarts,skipcellwt'
sas2 sample case 3a: 33 mwd/kgu, 17*17 pin, pwr, 3 cyc, dry-fuel cask
end
=origens
0$$ a8 26 a11 -71 e 1t
 sample case 3b
3$$ 21 0 1 -88 a33 -88 4** a4 1-35 2t
35$$ 0 4t
56$$ a14 5 1 74 e 5t
 sample case 3b
 60**  0.3 5i1 7 8.5 10
65$$  1 8z 1 2z 1 8z 2q21  61** f1-3
81$$ 2 0 26 1 e 82$$ a10 2
6t
 sample case 3b
56$$ 2z a10 10 e 6t
56$$ f0 t
end
=sas2h    parm='restarts,skipcellwt'
sas2 sample case 3b: 33 mwd/kgu, 17*17 pin, pwr, 3 cyc, dry-fuel cask
end
```

2.2.4 Sample Case 4

Sample case 4 is an example of a case for an actual storage cask designed to contain 52 BWR spent fuel assemblies. Gamma and neutron dose rates have be measured at various positions of the cask, although the assembly data is slightly different from that actually in the cask due to insufficient data on the measured assemblies. While the comparison of the measured and calculated dose rates show significant differences, see page S2.6.20 of the manual, considering the modeling differences and the 1-D calculation, the results from SAS2H show a good agreement.

This test case was successfully completed on the WPDD computers, and a diff comparison of the Oak Ridge output file and the WPDD output files showed that only creation date and elapsed time differences occurred. No differences were found regarding calculated numbers. Thus, Sample Case 4 confirms that the SAS2H sequence was properly installed and correctly executes on the WPDD computer platforms.

Table 4. Sample Case 4 Input File Listing
(Computer file name: sas2b.iput)

```
=sas2      parm='skipcellwt'
sas2 sample case 4: 25 mwd/kgu, 8*8 pin, bwr, 3 cyc, dry fuel cask
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'   mixtures of fuel-pin-unit-cell:
'
27burnuplib    latticecell
uo2  1 den=9.87  1  840  92234  0.021 92235 2.4 92236 0.011
                    92238 97.568  end
zircalloy  2 1  620   end
h2o  3 den=0.5039  1  558 end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'   mixtures of shipping cask:
'
ss304      4  0.1624 end
cu         4  3.832-2 end
b4c        4  den=2.034-2 1 end
al         4  den=2.486-2 1 end
zircalloy 4  3.97-2  end
'                ....above is average ss, cu & boral fuel basket
'                    and channel densities of fuel zone....
zircalloy  12  end
'                ....above is zirc. in assembly channel
arbm-b4c      2.156  2 1 1 0   5000 4   6012 1   13  0.35 end
arbm-al       2.156  1 0 0 0  13027 100          13  0.65 end
'                ....above is boral in outer side of tube
cu         14  end
'                ....above is the cu in outside of basket
ss304      5  1 end
'                ....above is stainless steel clad, 3 places in cask
pb         6  end
'                ....above is the lead for gamma shield
c          7  den=0.212  1 end
o          7  den=0.732  1 end
h          7  den=0.109  1 end
'                ....above is ethylene glycol/h2o for neutron shield
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'   mixtures of larger-unit-cell:
'
uo2  9 den=9.87  1  840  92234  0.021 92235 2.4 92236 0.011
                    92238 97.568  end
arbm-gdburn  9.87   7 0 1 1
           64154  2.18  64155 14.80  64156 20.47
           64157 15.65  64158 24.84  64160 21.86
            8016 150.0  9   0.02  840  end
'                ....above is 2 wt % gadolinium (as gd2-ox3) in the
'                    burnable poison pins of bwr assembly....
zircalloy  10  1  588 end
'                ....above is zircalloy casing around assembly
h2o        11 0.743  552 end
'                ....above is channel moderator at higher density
end comp
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'      fuel-pin-cell geometry:
'
squarepitch   1.6256 1.0795  1 3  1.25222  2  end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'    assembly and cycle parameters:
'
npin/assm=63  fuelngth=376  ncycles=3  nlib/cyc=1
```

Table 4. Sample Case 4 Input File Listing (Cont.)

```
printlevel=4  lightel=15  inplevel=2  numzones=6   end
9 0.53975 2 0.62611 3 0.91715 500 3.6398 10 3.8103 11 4.3261
'          ..these mixtures & radii place gadolinium pin at center
'            of 1/4 of assembly fuel, casing & channel mod.
power=2.49   burn=807  down= 59  end
power=4.07   burn=501  down=799  end
power=1.05   burn=712  down=950  end
       c   0.03222 n   0.01534  o 28.86     al 0.008748
       si  0.01796 p   0.008133 ti 0.01070  cr 0.4274
       mn  0.03348 fe  1.197    ni 0.4139   cu 0.00231
       zr 93.93    nb  0.003161 sn 1.535
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'   zone description and other parameters of cask:
'
27n-18couple   tempcask(k)=380 detectors=4 numzones=9 dryfuel=yes end
0  2.54  100  200
4 75.32  12 75.70  13 75.93  14 76.57  5 79.29
6 90.09  5 95.17  7 110.41  5 111.05
zone=1  fuelbndl=52
  end
end
```

2.2.5 SAS2H Installation Verification Test Results

All test cases (see Sections 2.2.1 through 2.2.4) were successfully completed on the WPDD computers, and the diff comparisons of the Oak Ridge output files and the WPDD output files showed that only creation date and elapsed time differences occurred for each HP 9000 CPU type (i.e., 700's and the C160's) and for each UNIX operating system version (i.e., HP9.X and HP10.X). No differences were found regarding calculated numbers in any of the test cases. Thus, the installation verification test cases confirm that the SAS2H sequence was properly installed and correctly executes on the WPDD computer platforms.

2.3 CSAS25 Installation Verification Tests

A series of test problems are provided for CSAS25 along with the SCALE 4.3 software. These test problems represent LWR fuel in a variety of cask designs, both dry and flooded with water moderator. The results of the installation test cases are tabulated in Table 5 for the 700's and Table 6 for the C160's. Inspection of this table shows that the CSAS25 sequence is properly installed.

2.3.1 Input for Installation Verification

(Computer file name: csas.inp)

```
=csas25
sample problem 1  set up 4aqueous 4 metal in csas25
hansen-roach   infhommedium
uranium        1 0.985 293  92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
solnuo2(no3)2  2 415 9.783-3 spg=1.555 1.0 293 92235 92.6 92238 5.9
                                                92234 1.0  92236 0.5 end
plexiglass     3 end
end comp
keno v.a sample problem 19 4 aqueous 4 metal array of arrays (samp prob 12)
read param  flx=yes fdn=yes nub=yes
end param
read geom
unit 1
com='uranyl nitrate solution in a plexiglas container'
cylinder  2 1 9.525 2p8.89
cylinder  3 1 10.16 2p9.525
cuboid  0 1 4p10.875 2p10.24
unit 2
com='uranium metal cylinder'
cylinder  1 1 5.748 2p5.3825
cuboid  0 1 4p6.59 2p6.225
unit 3
com='1x2x2 array of solution units'
array 1 3*0.0
unit 4
com='1x2x2 array of metal units padded to match solution array'
array 2 3*0.0
replicate 0 1 2*0.0 2*8.57 2*8.03 1
end geom
read array ara=1 nux=1 nuy=2 nuz=2 fill f1 end fill
ara=2 nux=1 nuy=2 nuz=2 fill f2 end fill gbl=3 ara=3 nux=2 nuy=1 nuz=1
com='composite array of solution and metal units'
fill 4 3 end fill
end array
end data
end
=clec_out
end
=csas4
sample problem 2  pwr-like fuel bundle
hansen-roach latticecell
uo2  1 .84 293. 92235 2.35 92238 97.65 end
zr  2 1 end
h2o  3 1 end
b4c  4 0.367 end
al  4 0.636 end
h2o  5 1 end
end comp
squarepitch  1.2751 .823 1 3 .9627 2 end
storage array of pwr-like fuel bundles in poison sheaths
read param  tme=7,0  nub=yes far=yes gen=53
end param
```

```
read array nux=17 nuy=17 nuz=1 end array
read bounds  xyf=mirror   end bounds
read geom
cylinder  1 1 .4115 183.0 -183.0
cylinder  2 1 .48135 183.1 -183.1
cuboid  3 1 .63755 -.63755 .63755 -.63755 183.1 -183.1
core  0 1 0 0 0
reflector 5 1 4*.635 2z 1
reflector 4 1 4*.9525 2z 1
reflector 5 1 4*1.27 2z 1
reflector 5 2 4z 2*3.0 5
end geom
read bias id=500 2 6 end bias
end data
read search  optimum pitch  end search
end
=clec_out
end
=csas4x
sample problem 3  sample fuel cask
hansen-roach latticecell
uo2  1 .84 293. 92235 2.35 92238 97.65 end
zr  2 1 end
h2o  3 1 end
b4c  4 0.367 end
al  4 0.636 end
h2o  5 1 end
al  6 1 end
end comp
squarepitch  1.275 .823 1 3 .9627 2 end
sample square fuel cask
read param  tme=5.0  nub=yes far=yes gen=53
end param
read array nux=2  nuy=2  nuz=1 end array
read geom
cuboid 500 1 4p10.8375 2p183.0
cuboid   4 1 4p11.5    2p183.0
cuboid   5 1 4p12.0    2p183.0
core     0 1 3*0
reflector 6 1 6*10.0 1
reflector 5 2 6*3 5
end geom
read bias id=500 2 6 end bias
end data
read search  optimum pitch  end search
end
=clec_out
end
=csas4
sample problem 4  set up 2c8 in csas25
hansen-roach   infhommedium
uranium  1 0.985 293  92235 93.2 92238 5.6 92234 1.0 92236 0.2 end
end comp
critical pitch search for case 2c8 bare
read parameters  tme=1.0 flx=yes fdn=yes far=yes
end parameters
read geometry
cylinder 1 1 5.748 5.3825 -5.3825
cuboid  0 1 4p7.248 2p6.8825
end geometry
read array  nux=2 nuy=2 nuz=2  end array
end data
read search   critical pitch   maxpitch=15.5  more
alter  unit=1 reg=2 +z=1.0 -z=1.0
end search
end
```

2.3.2 CSAS25 Installation Verification Test Results

Table 5 presents the results from the test cases executed on the HP 9000/C160's and Table 6 presents the results from the test cases executed on the HP 9000/700's. Inspection of these tables shows that the results for the all of test cases were identical. The results were identical because exactly the same input was used for the ORNL and WPDD calculations, and the computer versions are very similar. Thus the CSAS25 installation test cases confirm that the CSAS25 sequence was properly installed.

Table 5. CSAS25 Installation Verification Test Cases for the HP 9000/700

Table 6. CSAS25 Installation Verification Test Cases for the HP 9000/C160

CSAS25 Installation Verification Test Cases			
Case	ORNL k-effective sigma	WPDD k-effective sigma	Percent Difference

2.4 File List

```
total 12
drwxr-xr-x   2 root       sys            1024 Mar 10 08:04 bin
drwxr-xr-x   2 root       sys            1024 Mar  7 13:21 cmds
drwxr-xr-x   5 root       sys            1024 Mar  7 13:23 data
drwxr-xr-x   2 root       sys            1024 Mar  7 13:25 lib
drwxr-xr-x   6 root       sys            1024 Mar  7 13:27 pbmplus10dec91
drwxr-xr-x   2 root       sys            1024 Mar  7 14:15 qads


./bin:
total 27666
-rwxr-xr-x   1 root       sys          106496 Mar  7 13:21 aim
-rwxr-xr-x   1 root       sys           81920 Mar  7 13:21 ajax
-rwxr-xr-x   1 root       sys          110592 Mar  7 13:21 ale
-rwxr-xr-x   1 root       sys           86016 Mar  7 13:21 alpo
-rwxr-xr-x   1 root       sys          180224 Mar  7 13:21 bonami
lrwxr-xr-x   1 root       sys              32 Mar 10 08:04 clec_out ->
/opt/neut/Scale4.3/cmds/clec_out
-rwxr-xr-x   1 root       sys           32768 Mar  7 13:21 comment
-rwxr-xr-x   1 root       sys           98304 Mar  7 13:21 compoz
-rwxr-xr-x   1 root       sys           81920 Mar  7 13:21 corectol
-rwxr-xr-x   1 root       sys          244948 Mar  7 13:21 couple
-rwxr-xr-x   1 root       sys          633316 Mar  7 13:21 csas
-rwxr-xr-x   1 root       sys          598016 Mar  7 13:21 csas6
-rwxr-xr-x   1 root       sys           61440 Mar  7 13:21 h7map
-rwxr-xr-x   1 root       sys           49152 Mar  7 13:21 h7maprz
-rwxr-xr-x   1 root       sys           28672 Mar  7 13:21 h7mon
-rwxr-xr-x   1 root       sys           57344 Mar  7 13:21 h7tec
-rwxr-xr-x   1 root       sys          356352 Mar  7 13:21 heating
-rwxr-xr-x   1 root       sys          307200 Mar  7 13:21 htas1
-rwxr-xr-x   1 root       sys          356352 Mar  7 13:21 htng72
-rwxr-xr-x   1 root       sys          233472 Mar  7 13:21 ice
-rwxr-xr-x   1 root       sys          626688 Mar  7 13:21 kenova
-rwxr-xr-x   1 root       sys          688128 Mar  7 13:21 kenovi
-rwxr-xr-x   1 root       sys          102400 Mar  7 13:21 lava
-rwxr-xr-x   1 root       sys           90112 Mar  7 13:21 legend
-rwxr-xr-x   1 root       sys           20480 Mar  7 13:21 mal
-rwxr-xr-x   1 root       sys          143360 Mar  7 13:21 malocs
-rwxr-xr-x   1 root       sys          192512 Mar  7 13:21 modify
-rwxr-xr-x   1 root       sys          438272 Mar  7 13:21 morse
-rwxr-xr-x   1 root       sys          192512 Mar  7 13:21 nitawl
-rwxr-xr-x   1 root       sys          358572 Mar  7 13:21 o0o001
-rwxr-xr-x   1 root       sys          192512 Mar  7 13:21 o0o002
-rwxr-xr-x   1 root       sys          398300 Mar  7 13:21 o0o004
-rwxr-xr-x   1 root       sys          244948 Mar  7 13:21 o0o005
-rwxr-xr-x   1 root       sys          438272 Mar  7 13:21 o0o006
-rwxr-xr-x   1 root       sys          233472 Mar  7 13:21 o0o007
-rwxr-xr-x   1 root       sys          180224 Mar  7 13:21 o0o008
-rwxr-xr-x   1 root       sys          626688 Mar  7 13:21 o0o009
-rwxr-xr-x   1 root       sys          688128 Mar  7 13:21 o0o019
-rwxr-xr-x   1 root       sys           98304 Mar  7 13:21 o0o102
-rwxr-xr-x   1 root       sys          438272 Mar  7 13:21 o0o106
-rwxr-xr-x   1 root       sys          208896 Mar  7 13:21 ocular
-rwxr-xr-x   1 root       sys          200704 Mar  7 13:21 oculr72
-rwxr-xr-x   1 root       sys          398300 Mar  7 13:21 origen
-rwxr-xr-x   1 root       sys           49152 Mar  7 13:21 osbico
-rwxr-xr-x   1 root       sys           49152 Mar  7 13:21 osbire
-rwxr-xr-x   1 root       sys           98304 Mar  7 13:21 perfume
-rwxr-xr-x   1 root       sys          159744 Mar  7 13:21 picture
-rwxr-xr-x   1 root       sys           28672 Mar  7 13:21 ppmtogif
-rwxr-xr-x   1 root       sys          147456 Mar  7 13:21 rade
-rwxr-xr-x   1 root       sys           28672 Mar  7 13:21 rawtoppm
-rwxr-xr-x   1 root       sys          335872 Mar  7 13:21 sas1
```

```
-rwxr-xr-x   1 root       sys         483328 Mar  7 13:21 sas2
-rwxr-xr-x   1 root       sys         393216 Mar  7 13:21 sas3
-rwxr-xr-x   1 root       sys         475136 Mar  7 13:21 sas4
-rwxr-xr-x   1 root       sys          40960 Mar  7 13:21 scale
-rwxr-xr-x   1 root       sys          16384 Mar  7 13:21 shell
-rwxr-xr-x   1 root       sys          77824 Mar  7 13:21 wax
-rwxr-xr-x   1 root       sys          20480 Mar  7 13:21 wgt
-rwxr-xr-x   1 root       sys          98304 Mar  7 13:21 xsdose
-rwxr-xr-x   1 root       sys         358572 Mar  7 13:21 xsdrn

./cmds:
total 52
-rwxr-xr-x   1 root       sys            689 Mar 10 08:15 batch43
-rwxr-xr-x   1 root       sys            679 Mar  7 13:21 batch43.patn
-rwxr-xr-x   1 root       sys            279 Mar  7 13:21 clec_out
-rwxr-xr-x   1 root       sys            237 Mar  7 13:21 convert
-rwxr-xr-x   1 root       sys            251 Mar  7 13:21 fort90
-rwxr-xr-x   1 root       sys             19 Mar  7 13:21 getpid
-rwxr-xr-x   1 root       sys             89 Mar  7 13:21 h7map
-rwxr-xr-x   1 root       sys             77 Mar  7 13:21 h7map.patn
-rwxr-xr-x   1 root       sys             97 Mar  7 13:21 h7mon
-rwxr-xr-x   1 root       sys             85 Mar  7 13:21 h7mon.patn
-rwxr-xr-x   1 root       sys             97 Mar  7 13:21 h7tec
-rwxr-xr-x   1 root       sys             85 Mar  7 13:21 h7tec.patn
-rwxr-xr-x   1 root       sys            431 Mar  7 13:21 load90
-rwxr-xr-x   1 root       sys             37 Mar  7 13:21 ppid
-rwxr-xr-x   1 root       sys           3376 Mar  7 13:21 scale43
-rwxr-xr-x   1 root       sys           3376 Mar  7 13:21 scale43.badxn44
-rwxr-xr-x   1 root       sys           3339 Mar  7 13:21 scale43parallel

./data:
total 260828
drwxr-xr-x   2 root       sys              24 Mar  7 13:22 BE.xsecs
-rwxr-xr-x   1 root       sys          112000 Mar  7 13:22 albedos
-rwxr-xr-x   1 root       sys             346 Mar  7 13:22 aliases
-rwxr-xr-x   1 root       sys           27386 Mar  7 13:22 attenuat
-rwxr-xr-x   1 root       sys          394548 Mar  7 13:22 baslmfbr
-rwxr-xr-x   1 root       sys           97560 Mar  7 13:22 buildup
-rwxr-xr-x   1 root       sys          243405 Mar  7 13:22 h7matlib
drwxr-xr-x   2 root       sys            1024 Mar  7 13:22 keno
-rwxr-xr-x   1 root       sys          292728 Mar  7 13:22 maphh2ob
-rwxr-xr-x   1 root       sys          125104 Mar  7 13:22 maphnobr
-rwxr-xr-x   1 root       sys          292728 Mar  7 13:22 maphuo2b
drwxr-xr-x   2 root       sys            1024 Mar  7 13:22 origen
-rwxr-xr-x   1 root       sys          416128 Mar  7 13:22 prlimlwr
-rwxr-xr-x   1 root       sys           32300 Mar  7 13:22 pwr33f71.saslinp
-rwxr-xr-x   1 root       sys          501464 Mar  7 13:22 pwr33gwd
-rwxr-xr-x   1 root       sys            3245 Mar  7 13:22 qatable
-rwxr-xr-x   1 root       sys            4271 Mar  7 13:22 qatable.upd
-rwxr-xr-x   1 root       sys             729 Mar  7 13:22 scale.messages
-rwxr-xr-x   1 root       sys          205120 Mar  7 13:22 scale.rev01.qadxslib
-rwxr-xr-x   1 root       sys         1250052 Mar  7 13:22 scale.rev03.xg18
-rwxr-xr-x   1 root       sys          362140 Mar  7 13:22 scale.rev03.xn16
-rwxr-xr-x   1 root       sys          284316 Mar  7 13:22 scale.rev03.xn22g18
-rwxr-xr-x   1 root       sys        92110984 Mar  7 13:23 scale.rev03.xn238
-rwxr-xr-x   1 root       sys        11109356 Mar  7 13:23 scale.rev03.xn44.bad
-rwxr-xr-x   1 root       sys         9020996 Mar  7 13:23 scale.rev04.xn218
-rwxr-xr-x   1 root       sys          824404 Mar  7 13:23 scale.rev04.xn27
-rwxr-xr-x   1 root       sys         2770024 Mar  7 13:23 scale.rev04.xn27burn
-rwxr-xr-x   1 root       sys         1427972 Mar  7 13:23 scale.rev04.xn27g18
-rwxr-xr-x   1 root       sys        11109356 Mar  7 13:23 scale.rev04.xn44
-rwxr-xr-x   1 root       sys          162600 Mar  7 13:23 scale.rev10.sclib
-rwxr-xr-x   1 root       sys             333 Mar  7 13:23 update
-rwxr-xr-x   1 root       sys           44812 Mar  7 13:23 weights
```

```
./data/BE.xsecs:
total 0

./data/keno:
total 1084
-rwxr-xr-x   1 root       sys        374544 Mar  7 13:22 albedos.data
-rwxr-xr-x   1 root       sys            16 Mar  7 13:22 mal.in
-rwxr-xr-x   1 root       sys          2145 Mar  7 13:22 mal.out
-rwxr-xr-x   1 root       sys            16 Mar  7 13:22 weight.in
-rwxr-xr-x   1 root       sys           230 Mar  7 13:22 weight.out
-rwxr-xr-x   1 root       sys        151308 Mar  7 13:22 weights.data

./data/origen:
total 7524
-rwxr-xr-x   1 root       sys        412857 Mar  7 13:22 end6dec
-rwxr-xr-x   1 root       sys         21695 Mar  7 13:22 mkbinlib1.inp
-rwxr-xr-x   1 root       sys          4617 Mar  7 13:22 mkbinlib2.inp
-rwxr-xr-x   1 root       sys        561897 Mar  7 13:22 mpbrh2om
-rwxr-xr-x   1 root       sys         37260 Mar  7 13:22 mpbrh2op
-rwxr-xr-x   1 root       sys        561897 Mar  7 13:22 mpbruo2m
-rwxr-xr-x   1 root       sys         37260 Mar  7 13:22 mpbruo2p
-rwxr-xr-x   1 root       sys        396495 Mar  7 13:22 mpdkxgam
-rwxr-xr-x   1 root       sys         63423 Mar  7 13:22 mpsfangm
-rwxr-xr-x   1 root       sys         45955 Mar  7 13:22 mpsfangm.new
-rwxr-xr-x   1 root       sys            87 Mar  7 13:22 osbico1.inp
-rwxr-xr-x   1 root       sys            87 Mar  7 13:22 osbire1.inp
-rwxr-xr-x   1 root       sys        813289 Mar  7 13:22 xsectpho
-rwxr-xr-x   1 root       sys        813289 Mar  7 13:22 xsectpho.new

./lib:
total 14658
-rwxr-xr-x   1 root       sys         32948 Mar  7 13:25 libaim.a
-rwxr-xr-x   1 root       sys         13100 Mar  7 13:25 libajax.a
-rwxr-xr-x   1 root       sys         44352 Mar  7 13:25 libale.a
-rwxr-xr-x   1 root       sys         22504 Mar  7 13:25 libalpo.a
-rwxr-xr-x   1 root       sys        108984 Mar  7 13:25 libbonami.a
-rwxr-xr-x   1 root       sys         22536 Mar  7 13:25 libcompoz.a
-rwxr-xr-x   1 root       sys         13820 Mar  7 13:25 libcorectol.a
-rwxr-xr-x   1 root       sys        278720 Mar  7 13:25 libcouple.a
-rwxr-xr-x   1 root       sys        150228 Mar  7 13:25 libcsas.a
-rwxr-xr-x   1 root       sys         78388 Mar  7 13:25 libcsas6.a
-rwxr-xr-x   1 root       sys         13264 Mar  7 13:25 libdriver.a
-rwxr-xr-x   1 root       sys         58544 Mar  7 13:25 libh7map.a
-rwxr-xr-x   1 root       sys         17948 Mar  7 13:25 libh7mon.a
-rwxr-xr-x   1 root       sys         42364 Mar  7 13:25 libh7tec.a
-rwxr-xr-x   1 root       sys        559912 Mar  7 13:25 libheating.a
-rwxr-xr-x   1 root       sys        379008 Mar  7 13:25 libhtas1.a
-rwxr-xr-x   1 root       sys        178004 Mar  7 13:25 libice.a
-rwxr-xr-x   1 root       sys        803264 Mar  7 13:25 libkenova.a
-rwxr-xr-x   1 root       sys        912064 Mar  7 13:25 libkenovi.a
-rwxr-xr-x   1 root       sys         26756 Mar  7 13:25 liblava.a
-rwxr-xr-x   1 root       sys         59892 Mar  7 13:25 libmalocs.a
-rwxr-xr-x   1 root       sys        163824 Mar  7 13:25 libmars.a
-rwxr-xr-x   1 root       sys        297648 Mar  7 13:25 libmip.a
-rwxr-xr-x   1 root       sys         75412 Mar  7 13:25 libmodify.a
-rwxr-xr-x   1 root       sys        388200 Mar  7 13:25 libmorse.a
-rwxr-xr-x   1 root       sys        106116 Mar  7 13:25 libnitawl.a
-rwxr-xr-x   1 root       sys        228076 Mar  7 13:25 libocular.a
-rwxr-xr-x   1 root       sys        489396 Mar  7 13:25 liborigen.a
-rwxr-xr-x   1 root       sys         25380 Mar  7 13:25 libosbico.a
-rwxr-xr-x   1 root       sys         24308 Mar  7 13:25 libosbire.a
-rwxr-xr-x   1 root       sys         31492 Mar  7 13:25 libperfume.a
-rwxr-xr-x   1 root       sys         15576 Mar  7 13:25 libpicture.a
-rwxr-xr-x   1 root       sys        128896 Mar  7 13:25 libqads.a
-rwxr-xr-x   1 root       sys        103168 Mar  7 13:25 librade.a
```

```
-rwxr-xr-x   1 root       sys         68572 Mar  7 13:25 libsas1.a
-rwxr-xr-x   1 root       sys        375696 Mar  7 13:25 libsas2.a
-rwxr-xr-x   1 root       sys         48344 Mar  7 13:25 libsas3.a
-rwxr-xr-x   1 root       sys        163168 Mar  7 13:25 libsas4.a
-rwxr-xr-x   1 root       sys        222020 Mar  7 13:25 libsub.a
-rwxr-xr-x   1 root       sys         57772 Mar  7 13:25 libunix.a
-rwxr-xr-x   1 root       sys         11704 Mar  7 13:25 libwax.a
-rwxr-xr-x   1 root       sys         60908 Mar  7 13:25 libxsdose.a
-rwxr-xr-x   1 root       sys        344296 Mar  7 13:25 libxsdrn.a

./pbmplus10dec91:
total 150
-rwxr-xr-x   1 root       sys         12776 Mar  7 13:26 CHANGES
-rwxr-xr-x   1 root       sys          2170 Mar  7 13:26 FORMATS
-rwxr-xr-x   1 root       sys          1568 Mar  7 13:26 Imakefile
-rwxr-xr-x   1 root       sys          6115 Mar  7 13:26 Makefile
-rwxr-xr-x   1 root       sys          4593 Mar  7 13:26 OTHER.SYSTEMS
-rwxr-xr-x   1 root       sys          6893 Mar  7 13:26 Pbmplus.tmpl
-rwxr-xr-x   1 root       sys         15789 Mar  7 13:26 README
-rwxr-xr-x   1 root       sys           836 Mar  7 13:26 TODO
-rwxr-xr-x   1 root       sys          1023 Mar  7 13:26 compat.csh
-rwxr-xr-x   1 root       sys          1023 Mar  7 13:26 compat.ksh
-rwxr-xr-x   1 root       sys          1080 Mar  7 13:26 magic
drwxr-xr-x   2 root       sys          3072 Mar  7 13:26 pbm
-rwxr-xr-x   1 root       sys          6074 Mar  7 13:26 pbmplus.h
drwxr-xr-x   2 root       sys          2048 Mar  7 13:26 pgm
drwxr-xr-x   2 root       sys          2048 Mar  7 13:27 pnm
drwxr-xr-x   2 root       sys          4096 Mar  7 13:27 ppm
-rwxr-xr-x   1 root       sys           106 Mar  7 13:27 version.h

./pbmplus10dec91/pbm:
total 2358
-rwxr-xr-x   1 root       sys          5156 Mar  7 13:26 Imakefile
-rwxr-xr-x   1 root       sys          5153 Mar  7 13:26 Makefile
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 atktopbm
-rwxr-xr-x   1 root       sys           776 Mar  7 13:26 atktopbm.1
-rwxr-xr-x   1 root       sys          9210 Mar  7 13:26 atktopbm.c
-rwxr-xr-x   1 root       sys          2283 Mar  7 13:26 bitreverse.h
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 brushtopbm
-rwxr-xr-x   1 root       sys           810 Mar  7 13:26 brushtopbm.1
-rwxr-xr-x   1 root       sys          2392 Mar  7 13:26 brushtopbm.c
-rwxr-xr-x   1 root       sys           254 Mar  7 13:26 cmuwm.h
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 cmuwmtopbm
-rwxr-xr-x   1 root       sys           781 Mar  7 13:26 cmuwmtopbm.1
-rwxr-xr-x   1 root       sys          2691 Mar  7 13:26 cmuwmtopbm.c
-rwxr-xr-x   1 root       sys          6555 Mar  7 13:26 g3.h
-rwxr-xr-x   1 root       sys         28672 Mar  7 13:26 g3topbm
-rwxr-xr-x   1 root       sys          1538 Mar  7 13:26 g3topbm.1
-rwxr-xr-x   1 root       sys          6560 Mar  7 13:26 g3topbm.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 gemtopbm
-rwxr-xr-x   1 root       sys           850 Mar  7 13:26 gemtopbm.1
-rwxr-xr-x   1 root       sys          5968 Mar  7 13:26 gemtopbm.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 icontopbm
-rwxr-xr-x   1 root       sys           740 Mar  7 13:26 icontopbm.1
-rwxr-xr-x   1 root       sys          3517 Mar  7 13:26 icontopbm.c
-rwxr-xr-x   1 root       sys          4411 Mar  7 13:26 libpbm.3
-rwxr-xr-x   1 root       sys         23808 Mar  7 13:26 libpbm.a
-rwxr-xr-x   1 root       sys           438 Mar  7 13:26 libpbm.h
-rwxr-xr-x   1 root       sys         27437 Mar  7 13:26 libpbm.i
-rwxr-xr-x   1 root       sys         12385 Mar  7 13:26 libpbm1.c
-rwxr-xr-x   1 root       sys          9260 Mar  7 13:26 libpbm1.o
-rwxr-xr-x   1 root       sys          2715 Mar  7 13:26 libpbm2.c
-rwxr-xr-x   1 root       sys          2660 Mar  7 13:26 libpbm2.o
-rwxr-xr-x   1 root       sys          2632 Mar  7 13:26 libpbm3.c
-rwxr-xr-x   1 root       sys          2216 Mar  7 13:26 libpbm3.o
```

```
-rwxr-xr-x   1 root       sys          1539 Mar  7 13:26 libpbm4.c
-rwxr-xr-x   1 root       sys          1612 Mar  7 13:26 libpbm4.o
-rwxr-xr-x   1 root       sys         13641 Mar  7 13:26 libpbm5.c
-rwxr-xr-x   1 root       sys          5204 Mar  7 13:26 libpbm5.o
-rwxr-xr-x   1 root       sys           217 Mar  7 13:26 macp.h
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 macptopbm
-rwxr-xr-x   1 root       sys          1780 Mar  7 13:26 macptopbm.1
-rwxr-xr-x   1 root       sys          3463 Mar  7 13:26 macptopbm.c
-rwxr-xr-x   1 root       sys           384 Mar  7 13:26 mgr.h
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 mgrtopbm
-rwxr-xr-x   1 root       sys           717 Mar  7 13:26 mgrtopbm.1
-rwxr-xr-x   1 root       sys          3250 Mar  7 13:26 mgrtopbm.c
-rwxr-xr-x   1 root       sys          3199 Mar  7 13:26 pbm.5
-rwxr-xr-x   1 root       sys          1430 Mar  7 13:26 pbm.h
-rwxr-xr-x   1 root       sys           356 Mar  7 13:26 pbmfont.h
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmlife
-rwxr-xr-x   1 root       sys           877 Mar  7 13:26 pbmlife.1
-rwxr-xr-x   1 root       sys          2675 Mar  7 13:26 pbmlife.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmmake
-rwxr-xr-x   1 root       sys          1025 Mar  7 13:26 pbmmake.1
-rwxr-xr-x   1 root       sys          2050 Mar  7 13:26 pbmmake.c
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 pbmmask
-rwxr-xr-x   1 root       sys          2310 Mar  7 13:26 pbmmask.1
-rwxr-xr-x   1 root       sys          5295 Mar  7 13:26 pbmmask.c
-rwxr-xr-x   1 root       sys          2381 Mar  7 13:26 pbmmerge.c
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 pbmreduce
-rwxr-xr-x   1 root       sys          2067 Mar  7 13:26 pbmreduce.1
-rwxr-xr-x   1 root       sys          4536 Mar  7 13:26 pbmreduce.c
-rwxr-xr-x   1 root       sys         11539 Mar  7 13:26 pbmreduce.i
-rwxr-xr-x   1 root       sys         28672 Mar  7 13:26 pbmtext
-rwxr-xr-x   1 root       sys          1674 Mar  7 13:26 pbmtext.1
-rwxr-xr-x   1 root       sys          5260 Mar  7 13:26 pbmtext.c
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 pbmto10x
-rwxr-xr-x   1 root       sys          1109 Mar  7 13:26 pbmto10x.1
-rwxr-xr-x   1 root       sys          3011 Mar  7 13:26 pbmto10x.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtoascii
-rwxr-xr-x   1 root       sys           784 Mar  7 13:26 pbmtoascii.1
-rwxr-xr-x   1 root       sys          1628 Mar  7 13:26 pbmtoascii.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtoatk
-rwxr-xr-x   1 root       sys           775 Mar  7 13:26 pbmtoatk.1
-rwxr-xr-x   1 root       sys          4347 Mar  7 13:26 pbmtoatk.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtobbnbg
-rwxr-xr-x   1 root       sys          1088 Mar  7 13:26 pbmtobbnbg.1
-rwxr-xr-x   1 root       sys          2948 Mar  7 13:26 pbmtobbnbg.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtocmuwm
-rwxr-xr-x   1 root       sys           779 Mar  7 13:26 pbmtocmuwm.1
-rwxr-xr-x   1 root       sys          2504 Mar  7 13:26 pbmtocmuwm.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtoepson
-rwxr-xr-x   1 root       sys           865 Mar  7 13:26 pbmtoepson.1
-rwxr-xr-x   1 root       sys          2070 Mar  7 13:26 pbmtoepson.c
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 pbmtog3
-rwxr-xr-x   1 root       sys           867 Mar  7 13:26 pbmtog3.1
-rwxr-xr-x   1 root       sys          3897 Mar  7 13:26 pbmtog3.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtogem
-rwxr-xr-x   1 root       sys           732 Mar  7 13:26 pbmtogem.1
-rwxr-xr-x   1 root       sys          3821 Mar  7 13:26 pbmtogem.c
-rwxr-xr-x   1 root       sys         24576 Mar  7 13:26 pbmtogo
-rwxr-xr-x   1 root       sys          1009 Mar  7 13:26 pbmtogo.1
-rwxr-xr-x   1 root       sys          7797 Mar  7 13:26 pbmtogo.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtoicon
-rwxr-xr-x   1 root       sys           739 Mar  7 13:26 pbmtoicon.1
-rwxr-xr-x   1 root       sys          2821 Mar  7 13:26 pbmtoicon.c
-rwxr-xr-x   1 root       sys         20480 Mar  7 13:26 pbmtolj
-rwxr-xr-x   1 root       sys          1015 Mar  7 13:26 pbmtolj.1
-rwxr-xr-x   1 root       sys          3595 Mar  7 13:26 pbmtolj.c
```

```
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pbmtomacp
-rwxr-xr-x   1 root       sys         1474 Mar  7 13:26 pbmtomacp.1
-rwxr-xr-x   1 root       sys         6349 Mar  7 13:26 pbmtomacp.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pbmtomgr
-rwxr-xr-x   1 root       sys          717 Mar  7 13:26 pbmtomgr.1
-rwxr-xr-x   1 root       sys         2545 Mar  7 13:26 pbmtomgr.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pbmtopi3
-rwxr-xr-x   1 root       sys          742 Mar  7 13:26 pbmtopi3.1
-rwxr-xr-x   1 root       sys         2508 Mar  7 13:26 pbmtopi3.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pbmtoplot
-rwxr-xr-x   1 root       sys          803 Mar  7 13:26 pbmtoplot.1
-rwxr-xr-x   1 root       sys         1582 Mar  7 13:26 pbmtoplot.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pbmtoptx
-rwxr-xr-x   1 root       sys          824 Mar  7 13:26 pbmtoptx.1
-rwxr-xr-x   1 root       sys         1951 Mar  7 13:26 pbmtoptx.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pbmtox10bm
-rwxr-xr-x   1 root       sys          917 Mar  7 13:26 pbmtox10bm.1
-rwxr-xr-x   1 root       sys         2653 Mar  7 13:26 pbmtox10bm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pbmtoxbm
-rwxr-xr-x   1 root       sys          762 Mar  7 13:26 pbmtoxbm.1
-rwxr-xr-x   1 root       sys         2579 Mar  7 13:26 pbmtoxbm.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pbmtoybm
-rwxr-xr-x   1 root       sys          845 Mar  7 13:26 pbmtoybm.1
-rwxr-xr-x   1 root       sys         2422 Mar  7 13:26 pbmtoybm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pbmtozinc
-rwxr-xr-x   1 root       sys          952 Mar  7 13:26 pbmtozinc.1
-rwxr-xr-x   1 root       sys         2964 Mar  7 13:26 pbmtozinc.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pbmupc
-rwxr-xr-x   1 root       sys         1567 Mar  7 13:26 pbmupc.1
-rwxr-xr-x   1 root       sys        16584 Mar  7 13:26 pbmupc.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 pi3topbm
-rwxr-xr-x   1 root       sys          749 Mar  7 13:26 pi3topbm.1
-rwxr-xr-x   1 root       sys         2205 Mar  7 13:26 pi3topbm.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 xbmtopbm
-rwxr-xr-x   1 root       sys          779 Mar  7 13:26 xbmtopbm.1
-rwxr-xr-x   1 root       sys         5287 Mar  7 13:26 xbmtopbm.c
-rwxr-xr-x   1 root       sys        20480 Mar  7 13:26 ybmtopbm
-rwxr-xr-x   1 root       sys          835 Mar  7 13:26 ybmtopbm.1
-rwxr-xr-x   1 root       sys         2684 Mar  7 13:26 ybmtopbm.c

./pbmplus10dec91/pgm:
total 1466
-rwxr-xr-x   1 root       sys         3534 Mar  7 13:26 Imakefile
-rwxr-xr-x   1 root       sys         4199 Mar  7 13:26 Makefile
-rwxr-xr-x   1 root       sys         3499 Mar  7 13:26 dithers.h
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 fitstopgm
-rwxr-xr-x   1 root       sys         1288 Mar  7 13:26 fitstopgm.1
-rwxr-xr-x   1 root       sys         6085 Mar  7 13:26 fitstopgm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 fstopgm
-rwxr-xr-x   1 root       sys         1668 Mar  7 13:26 fstopgm.1
-rwxr-xr-x   1 root       sys         3318 Mar  7 13:26 fstopgm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 hipstopgm
-rwxr-xr-x   1 root       sys          908 Mar  7 13:26 hipstopgm.1
-rwxr-xr-x   1 root       sys         4408 Mar  7 13:26 hipstopgm.c
-rwxr-xr-x   1 root       sys         3036 Mar  7 13:26 libpgm.3
-rwxr-xr-x   1 root       sys         6196 Mar  7 13:26 libpgm.a
-rwxr-xr-x   1 root       sys          282 Mar  7 13:26 libpgm.h
-rwxr-xr-x   1 root       sys         3260 Mar  7 13:26 libpgm1.c
-rwxr-xr-x   1 root       sys         2756 Mar  7 13:26 libpgm1.o
-rwxr-xr-x   1 root       sys         3581 Mar  7 13:26 libpgm2.c
-rwxr-xr-x   1 root       sys         2496 Mar  7 13:26 libpgm2.o
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 lispmtopgm
-rwxr-xr-x   1 root       sys         1643 Mar  7 13:26 lispmtopgm.1
-rwxr-xr-x   1 root       sys         5226 Mar  7 13:26 lispmtopgm.c
-rwxr-xr-x   1 root       sys         3222 Mar  7 13:26 pgm.5
```

```
-rwxr-xr-x   1 root       sys         1832 Mar  7 13:26 pgm.h
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmbentley
-rwxr-xr-x   1 root       sys          930 Mar  7 13:26 pgmbentley.1
-rwxr-xr-x   1 root       sys         1451 Mar  7 13:26 pgmbentley.c
-rwxr-xr-x   1 root       sys        57344 Mar  7 13:26 pgmcrater
-rwxr-xr-x   1 root       sys         5160 Mar  7 13:26 pgmcrater.1
-rwxr-xr-x   1 root       sys        10318 Mar  7 13:26 pgmcrater.c
-rwxr-xr-x   1 root       sys        45056 Mar  7 13:26 pgmedge
-rwxr-xr-x   1 root       sys         1114 Mar  7 13:26 pgmedge.1
-rwxr-xr-x   1 root       sys         2805 Mar  7 13:26 pgmedge.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmenhance
-rwxr-xr-x   1 root       sys         1217 Mar  7 13:26 pgmenhance.1
-rwxr-xr-x   1 root       sys         3219 Mar  7 13:26 pgmenhance.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmhist
-rwxr-xr-x   1 root       sys          734 Mar  7 13:26 pgmhist.1
-rwxr-xr-x   1 root       sys         2055 Mar  7 13:26 pgmhist.c
-rwxr-xr-x   1 root       sys         1643 Mar  7 13:26 pgmmerge.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmnorm
-rwxr-xr-x   1 root       sys         1886 Mar  7 13:26 pgmnorm.1
-rwxr-xr-x   1 root       sys         5108 Mar  7 13:26 pgmnorm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmoil
-rwxr-xr-x   1 root       sys         1069 Mar  7 13:26 pgmoil.1
-rwxr-xr-x   1 root       sys         2135 Mar  7 13:26 pgmoil.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmramp
-rwxr-xr-x   1 root       sys         1082 Mar  7 13:26 pgmramp.1
-rwxr-xr-x   1 root       sys         2401 Mar  7 13:26 pgmramp.c
-rwxr-xr-x   1 root       sys        57344 Mar  7 13:26 pgmtexture
-rwxr-xr-x   1 root       sys         2407 Mar  7 13:26 pgmtexture.1
-rwxr-xr-x   1 root       sys        23779 Mar  7 13:26 pgmtexture.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmtofits
-rwxr-xr-x   1 root       sys          899 Mar  7 13:26 pgmtofits.1
-rwxr-xr-x   1 root       sys         3525 Mar  7 13:26 pgmtofits.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmtofs
-rwxr-xr-x   1 root       sys          826 Mar  7 13:26 pgmtofs.1
-rwxr-xr-x   1 root       sys         3317 Mar  7 13:26 pgmtofs.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pgmtolispm
-rwxr-xr-x   1 root       sys         1493 Mar  7 13:26 pgmtolispm.1
-rwxr-xr-x   1 root       sys         4012 Mar  7 13:26 pgmtolispm.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pgmtopbm
-rwxr-xr-x   1 root       sys         2165 Mar  7 13:26 pgmtopbm.1
-rwxr-xr-x   1 root       sys         6672 Mar  7 13:26 pgmtopbm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 psidtopgm
-rwxr-xr-x   1 root       sys         1477 Mar  7 13:26 psidtopgm.1
-rwxr-xr-x   1 root       sys         2853 Mar  7 13:26 psidtopgm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 rawtopgm
-rwxr-xr-x   1 root       sys         1492 Mar  7 13:26 rawtopgm.1
-rwxr-xr-x   1 root       sys         2405 Mar  7 13:26 rawtopgm.c

./pbmplus10dec91/pnm:
total 2182
-rwxr-xr-x   1 root       sys         5158 Mar  7 13:26 Imakefile
-rwxr-xr-x   1 root       sys         5937 Mar  7 13:26 Makefile
-rwxr-xr-x   1 root       sys         3440 Mar  7 13:26 anytopnm
-rwxr-xr-x   1 root       sys         1079 Mar  7 13:26 anytopnm.1
-rwxr-xr-x   1 root       sys         4891 Mar  7 13:26 libpnm.3
-rwxr-xr-x   1 root       sys        18708 Mar  7 13:26 libpnm.a
-rwxr-xr-x   1 root       sys         2931 Mar  7 13:26 libpnm1.c
-rwxr-xr-x   1 root       sys         2708 Mar  7 13:26 libpnm1.o
-rwxr-xr-x   1 root       sys         2970 Mar  7 13:26 libpnm2.c
-rwxr-xr-x   1 root       sys         2164 Mar  7 13:26 libpnm2.o
-rwxr-xr-x   1 root       sys         8773 Mar  7 13:26 libpnm3.c
-rwxr-xr-x   1 root       sys         6988 Mar  7 13:26 libpnm3.o
-rwxr-xr-x   1 root       sys        10085 Mar  7 13:26 libpnm4.c
-rwxr-xr-x   1 root       sys         5040 Mar  7 13:26 libpnm4.o
-rwxr-xr-x   1 root       sys         1117 Mar  7 13:26 pnm.5
```

```
-rwxr-xr-x   1 root       sys         2140 Mar  7 13:26 pnm.h
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:26 pnmarith
-rwxr-xr-x   1 root       sys         1158 Mar  7 13:26 pnmarith.1
-rwxr-xr-x   1 root       sys         4720 Mar  7 13:26 pnmarith.c
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:26 pnmcat
-rwxr-xr-x   1 root       sys         1534 Mar  7 13:26 pnmcat.1
-rwxr-xr-x   1 root       sys         6439 Mar  7 13:26 pnmcat.c
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:26 pnmconvol
-rwxr-xr-x   1 root       sys         1961 Mar  7 13:26 pnmconvol.1
-rwxr-xr-x   1 root       sys         6624 Mar  7 13:26 pnmconvol.c
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:26 pnmcrop
-rwxr-xr-x   1 root       sys          990 Mar  7 13:26 pnmcrop.1
-rwxr-xr-x   1 root       sys         3616 Mar  7 13:26 pnmcrop.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pnmcut
-rwxr-xr-x   1 root       sys          889 Mar  7 13:26 pnmcut.1
-rwxr-xr-x   1 root       sys         2359 Mar  7 13:26 pnmcut.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pnmdepth
-rwxr-xr-x   1 root       sys         1023 Mar  7 13:26 pnmdepth.1
-rwxr-xr-x   1 root       sys         2433 Mar  7 13:26 pnmdepth.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pnmenlarge
-rwxr-xr-x   1 root       sys         1217 Mar  7 13:26 pnmenlarge.1
-rwxr-xr-x   1 root       sys         1852 Mar  7 13:26 pnmenlarge.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:26 pnmfile
-rwxr-xr-x   1 root       sys          812 Mar  7 13:26 pnmfile.1
-rwxr-xr-x   1 root       sys         1690 Mar  7 13:26 pnmfile.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:26 pnmflip
-rwxr-xr-x   1 root       sys         1523 Mar  7 13:26 pnmflip.1
-rwxr-xr-x   1 root       sys         6436 Mar  7 13:26 pnmflip.c
-rwxr-xr-x   1 root       sys        57344 Mar  7 13:26 pnmgamma
-rwxr-xr-x   1 root       sys         1003 Mar  7 13:26 pnmgamma.1
-rwxr-xr-x   1 root       sys         4710 Mar  7 13:26 pnmgamma.c
-rwxr-xr-x   1 root       sys         3175 Mar  7 13:26 pnmindex
-rwxr-xr-x   1 root       sys         1516 Mar  7 13:26 pnmindex.1
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:26 pnminvert
-rwxr-xr-x   1 root       sys          716 Mar  7 13:26 pnminvert.1
-rwxr-xr-x   1 root       sys         1333 Mar  7 13:26 pnminvert.c
-rwxr-xr-x   1 root       sys         1724 Mar  7 13:26 pnmmargin
-rwxr-xr-x   1 root       sys         1062 Mar  7 13:26 pnmmargin.1
-rwxr-xr-x   1 root       sys         1885 Mar  7 13:26 pnmmerge.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:26 pnmnoraw
-rwxr-xr-x   1 root       sys          800 Mar  7 13:26 pnmnoraw.1
-rwxr-xr-x   1 root       sys         1205 Mar  7 13:26 pnmnoraw.c
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:27 pnmpaste
-rwxr-xr-x   1 root       sys         1815 Mar  7 13:27 pnmpaste.1
-rwxr-xr-x   1 root       sys         4576 Mar  7 13:27 pnmpaste.c
-rwxr-xr-x   1 root       sys        65536 Mar  7 13:27 pnmrotate
-rwxr-xr-x   1 root       sys         2134 Mar  7 13:27 pnmrotate.1
-rwxr-xr-x   1 root       sys         9817 Mar  7 13:27 pnmrotate.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 pnmscale
-rwxr-xr-x   1 root       sys         1883 Mar  7 13:27 pnmscale.1
-rwxr-xr-x   1 root       sys        11364 Mar  7 13:27 pnmscale.c
-rwxr-xr-x   1 root       sys        61440 Mar  7 13:27 pnmshear
-rwxr-xr-x   1 root       sys         2131 Mar  7 13:27 pnmshear.1
-rwxr-xr-x   1 root       sys         4738 Mar  7 13:27 pnmshear.c
-rwxr-xr-x   1 root       sys          257 Mar  7 13:27 pnmsmooth
-rwxr-xr-x   1 root       sys          904 Mar  7 13:27 pnmsmooth.1
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 pnmtile
-rwxr-xr-x   1 root       sys          776 Mar  7 13:27 pnmtile.1
-rwxr-xr-x   1 root       sys         1598 Mar  7 13:27 pnmtile.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 pnmtops
-rwxr-xr-x   1 root       sys         2869 Mar  7 13:27 pnmtops.1
-rwxr-xr-x   1 root       sys        13823 Mar  7 13:27 pnmtops.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 pnmtorast
-rwxr-xr-x   1 root       sys         1203 Mar  7 13:27 pnmtorast.1
-rwxr-xr-x   1 root       sys         7737 Mar  7 13:27 pnmtorast.c
```

```
-rwxr-xr-x   1 root       sys         3005 Mar  7 13:27 pnmtotiff.1
-rwxr-xr-x   1 root       sys         9250 Mar  7 13:27 pnmtotiff.c
-rwxr-xr-x   1 root       sys        36864 Mar  7 13:27 pnmtoxwd
-rwxr-xr-x   1 root       sys         1275 Mar  7 13:27 pnmtoxwd.1
-rwxr-xr-x   1 root       sys         8692 Mar  7 13:27 pnmtoxwd.c
-rwxr-xr-x   1 root       sys         3572 Mar  7 13:27 rast.h
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 rasttopnm
-rwxr-xr-x   1 root       sys          964 Mar  7 13:27 rasttopnm.1
-rwxr-xr-x   1 root       sys         5962 Mar  7 13:27 rasttopnm.c
-rwxr-xr-x   1 root       sys         1787 Mar  7 13:27 tifftopnm.1
-rwxr-xr-x   1 root       sys         6385 Mar  7 13:27 tifftopnm.c
-rwxr-xr-x   1 root       sys         1011 Mar  7 13:27 x10wd.h
-rwxr-xr-x   1 root       sys         1878 Mar  7 13:27 x11wd.h
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 xwdtopnm
-rwxr-xr-x   1 root       sys         1353 Mar  7 13:27 xwdtopnm.1
-rwxr-xr-x   1 root       sys        15699 Mar  7 13:27 xwdtopnm.c

./pbmplus10dec91/ppm:
total 3814
-rwxr-xr-x   1 root       sys         5811 Mar  7 13:27 Imakefile
-rwxr-xr-x   1 root       sys         6737 Mar  7 13:27 Makefile
-rwxr-xr-x   1 root       sys         4290 Mar  7 13:27 autocad.h
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 giftoppm
-rwxr-xr-x   1 root       sys         1228 Mar  7 13:27 giftoppm.1
-rwxr-xr-x   1 root       sys        12570 Mar  7 13:27 giftoppm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 gouldtoppm
-rwxr-xr-x   1 root       sys          760 Mar  7 13:27 gouldtoppm.1
-rwxr-xr-x   1 root       sys         3205 Mar  7 13:27 gouldtoppm.c
-rwxr-xr-x   1 root       sys          696 Mar  7 13:27 ilbm.h
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ilbmtoppm
-rwxr-xr-x   1 root       sys          791 Mar  7 13:27 ilbmtoppm.1
-rwxr-xr-x   1 root       sys        10303 Mar  7 13:27 ilbmtoppm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 imgtoppm
-rwxr-xr-x   1 root       sys          909 Mar  7 13:27 imgtoppm.1
-rwxr-xr-x   1 root       sys         3246 Mar  7 13:27 imgtoppm.c
-rwxr-xr-x   1 root       sys         4623 Mar  7 13:27 libppm.3
-rwxr-xr-x   1 root       sys        28892 Mar  7 13:27 libppm.a
-rwxr-xr-x   1 root       sys          283 Mar  7 13:27 libppm.h
-rwxr-xr-x   1 root       sys         4463 Mar  7 13:27 libppm1.c
-rwxr-xr-x   1 root       sys         3140 Mar  7 13:27 libppm1.o
-rwxr-xr-x   1 root       sys         4458 Mar  7 13:27 libppm2.c
-rwxr-xr-x   1 root       sys         2796 Mar  7 13:27 libppm2.o
-rwxr-xr-x   1 root       sys         6356 Mar  7 13:27 libppm3.c
-rwxr-xr-x   1 root       sys         4732 Mar  7 13:27 libppm3.o
-rwxr-xr-x   1 root       sys         8339 Mar  7 13:27 libppm4.c
-rwxr-xr-x   1 root       sys         6208 Mar  7 13:27 libppm4.o
-rwxr-xr-x   1 root       sys        16578 Mar  7 13:27 libppm5.c
-rwxr-xr-x   1 root       sys         9416 Mar  7 13:27 libppm5.o
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 mtvtoppm
-rwxr-xr-x   1 root       sys          846 Mar  7 13:27 mtvtoppm.1
-rwxr-xr-x   1 root       sys         1740 Mar  7 13:27 mtvtoppm.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 pcxtoppm
-rwxr-xr-x   1 root       sys          713 Mar  7 13:27 pcxtoppm.1
-rwxr-xr-x   1 root       sys         8084 Mar  7 13:27 pcxtoppm.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 pgmtoppm
-rwxr-xr-x   1 root       sys         2259 Mar  7 13:27 pgmtoppm.1
-rwxr-xr-x   1 root       sys         3431 Mar  7 13:27 pgmtoppm.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 piltoppm
-rwxr-xr-x   1 root       sys          810 Mar  7 13:27 piltoppm.1
-rwxr-xr-x   1 root       sys         2156 Mar  7 13:27 piltoppm.c
-rwxr-xr-x   1 root       sys        40960 Mar  7 13:27 picttoppm
-rwxr-xr-x   1 root       sys         1205 Mar  7 13:27 picttoppm.1
-rwxr-xr-x   1 root       sys        31716 Mar  7 13:27 picttoppm.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 pjtoppm
-rwxr-xr-x   1 root       sys          966 Mar  7 13:27 pjtoppm.1
```

```
-rwxr-xr-x   1 root       sys         6172 Mar  7 13:27 pjtoppm.c
-rwxr-xr-x   1 root       sys         3319 Mar  7 13:27 ppm.5
-rwxr-xr-x   1 root       sys         3059 Mar  7 13:27 ppm.h
-rwxr-xr-x   1 root       sys         1375 Mar  7 13:27 ppmcmap.h
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmdither
-rwxr-xr-x   1 root       sys         1557 Mar  7 13:27 ppmdither.1
-rwxr-xr-x   1 root       sys         6543 Mar  7 13:27 ppmdither.c
-rwxr-xr-x   1 root       sys         4930 Mar  7 13:27 ppmdraw.h
-rwxr-xr-x   1 root       sys        65536 Mar  7 13:27 ppmforge
-rwxr-xr-x   1 root       sys        15385 Mar  7 13:27 ppmforge.1
-rwxr-xr-x   1 root       sys        27513 Mar  7 13:27 ppmforge.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 ppmhist
-rwxr-xr-x   1 root       sys          715 Mar  7 13:27 ppmhist.1
-rwxr-xr-x   1 root       sys         1851 Mar  7 13:27 ppmhist.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmmake
-rwxr-xr-x   1 root       sys         1459 Mar  7 13:27 ppmmake.1
-rwxr-xr-x   1 root       sys         1522 Mar  7 13:27 ppmmake.c
-rwxr-xr-x   1 root       sys         2517 Mar  7 13:27 ppmmerge.c
-rwxr-xr-x   1 root       sys        73728 Mar  7 13:27 ppmpat
-rwxr-xr-x   1 root       sys         2054 Mar  7 13:27 ppmpat.1
-rwxr-xr-x   1 root       sys        31540 Mar  7 13:27 ppmpat.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 ppmquant
-rwxr-xr-x   1 root       sys         2302 Mar  7 13:27 ppmquant.1
-rwxr-xr-x   1 root       sys        17210 Mar  7 13:27 ppmquant.c
-rwxr-xr-x   1 root       sys         1334 Mar  7 13:27 ppmquantall
-rwxr-xr-x   1 root       sys         1742 Mar  7 13:27 ppmquantall.1
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 ppmrelief
-rwxr-xr-x   1 root       sys          961 Mar  7 13:27 ppmrelief.1
-rwxr-xr-x   1 root       sys         2679 Mar  7 13:27 ppmrelief.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtoacad
-rwxr-xr-x   1 root       sys         4541 Mar  7 13:27 ppmtoacad.1
-rwxr-xr-x   1 root       sys        11612 Mar  7 13:27 ppmtoacad.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtogif
-rwxr-xr-x   1 root       sys         1162 Mar  7 13:27 ppmtogif.1
-rwxr-xr-x   1 root       sys        21185 Mar  7 13:27 ppmtogif.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtoicr
-rwxr-xr-x   1 root       sys         3183 Mar  7 13:27 ppmtoicr.1
-rwxr-xr-x   1 root       sys         7003 Mar  7 13:27 ppmtoicr.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtoilbm
-rwxr-xr-x   1 root       sys          951 Mar  7 13:27 ppmtoilbm.1
-rwxr-xr-x   1 root       sys         8285 Mar  7 13:27 ppmtoilbm.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtopcx
-rwxr-xr-x   1 root       sys          714 Mar  7 13:27 ppmtopcx.1
-rwxr-xr-x   1 root       sys         8668 Mar  7 13:27 ppmtopcx.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtopgm
-rwxr-xr-x   1 root       sys         1331 Mar  7 13:27 ppmtopgm.1
-rwxr-xr-x   1 root       sys         7480 Mar  7 13:27 ppmtopgm.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtopi1
-rwxr-xr-x   1 root       sys          815 Mar  7 13:27 ppmtopi1.1
-rwxr-xr-x   1 root       sys         3122 Mar  7 13:27 ppmtopi1.c
-rwxr-xr-x   1 root       sys        32768 Mar  7 13:27 ppmtopict
-rwxr-xr-x   1 root       sys         1404 Mar  7 13:27 ppmtopict.1
-rwxr-xr-x   1 root       sys        10905 Mar  7 13:27 ppmtopict.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 ppmtopj
-rwxr-xr-x   1 root       sys         2151 Mar  7 13:27 ppmtopj.1
-rwxr-xr-x   1 root       sys         6853 Mar  7 13:27 ppmtopj.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtopuzz
-rwxr-xr-x   1 root       sys          912 Mar  7 13:27 ppmtopuzz.1
-rwxr-xr-x   1 root       sys         2521 Mar  7 13:27 ppmtopuzz.c
-rwxr-xr-x   1 root       sys        24576 Mar  7 13:27 ppmtorgb3
-rwxr-xr-x   1 root       sys         1141 Mar  7 13:27 ppmtorgb3.1
-rwxr-xr-x   1 root       sys         2586 Mar  7 13:27 ppmtorgb3.c
-rwxr-xr-x   1 root       sys        28672 Mar  7 13:27 ppmtosixel
-rwxr-xr-x   1 root       sys         2147 Mar  7 13:27 ppmtosixel.1
-rwxr-xr-x   1 root       sys         4973 Mar  7 13:27 ppmtosixel.c
```

```
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 ppmtotga
-rwxr-xr-x   1 root       sys           1631 Mar  7 13:27 ppmtotga.1
-rwxr-xr-x   1 root       sys          11409 Mar  7 13:27 ppmtotga.c
-rwxr-xr-x   1 root       sys          32768 Mar  7 13:27 ppmtouil
-rwxr-xr-x   1 root       sys           1624 Mar  7 13:27 ppmtouil.1
-rwxr-xr-x   1 root       sys           8009 Mar  7 13:27 ppmtouil.c
-rwxr-xr-x   1 root       sys          32768 Mar  7 13:27 ppmtoxpm
-rwxr-xr-x   1 root       sys           2180 Mar  7 13:27 ppmtoxpm.1
-rwxr-xr-x   1 root       sys           6636 Mar  7 13:27 ppmtoxpm.c
-rwxr-xr-x   1 root       sys          24576 Mar  7 13:27 ppmtoyuv
-rwxr-xr-x   1 root       sys            909 Mar  7 13:27 ppmtoyuv.1
-rwxr-xr-x   1 root       sys           2365 Mar  7 13:27 ppmtoyuv.c
-rwxr-xr-x   1 root       sys          24576 Mar  7 13:27 qrttoppm
-rwxr-xr-x   1 root       sys            731 Mar  7 13:27 qrttoppm.1
-rwxr-xr-x   1 root       sys           1788 Mar  7 13:27 qrttoppm.c
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 rawtoppm
-rwxr-xr-x   1 root       sys           2171 Mar  7 13:27 rawtoppm.1
-rwxr-xr-x   1 root       sys           5612 Mar  7 13:27 rawtoppm.c
-rwxr-xr-x   1 root       sys          24576 Mar  7 13:27 rgb3toppm
-rwxr-xr-x   1 root       sys            816 Mar  7 13:27 rgb3toppm.1
-rwxr-xr-x   1 root       sys           2567 Mar  7 13:27 rgb3toppm.c
-rwxr-xr-x   1 root       sys          40960 Mar  7 13:27 sldtoppm
-rwxr-xr-x   1 root       sys           4785 Mar  7 13:27 sldtoppm.1
-rwxr-xr-x   1 root       sys          17951 Mar  7 13:27 sldtoppm.c
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 spctoppm
-rwxr-xr-x   1 root       sys            803 Mar  7 13:27 spctoppm.1
-rwxr-xr-x   1 root       sys           4384 Mar  7 13:27 spctoppm.c
-rwxr-xr-x   1 root       sys          24576 Mar  7 13:27 sputoppm
-rwxr-xr-x   1 root       sys            807 Mar  7 13:27 sputoppm.1
-rwxr-xr-x   1 root       sys           2510 Mar  7 13:27 sputoppm.c
-rwxr-xr-x   1 root       sys           1424 Mar  7 13:27 tga.h
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 tgatoppm
-rwxr-xr-x   1 root       sys           1019 Mar  7 13:27 tgatoppm.1
-rwxr-xr-x   1 root       sys           9657 Mar  7 13:27 tgatoppm.c
-rwxr-xr-x   1 root       sys           5534 Mar  7 13:27 xim.h
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 ximtoppm
-rwxr-xr-x   1 root       sys            794 Mar  7 13:27 ximtoppm.1
-rwxr-xr-x   1 root       sys          11318 Mar  7 13:27 ximtoppm.c
-rwxr-xr-x   1 root       sys          32768 Mar  7 13:27 xpmtoppm
-rwxr-xr-x   1 root       sys            746 Mar  7 13:27 xpmtoppm.1
-rwxr-xr-x   1 root       sys           6361 Mar  7 13:27 xpmtoppm.c
-rwxr-xr-x   1 root       sys          28672 Mar  7 13:27 yuvtoppm
-rwxr-xr-x   1 root       sys           1114 Mar  7 13:27 yuvtoppm.1
-rwxr-xr-x   1 root       sys           2515 Mar  7 13:27 yuvtoppm.c

./qads:
total 624
-rwxr-xr-x   1 root       sys         309328 Mar  7 13:27 qads
```

3.0 VALIDATION

3.1 SAS2H Validation Tests

The SAS2H module of the SCALE 4.3 modular code system computes the isotopic content of Light Water Reactor (LWR) fuel. The discussion contained here relates to the validation of this methodology. Specifically, two PWR fuel assemblies will be modeled with the SAS2H sequence. The concentration predicted by SAS2H for selected actinide and fission product isotopes are compared with measured values for the selected assemblies. The agreement noted by this comparison provides the validation for this module.

Measured Data

A set of measured data has been compiled (ORNL/TM-12667, *Validation of the SCALE System for PWR Spent Fuel Isotopic Composition Analyses*) from which the validation cases will be selected. The data only covers assay measurements of PWR spent fuel and does not reference any similar data for BWR fuel assemblies. However, the lack of specific assay data for BWR fuel assemblies does not degrade the validation of the SAS2H module. The methodology used by SAS2H is the same for either BWR or PWR fuel assemblies, since both are Light Water Reactor (LWR) fuel assemblies. The difference between the analysis resides with the input parameters used, primarily related to the larger axial moderator density variations for irradiation of the BWR fuel. Other differences between these fuel assemblies exist, e.g. geometry, fuel loadings, fuel temperature, but, as with the moderator density, they are independent of the analytical solution method of SAS2H and the ORIGEN-S depletion program of that module.

The compilation comprises three sets of data for PWR spent fuel. Two PWR fuel assemblies manufactured in the U.S. are included in the data set. They provide 4 data sets as a function of both initial enrichment, burnup, and axial location in the assembly. The last set provides measured isotopic concentrations averaged over the assembly axial height. The data was obtained for a PWR assembly of German design. The data covers a wide range of actinide and fission product isotopes of paramount interest to the validation of ORIGEN-S for burnup credit applications. In addition to the measurement results, the compilation provides information on the irradiation parameters for the fuel assemblies assayed. This information is required to appropriately model the irradiation of the assembly with SAS2H/ORIGEN-S and provide a best estimate calculation of the isotopic assay provided by the measurements.

For the Waste Package Development (WPD) program, the U.S. PWR data is very representative of the baseline fuel. In addition, the data characterizes the axial variation of irradiation in the assembly. This type of information is necessary for WPD analyses. The compilation not only lists the measured data; it provides comparisons between the measured data and SAS2H results. Thus, the referenced document provides validation for the SAS2H module of the SCALE 4.3 code system. To provide additional assurance that the code system has been correctly implemented on the WPD HP 9000 series computers, two of the measurements in the compilation are executed on each of the WPD HP computer platforms (i.e., 700 and the C160). Based on agreement equivalent to that in the compilation for the selected cases, similar agreement for all the measured data will be inferred. The

two selected validation cases are the Calvert Cliffs Unit 1 assembly D047 and the H.B. Robinson Unit 2 B05 assembly. These two assemblies provide an enrichment near the 3 wt% base enrichment for the WPD analyses (3.0 wt% enrichment with a high burnup of 44 GWd/MTU for the D047 assembly and 2.56 wt% enrichment with a 31.7 GWD/MTU burnup for the B05 assembly).

3.1.1 Validation Test Case 1: Calvert Cliffs

```
=sas2      parm='halt04,skipshipdata'
calvert cliffs 1 pwr, d047, rod mkp109, 165.22 cm, 44.34/mtu b4 aug-94
'    1870 d cooling time
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'    mixtures of fuel-pin-unit-cell:
'
44group     latticecell
uo2   1 den=10.045  1  873
   92234 0.027 92235 3.038 92236 0.014 92238 96.921    end
c     1 den=1.8-4   1  873  end
n     1 den=2.3-4   1  873  end
co-59   3 0 1-20 570  end
zr-94   1 0 1-20 873  end
mo-94   1 0 1-20 873  end
nb-95   1 0 1-20 873  end
mo-95   1 0 1-20 873  end
tc-99   1 0 1-20 873  end
rh-103  1 0 1-20 873  end
rh-105  1 0 1-20 873  end
ru-106  1 0 1-20 873  end
sn-126  1 0 1-20 873  end
xe-131  1 0 1-20 873  end
cs-134  1 0 1-20 873  end
cs-135  1 0 1-20 873  end
cs-137  1 0 1-20 873  end
pr-143  1 0 1-20 873  end
nd-143  1 0 1-20 873  end
ce-144  1 0 1-20 873  end
nd-144  1 0 1-20 873  end
nd-145  1 0 1-20 873  end
nd-146  1 0 1-20 873  end
nd-147  1 0 1-20 873  end
pm-147  1 0 1-20 873  end
sm-147  1 0 1-20 873  end
nd-148  1 0 1-20 873  end
pm-148  1 0 1-20 873  end
sm-148  1 0 1-20 873  end
pm-149  1 0 1-20 873  end
sm-149  1 0 1-20 873  end
nd-150  1 0 1-20 873  end
sm-150  1 0 1-20 873  end
sm-151  1 0 1-20 873  end
eu-151  1 0 1-20 873  end
sm-152  1 0 1-20 873  end
eu-153  1 0 1-20 873  end
eu-154  1 0 1-20 873  end
gd-154  1 0 1-20 873  end
eu-155  1 0 1-20 873  end
gd-155  1 0 1-20 873  end
gd-157  1 0 1-20 873  end
gd-158  1 0 1-20 873  end
gd-160  1 0 1-20 873  end
'    need the following to use endf/b5 library:
```

```
'   from st5:  (2nd line same as def. of zircalloy in sect. m8, scale-4.1)
' arbmzirc 6.5 4 0 0 1 40000 97.91  26000 0.5  50118 0.64  50120 0.95 2 1  end
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50118 0.64 50120 0.95 2 1 620  end
h2o  3 den=0.7332  1  570 end
arbm-bormod  0.7332 1 1 0 0 5000 100 3 330.8e-6  570  end
'
'  331 ppm boron (wt) in moderator
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
end comp
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'      fuel-pin-cell geometry:
'
squarepitch   1.4732  0.9563 1  3  1.1176  2  0.9855   0  end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'    assembly and cycle parameters:
'
npin/assm=176 fuelnght=787.52 ncycles=4  nlib/cyc=1
printlevel=4 lightel=9  inplevel=2 numztotal=5   end
3  1.314  2  1.416  3  1.662  500  5.203  3  5.243
power=27.432 burn=306.0  down=71     end
power=28.654 burn=381.7  down=81.3  bfrac=1.419   end
power=23.094 burn=466.0  down=85    bfrac=1.523   end
power=19.499 burn=461.1  down=1870  bfrac=1.488   end
  o 119  cr  5.2  mn  0.29
  fe 11. co 0.066 ni  8.7
  zr 195 nb  0.63 sn  3.2
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
end
```

3.1.2 Validation Test Case 2: H.B. Robinson

```
=sas2h    parm='halt04,skipshipdata'
h.b. robinson 1 pwr case 1-d: b0-5, rod n-9, 226 cm, 31.66gwd/mtu b4 aug-94
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'  for burnup credit project (see exper-data of April 84 in atm-101)
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'   mixtures of fuel-pin-unit-cell:
'
44group    latticecell
uo2  1 den=9.944 1  923
          92234 0.023 92235 2.561 92236 0.013 92238 97.403   end
co-59   3 0 1-20 579  end
zr-94   1 0 1-20 923  end
mo-94   1 0 1-20 923  end
nb-95   1 0 1-20 923  end
mo-95   1 0 1-20 923  end
tc-99   1 0 1-20 923  end
rh-103  1 0 1-20 923  end
rh-105  1 0 1-20 923  end
ru-106  1 0 1-20 923  end
xe-131  1 0 1-20 923  end
cs-134  1 0 1-20 923  end
cs-135  1 0 1-20 923  end
```

```
cs-137 1 0 1-20 923  end
pr-143 1 0 1-20 923  end
nd-143 1 0 1-20 923  end
ce-144 1 0 1-20 923  end
nd-145 1 0 1-20 923  end
nd-146 1 0 1-20 923  end
nd-147 1 0 1-20 923  end
pm-147 1 0 1-20 923  end
sm-147 1 0 1-20 923  end
nd-148 1 0 1-20 923  end
pm-149 1 0 1-20 923  end
sm-149 1 0 1-20 923  end
sm-150 1 0 1-20 923  end
sm-151 1 0 1-20 923  end
eu-151 1 0 1-20 923  end
sm-152 1 0 1-20 923  end
eu-153 1 0 1-20 923  end
eu-154 1 0 1-20 923  end
gd-154 1 0 1-20 923  end
eu-155 1 0 1-20 923  end
gd-155 1 0 1-20 923  end
gd-157 1 0 1-20 923  end
gd-158 1 0 1-20 923  end
gd-160 1 0 1-20 923  end
'   need the following to use endf/b5 library:
'   from st5:  (2nd line same as def. of zircalloy in sect. m8, scale-4.1)
' arbmzirc 6.5 4 0 0 1 40000 97.91  26000 0.5  50118 0.64  50120 0.95 2 1  end
arbmzirc 6.44 4 0 0 1 40000 97.91 26000 0.5 50118 0.64 50120 0.95 2 1 595  end
h2o  3 den=0.7135  1  579 end
arbm-bormod  0.7135 1 1 0 0 5000 100 3 652.5e-6  579  end
'
'  652.5 ppm boron (wt) in moderator
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'  input materials for the burnable poison coupled assembly:
'
ss304  5 1 579  end
o      6 0  0.04497   579  end
na     6 0  0.00165   579  end
al     6 0  0.00058   579  end
si     6 0  0.01799   579  end
k      6 0  0.00011   579  end
b-10   6 0  9.595-4   579  end
b-11   6 0  3.863-3   579  end
n      4 0  5-5       579  end
'
end comp
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'      fuel-pin-cell geometry:
'
squarepitch   1.4300  0.9294 1  3  1.0719  2  0.9484   0  end
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
'    assembly and cycle parameters:
'
npin/assm=204 fuelnght=726.63 ncycles=4  nlib/cyc=1
printlevel=5 lightel=9  inplevel=2 numztotal=10 mxrepeats=0   end
'  the 10 larger unit cell zones follow for 2 passes bp, 2 passes h2o :
4  0.21457 5  0.22705 4  0.23329 6  0.38017 4  0.38449 5  0.42145
3  0.65024 2  0.69342 3  0.80680 500  2.64088
4  0.21457 5  0.22705 4  0.23329 6  0.38017 4  0.38449 5  0.42145
3  0.65024 2  0.69342 3  0.80680 500  2.64088
3  0.21457 3  0.22705 3  0.23329 3  0.38017 3  0.38449 3  0.42145
```

```
3  0.65024 2  0.69342 3  0.80680 500  2.64088
3  0.21457 3  0.22705 3  0.23329 3  0.38017 3  0.38449 3  0.42145
3  0.65024 2  0.69342 3  0.80680 500  2.64088
'
power=39.382 burn=243.5  down=40      end
power=35.477 burn=243.5  down=64   bfrac=0.379   end
power=32.274 burn=156    down=39   bfrac=1.0     end
power=29.772 burn=156    down=3631  bfrac=0.379  end
  o 119  cr  5.2  mn  0.29

  fe 11. co 0.066 ni  8.7

  zr 195 nb  0.63 sn  3.2

'
'   the above light elements converted to kg per mtuo2...
'
' - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
'
end
```

3.1.3 SAS2H Validation Test Results

The number of grams of various actinide isotopes, including uranium and plutonium isotopes, are tabulated in Table B.3 (*Validation of the SCALE Broad Structure 44-Group ENDF/B-V Cross-Section Library for Use in Criticality Safety Analyses*) for the Calvert Cliffs case and Table B.13 for the H.B. Robinson case. A comparison of the outputs from WPDD computer platforms (i.e., HP 9000/700 and HP 9000/C160) SAS2H calculations and these tables showed that the WPDD calculations produced exactly the same results as the tabulated values. Therefore, it is concluded that the WPDD implementation of the SCALE 4.3 SAS2H sequence is valid for PWR and BWR fuel assemblies.

3.2 CSAS25 Validation Tests

The CSAS25 sequence calculates k-effective for systems, such as waste packages, which contain BWR or PWR fuel assemblies. The sequence prepares adjusted cross-section data sets which are appropriate for the particular fuel parameters of the system being modeled. A series of 92 benchmark critical experiments has been compiled (ORNL/TM-12460 (NUREG/CR-6102), *Validation of the SCALE Broad Structure 44-Group ENDF/B-V Cross-Section Library for Use in Criticality Safety Analyses*) to test the validity of CSAS25 over a range of PWR and BWR fuel assembly parameters and in a variety of systems, including dry storage casks which are neutronically very similar to waste packages. The first 59 experiments of the series test LWR fuel pin geometries, and are included in this validation. The subsequent experiments test mixed oxide and FFTF (liquid metal cooled) conditions, and are not included. The final experiment is actually a subcritical model of a spent fuel cask, and is included. The results of the test cases are presented below for each of the WPDD computer platforms (i.e., HP 9000/700 and HP 9000/C160). All input files are provided in the Validation reference, and hence these input files are not reproduced here. The results of the validation test cases are tabulated below:

Table 7. CSAS25 Installation Verification Test Cases for the HP 9000/700

CSAS25 Validation Test Cases						
		Oak Ridge		WPDD		Percent
Case	Case Name	k-effective	sigma	k-effective	sigma	Difference
1	p2438x05	0.9947	0.0013	0.99868	0.00132	0.4
2	p2438x17	0.9974	0.0010	0.99701	0.00094	0.0
3	p2438x28	1.0007	0.0014	0.99542	0.00142	-0.5
4	p2615x14	0.9966	0.0014	0.99866	0.00157	0.2
5	p2615x23	0.9976	0.0015	0.99946	0.00155	0.2
6	p2615x31	0.9990	0.0016	0.99880	0.00149	0.0
7	p2827u2a	1.0021	0.0012	0.99969	0.00133	-0.2
8	p282712a	1.0029	0.0014	1.00436	0.00142	0.1
9	p2827non	0.9946	0.0014	0.99581	0.00131	0.1
10	p2827u2b	1.0033	0.0014	1.00027	0.00145	-0.3
11	p282712b	1.0096	0.0008	1.00795	0.00078	-0.2
12	p3314a	1.0038	0.0016	1.00453	0.00147	0.1
13	p3314b	1.0001	0.0011	0.99989	0.00111	0.0
14	p3602n2	0.9917	0.0013	1.00037	0.00134	0.9
15	p3602non	0.9981	0.0016	0.99994	0.00153	0.2
16	p3602s4	0.9936	0.0016	1.00177	0.00157	0.8
17	p3602b4	0.9950	0.0015	1.00035	0.00156	0.5
18	p3602c4	0.9979	0.0011	0.99772	0.00112	0.0
19	p3926u2a	1.0020	0.0013	0.99882	0.00125	-0.3
20	p392612a	1.0010	0.0013	1.00388	0.00142	0.3
21	p3926n2	0.9974	0.0014	0.99712	0.00141	0.0
22	p3926u4a	1.0036	0.0016	1.00180	0.00145	-0.2
23	p392614a	1.0069	0.0015	1.00697	0.00148	0.0
24	p3926nob	0.9988	0.0016	0.99781	0.00154	-0.1
25	p4267a	0.9975	0.0011	0.99875	0.00114	0.1
26	p4267b	1.0037	0.0013	1.00177	0.00126	-0.2
27	p4267c	0.9994	0.0011	0.99946	0.00105	0.0
28	p4267d	0.9945	0.0013	0.99737	0.00125	0.3
29	pn1194	1.0088	0.0014	1.00826	0.00139	-0.1

Table 7. CSAS25 Installation Verification Test Cases for the HP 9000/700 (cont.)

CSAS25 Validation Test Cases (Continued)						
Case	Case Name	Oak Ridge k-effective	Oak Ridge sigma	WPDD k-effective	WPDD sigma	Percent Difference
30	ft214r	0.9955	0.0016	0.99585	0.00156	0.0
31	ft214v3	0.9967	0.0011	0.99585	0.00112	-0.1
32	baw1231a	0.9962	0.0010	0.99539	0.00095	-0.1
33	baw1231b	0.9981	0.0008	0.99706	0.00077	-0.1
34	baw1273m	0.9980	0.0011	0.99445	0.00110	-0.4
35	baw1484a	0.9942	0.0010	0.99119	0.00099	-0.3
36	baw1484b	0.9944	0.0014	0.99307	0.00139	-0.1
37	baw1484c	0.9962	0.0014	0.99500	0.00134	-0.1
38	baw1484d	0.9920	0.0015	0.99354	0.00139	0.2
39	baw1645t	1.0069	0.0009	1.00764	0.00086	0.1
40	baw1645s	1.0045	0.0012	1.00220	0.00125	-0.2
41	bw1645so	0.9986	0.0012		Not run	
42	bnw1810a	1.0008	0.0011	0.99769	0.00105	-0.3
43	nbw1810b	0.9999	0.0011	0.99868	0.00104	-0.1
44	bnw1810c	0.9958	0.0011	0.99786	0.00108	0.2
45	e196u6n	0.9936	0.0015	0.99951	0.00144	0.6
46	epru615b	1.0004	0.0013		Not run	
47	epru75	0.9966	0.0010	0.99700	0.00096	0.0
48	epru75b	0.9986	0.0008	1.00047	0.00086	0.2
49	e196u87c	0.9998	0.0013	0.99837	0.00130	-0.1
50	epru87b	1.0000	0.0012	0.99945	0.00123	-0.1
51	saxu56	0.9932	0.0017	0.99632	0.00155	0.3
52	saxu792	0.9995	0.0011	0.99667	0.00111	-0.3
53	w3269a	1.0063	0.0010		Not run	
54	w3269b	0.9983	0.0014	1.00308	0.00138	0.5
55	w3269c	0.9939	0.0010	0.99540	0.00100	0.2
56	ans33bp2	0.9987	0.0012	0.99822	0.00112	0.0
57	ans33bb2	1.0096	0.0011	1.00943	0.00114	0.0
58	ans33bh2	1.0129	0.0012	1.01140	0.00112	-0.1
59	ans33h2	0.9983	0.0011	0.99703	0.00116	-0.1
93	p6838	0.9057	0.0016	0.90233	0.00165	-0.4

Table 8. CSAS25 Installation Verification Test Cases for the HP 9000/C160

CSAS25 Validation Test Cases						
Case	Case Name	Oak Ridge k-effective	Oak Ridge sigma	WPDD k-effective	WPDD sigma	Percent Difference
1	p2438x05	0.9947	0.0013	0.99868	0.00132	0.4
2	p2438x17	0.9974	0.0010	0.99701	0.00094	0.0
3	p2438x28	1.0007	0.0014	0.99542	0.00142	-0.5
4	p2615x14	0.9966	0.0014	0.99866	0.00157	0.2
5	p2615x23	0.9976	0.0015	0.99946	0.00155	0.2
6	p2615x31	0.9990	0.0016	0.99880	0.00149	0.0
7	p2827u2a	1.0021	0.0012	0.99969	0.00133	-0.2
8	p282712a	1.0029	0.0014	1.00436	0.00142	0.1
9	p2827non	0.9946	0.0014	0.99581	0.00131	0.1
10	p2827u2b	1.0033	0.0014	1.00027	0.00145	-0.3
11	p282712b	1.0096	0.0008	1.00795	0.00078	-0.2
12	p3314a	1.0038	0.0016	1.00453	0.00147	0.1
13	p3314b	1.0001	0.0011	0.99989	0.00111	0.0
14	p3602n2	0.9917	0.0013	1.00037	0.00134	0.9
15	p3602non	0.9981	0.0016	0.99994	0.00153	0.2
16	p3602s4	0.9936	0.0016	1.00177	0.00157	0.8
17	p3602b4	0.9950	0.0015	1.00035	0.00156	0.5
18	p3602c4	0.9979	0.0011	0.99772	0.00112	0.0
19	p3926u2a	1.0020	0.0013	0.99882	0.00125	-0.3
20	p392612a	1.0010	0.0013	1.00388	0.00142	0.3
21	p3926n2	0.9974	0.0014	0.99712	0.00141	0.0
22	p3926u4a	1.0036	0.0016	1.00180	0.00145	-0.2
23	p392614a	1.0069	0.0015	1.00697	0.00148	0.0
24	p3926nob	0.9988	0.0016	0.99781	0.00154	-0.1
25	p4267a	0.9975	0.0011	0.99875	0.00114	0.1
26	p4267b	1.0037	0.0013	1.00177	0.00126	-0.2
27	p4267c	0.9994	0.0011	0.99946	0.00105	0.0
28	p4267d	0.9945	0.0013	0.99737	0.00125	0.3
29	pn1194	1.0088	0.0014	1.00826	0.00139	-0.1

Table 8. CSAS25 Installation Verification Test Cases for the HP 9000/C160 (cont.)

CSAS25 Validation Test Cases (Continued)						
Case	Case Name	Oak-Ridge k-effective	Oak-Ridge sigma	WPDD k-effective	WPDD sigma	Percent Difference
30	fl214r	0.9955	0.0016	0.99585	0.00156	0.0
31	fl214v3	0.9967	0.0011	0.99585	0.00112	-0.1
32	baw1231a	0.9962	0.0010	0.99539	0.00095	-0.1
33	baw1231b	0.9981	0.0008	0.99706	0.00077	-0.1
34	baw1273m	0.9980	0.0011	0.99445	0.00110	-0.4
35	baw1484a	0.9942	0.0010	0.99119	0.00099	-0.3
36	baw1484b	0.9944	0.0014	0.99307	0.00139	-0.1
37	baw1484c	0.9962	0.0014	0.99500	0.00134	-0.1
38	baw1484d	0.9920	0.0015	0.99354	0.00139	0.2
39	baw1645t	1.0069	0.0009	1.00764	0.00086	0.1
40	baw1645s	1.0045	0.0012	1.00220	0.00125	-0.2
41	bw1645so	0.9986	0.0012		Not run	
42	bnw1810a	1.0008	0.0011	0.99769	0.00105	-0.3
43	nbw1810b	0.9999	0.0011	0.99868	0.00104	-0.1
44	bnw1810c	0.9958	0.0011	0.99786	0.00108	0.2
45	e196u6n	0.9936	0.0015	0.99951	0.00144	0.6
46	epru615b	1.0004	0.0013		Not run	
47	epru75	0.9966	0.0010	0.99700	0.00096	0.0
48	epru75b	0.9986	0.0008	1.00047	0.00086	0.2
49	e196u87c	0.9998	0.0013	0.99837	0.00130	-0.1
50	epru87b	1.0000	0.0012	0.99945	0.00123	-0.1
51	saxu56	0.9932	0.0017	0.99632	0.00155	0.3
52	saxu792	0.9995	0.0011	0.99667	0.00111	-0.3
53	w3269a	1.0063	0.0010		Not run	
54	w3269b	0.9983	0.0014	1.00308	0.00138	0.5
55	w3269c	0.9939	0.0010	0.99540	0.00100	0.2
56	ans33bp2	0.9987	0.0012	0.99822	0.00112	0.0
57	ans33bb2	1.0096	0.0011	1.00943	0.00114	0.0
58	ans33bh2	1.0129	0.0012	1.01140	0.00112	-0.1
59	ans33h2	0.9983	0.0011	0.99703	0.00116	-0.1
93	p6838	0.9057	0.0016	0.90233	0.00165	-0.4

3.2.1 CSAS25 Validation Test Results

Inspection of the tables of CSAS25 Validation Test cases shows that the largest difference between results obtained at Oak Ridge and with the WPDD computer is 0.9 percent, and the average difference is 0.02 percent. These results indicate very good agreement between the results obtained by Oak Ridge and by the WPDD. Therefore, the CSAS25 sequence produces correct and valid results for k-effective calculations.

4.0 RECOMMENDATIONS

The installations of SCALE 4.3 sequences for SAS2H and CSAS25 on the WPDD HP 9000/700 and HP 9000/C160 series machines were reviewed and found to have been accomplished according to the instructions provided by the supplier. Validation test cases were performed on each computer platform for the SAS2H and CSAS25 sequences based upon published validation reports. With these verification and validation tests, and the acceptance of these code systems by the NRC, it is recommended that the SAS2H sequence and the CSAS25 sequence be approved for use in work that is subject to QARD requirements, for PWR and BWR fuel types.

Other SCALE 4.3 sequences and/or computer platforms which are required at a future date may be verified and validated as necessary.

5.0 ATTACHMENTS

Attachment I: SCALE 4.2 Software Acquisition Correspondence

Attachment I: Software Acquisition Correspondence

This attachment contains a copy of the CRWMS/M&O purchase requisition requesting the SCALE 4.3 package from RSIC and a copy of the RSIC letter that accompanied the package.

c545.rme
May 24, 1996

SCALE users should retrieve the AMPX master 44-group library via binary ftp from infosrv1.ctd.ornl.gov in directory pub/rsic/scale. Details of the changes are available in the RSIC May 1996 Newsletter. These data are distributed in BINARY mode and replace the erroneous file in the original release of SCALE4.3.

PC users must get "scale.rev04.xn44.dos" and copy it in the subdirectory with the other AMPX master libraries under the scale43 directory to datalib/ft83f001. This will overwrite the 44-group library in the original release. No other changes are required to use the new file.

Unix users must get the library and copy it in the subdirectory with the other AMPX master libraries under the Scale4.3 directory to data/scale.rev04.xn44 then edit the "scale43" file in the "cmds" directory to link this new file to ft83f001. Users of Big Endian machines (IBM, SUN, HP, and SGI) must get the file named "scale.rev04.xn44.unix.big.endian". Users of Little Endian (DEC) users must get file "scale.rev04.xn44.unix.little.endian".