Decay Heat (DCH) Package
Users' Guide

The MELCOR decay heat package models the decay heat power resulting from the radioactive decay of fission products. Decay heat is evaluated for reactor core material and for suspended or deposited aerosols and gases. MELCOR couples thermal-hydraulic processes and fission product behavior during the calculation.

Both the radionuclides present in the reactor at the time of the accident and the radionuclide daughter products contribute to the decay heat. In the calculation of decay heat, MELCOR does not explicitly treat each decay chain, since detailed tracking of radionuclide decay chains would be too costly. When the radionuclide package is active, the decay heat is calculated for each radionuclide class by using pre-calculated tables from ORIGEN program runs. If the radionuclide package is not active, the whole-core decay heat is computed from one of several possible user-specified calculations.

This Users' Guide describes the input to the DCH package, including a brief description of the models employed, the input format, sample input, discussion of the output, sensitivity coefficients, plot variables, and control variables. Details on the models can be found in the DCH Package Reference Manual.

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1. Introduction

The MELCOR Decay Heat (DCH) package models the heating from the radioactive decay of fission products. Decay heat power is evaluated for the fission products assumed to reside in reactor core materials, cavity materials, and in suspended or deposited aerosols and vapors. Decay heat power levels as a function of time are supplied as a utility function within MELCOR that may be called by other phenomenological packages. The DCH package is not involved in the calculation of fission product transport or chemical interactions. These processes are calculated by the RadioNuclide (RN) package (see the RN Package Reference Manual).

Both the radionuclides present in the reactor core and/or cavity from the time of reactor shutdown and the radionuclide daughters from decay contribute to the total decay heat power. In the calculation of decay heat power, the DCH package does not explicitly treat decay chains. Detailed tracking of radionuclide decay chains was seen as computationally costly and too detailed for MELCOR. Instead, when the RN package is active, elemental decay heat power information based on ORIGEN calculations is summed into the RN class structure, as described in the DCH Package Reference Manual.

There are also several options for calculating decay heat power when the RN package is not active (that is, when tracking of fission products is not desired). These are called *whole-core calculations* in the DCH package, although they may be applied to cavity inventories of melt debris as well.

2. User Input

2.1 MELGEN Input

2.1.1 General Input

These input records describe data used by both the whole-core and class decay heat calculations.

DCHREACTOR – Reactor type
Optional

This record enables the user to specify the type of reactor. This will affect the default power levels and, for the radionuclide class calculation, the radionuclide mass inventories. The valid options and the default are core-model specific; values given here are for the LWR COR package. Users of an alternate core package

should consult the documentation for that package. Note that the default type of 'PWR' is inconsistent with the default reactor type in the Core package on record COR00002; one or the other should be changed by the user.

(1) REACTP - Character string selecting reactor type:
(1) 'PWR', use PWR mass inventories for radionuclide class calculation and set default power to 3412 MW.
(2) 'BWR', use BWR mass inventories for radionuclide class calculation and set default power to 3578 MW.
(type = character * 3, default = 'PWR')

DCHSHUT – Reactor Shutdown Time
Optional

This record defines the problem time at which reactor shutdown occurs for purposes of decay heat computation.

(1) ISHTCF - Reactor shutdown trip control function number. If less than or equal to zero no reactor trip function is used. If positive, then a logical valued control function ISHTCF is used to determine the reactor shutdown time. During computation the reactor shutdown time is set to the current problem time whenever the control function value changes from .FALSE. to .TRUE.
(type = integer, default = 0, units = none)

(2) TMSHUT - Reactor shutdown time. If DCHSHUT record is input and ISHTCF field does not contain a positive integer then the TMSHUT field is required.
(type = real, default = 0.0, units = s)

2.1.2 Whole-Core Input

These input records describe data used by the whole-core decay heat calculations.

DCHDECPOW – Decay Power of Nuclides
Optional

This record enables the user to specify the calculation to be used for the whole-core decay heat calculation.

(1) WCTYPE - Character string of four possible forms:
(1) 'ORIGEN', use summation of default ORIGEN radionuclide decay heats
(2) 'ANS', use ANS standard calculation

(3) 'CF-nnn', use control function nnn for decay heat (W)
(4) 'TF-nnn', use tabular function nnn as table of whole-core decay heat (W) as function of time since shutdown in seconds
(type = character * 6, default = 'ORIGEN')

DCHFPOW – Fission Power of Nuclides
Optional

This record defines the total thermal operating power due to the nuclides U-235, Pu-239, and U-238 (from both fission and decay heat). These data are used only if WCTYPE on card DCHDECPOW is 'ORIGEN' or 'ANS.' The defaults are core-model specific; values given here are for the LWR COR package. These defaults are taken from a SANDIA-ORIGEN run giving the powers averaged over an equilibrium fuel cycle. The defaults for total power are 3412 MW (PWR) and 3578 MW (BWR). Users of an alternate core package should consult the documentation for that package.

(1) U235P - Power due to thermal fission of U-235.
(type = real, default = 2.2086E9 (PWR), 2.316E9 (BWR), units = W)

(2) PU239P - Power due to thermal fission of Pu-239.
(type = real, default = 1.0598E9 (PWR), 1.1114E9 (BWR), units = W)

(3) U238P - Power due to fast fission of U-238.
(type = real, default = 1.436E8 (PWR), 1.506E8 (BWR), units = W)

DCHOPRTIME – Reactor Operating Time
Optional

This record defines the irradiation time, the length of time the reactor fuel has been undergoing fission. A constant fission rate is assumed during this time. The default value is 0.8 x 2 years, or 584 days, chosen to match the ORIGEN run with an average in-core time of 2 years for the fuel at the end of the equilibrium cycle with an 80% capacity factor. These data are used only if WCTYPE on card DCHDECPOW is 'ANS.'

OPRTIM - Reactor operating time.
(type = real, default = 5.05E7, units = s)

DCHNCPSI – Number of fissions per Initial Fissile Atom
Optional

This factor is used as in the calculation of the neutron capture correction factor *G(t)* (see Section 3.2 of the DCH Package Reference Manual). The default is computed from SANDIA-ORIGEN data for a representative fissile material inventory. These data are used only if WCTYPE on card DCHDECPOW is 'ANS.'

(1) PSINC - Number of Fissions per initial fissile atom.
(type = real, default = 0.713, units = fissions/atom)

2.1.3 Radionuclide Class Input

These input records describe data used for the radionuclide class decay heat calculations. The grouping of elements into RN classes is described in detail in Section 2.2 of the DCH Package Reference Manual. The valid names for default elements input on records DCHNEMnn00 and DCHCLSnnnm are listed below. Only those listed without parentheses in Table 2.1 of the DCH Package Reference Manual have decay heat tables in MELCOR.

```
'H',  'HE', 'LI', 'BE', 'B',  'C',  'N',  'O',  'F',  'NE',
'NA', 'MG', 'AL', 'SI', 'P',  'S',  'CL', 'AR', 'K',  'CA',
'SC', 'TI', 'V',  'CR', 'MN', 'FE', 'CO', 'NI', 'CU', 'ZN',
'GA', 'GE', 'AS', 'SE', 'BR', 'KR', 'RB', 'SR', 'Y',  'ZR',
'NB', 'MO', 'TC', 'RU', 'RH', 'PD', 'AG', 'CD', 'IN', 'SN',
'SB', 'TE', 'I',  'XE', 'CS', 'BA', 'LA', 'CE', 'PR', 'ND',
'PM', 'SM', 'EU', 'GD', 'TB', 'DY', 'HO', 'ER', 'TM', 'YB',
'LU', 'HF', 'TA', 'W',  'RE', 'OS', 'IR', 'PT', 'AU', 'HG',
'TL', 'PB', 'BI', 'PO', 'AT', 'RN', 'FR', 'RA', 'AC', 'TH',
'PA', 'U',  'NP', 'PU', 'AM', 'CM', 'BK', 'CF', 'ES', 'FM',
'WT'(water)       'CC'(concrete)
```

DCHNEMnn00 – Element Name
$0 \leq nn \leq 99$, nn is the user-defined element number
Optional

This record, in conjunction with the DCHNEMnnmm records, allows the user to define a new element or to redefine a default element for purposes of decay heat calculation. If the user inputs a default element, the user-defined element decay

heat data are used instead of the default data. If the same element is input more than once, the first definition is used and a warning message is printed.

(1) ELMNAM - User-input element name. May be a default element or a new name.
(type = character * 2)

(2) ELMMAS - Mass inventory of element ELMNAM in reactor at shutdown.
(type = real, default = none, units = kg)

DCHNEMnnmm – Time, Decay Heat Data
$0 \leq nn \leq 99$, nn is the user-defined element number
$1 \leq mm \leq 99$, mm is used for ordering the input
Optional

These records define the pairs of decay heat data for element ELMNAM. The first field in a pair is the time after shutdown, and the second field is the decay heat power per unit mass at that time. There may be an arbitrary number of pairs on a record, but a pair may not be split across a record. The decay heat times do not have to be in ascending order.

(1) TIME - Time after shutdown.
(type = real, default = none, units = s)

(2) DCHEAT - Decay heat power per unit mass for this element at time TIME.
(type = real, default = none, units = W/kg)

DCHCLSnnn0 – Radionuclide Class Name
$0 \leq nnn \leq 999$, nnn is the class ID number
Optional

This record, in conjunction with the DCHCLSnnnm records, allows the user to define a new class or to redefine a default class for purposes of decay heat calculation. If the user inputs a default class ID number (1 through 15), the user-defined class is used instead of the default class listed in Table 2.1 of the DCH Package Reference Manual.

(1) RDCNAM - User-input class name
(type = character * 32)

DCHCLSnnnm – Elements in class

$0 \leq nnn \leq 999$, nnn is the class ID number
$1 \leq mm \leq 9$, m is used for ordering the input
Optional

These records define the elements in the class with ID nnn and name RDCNAM. The element names may be user-defined elements or default elements. There may be an arbitrary number of elements on a record.

(1) CLSELM - Name of element in class.
(type = character * 2)

DCHDEFCLSm – Default Classes

$0 \leq m \leq 9$, m is used for ordering the input
Optional (if not input, no default radionuclide classes are defined)

This record selects the default classes to be used in the radionuclide calculation. The default classes, numbered 1 through 15, are given in Table 2.1 of the DCH Package Reference Manual. A default class with a given ID may be input only once.

(1) DEFCLS - This field can be of two types:

integer - default class ID number. Numbers must be in the range from 1 through 15, and can be in any order. This field may be repeated on a record as often as necessary.
(default = none, units = none)

character - 'ALL' indicates that all default classes listed in Table 2.1 of the DCH Package Reference Manual are to be used in the calculation.
(type = character *3)

DCHCLSNORM – Class Decay Heat Normalization Flag

Optional

This record allows the user to have the radionuclide class decay heat power normalized to the whole-core decay heat power. If the normalization flag is set to 'YES', the calculated decay heat for each class (whether default or user-defined) will be multiplied by the ratio of the sum of all the class decay heats and the whole-core decay heat. Thus, the sum of all the class decay powers will be equal to the whole-core decay power.

If the whole-core power is 'ORIGEN', the sum of class powers including the effects of sensitivity coefficients 3210 and 3211 will be renormalized to the sum of class powers before these sensitivity coefficients are considered.

(1) CLSNRM - Class Normalization Flag
'YES' - Normalize class decay heats to whole-core decay heat
'NO' - No normalization
(type = character* 3, default = 'YES')

2.2 MELCOR Input

There is at present no MELCOR input to the decay heat package.

3. Sensitivity Coefficients

The *sensitivity coefficient* feature in MELCOR is a powerful feature that gives the user the ability to change selected parameters in the physics models that would otherwise require modification of the Fortran source code. Their use is described in Section 7 of the MELCOR EXEC Users' Guide.

3.1 DCH Sensitivity Coefficients

The sensitivity coefficients for the DCH package have identifier numbers from 3200 through 3299.

3200 – Multiplier for ANS decay heat curve

This sensitivity coefficient is the multiplier M_{user} given in the ANS decay heat equation (see Section 3.2 of the DCH Package Reference Manual).

(1) - Multiplier for ANS decay heat curve.
(default = 1.0, units = none, equiv = ANSMUL)

3201 – Energy per Fission for Nuclides

These sensitivity coefficients are the Q factors in the ANS decay heat equation (see Section 3.2 of the DCH Package Reference Manual). The defaults are computed from SANDIA-ORIGEN data giving the fissioning rates for each nuclide. The energies include both fission and decay energies.

(1) - Energy per thermal fission of U-235
(default = 199.0 units = MeV/fission, equiv = FEU235)

(2) - Energy per thermal fission of Pu-239
(default = 210.2, units = MeV/fission, equiv = FEP239)

(3) - Energy per fast fission of U-238
(default = 199.3, units = MeV/fission, equiv = FEU238)

3202 – Times for ANS decay heat power tables

These sensitivity coefficients provide the times at which the ANS decay heat powers for the nuclides and the neutron capture correction factors are available. The defaults, taken from the 56 tabulated times in the ANS standard (see Section 3.2 of the DCH Package Reference Manual), run from 0.0 s to 10^9 s.

(1–56)
- Times after shutdown for decay heat tables (sensitivity coefficient 3203) and neutron capture factors (sensitivity coefficient 3204).
(default = tabulated times from ANS standard, units = s, equiv = TIMDCH(1:56))

3203 – Decay heat powers for ANS decay heat curve

These sensitivity coefficients are the factors $F(t,\infty)$ needed to compute *F(t,T)* used in the ANS decay heat equation (see Section 3.2 of the DCH Package Reference Manual). The calculation is $F(t,T) = F(t,\infty) - F(t+T,\infty)$.

(1–56,
1–3) - Decay heat powers DCHPOW (I, J), corresponding to times TIMDCH(I) in sensitivity coefficient 3202, resulting from decay of products fissioning of nuclide J, where J indicates nuclide:
J = 1, U-235
J = 2, Pu-239
J = 3, U-238
(default = values from Tables 4, 5, and 6 of the ANS standard, units = MeV/fission, equiv = DCHPOW (1:56,1:3))

3204 – Neutron capture correction factors for ANS decay heat curve

These sensitivity coefficients are the factors $G_{max}(t)$ that are used for *G(t)* for shutdown times greater than 10^4 seconds. *G(t)* is used in the ANS decay heat equation (see Section 3.2 of the DCH Package Reference Manual).

(1–56)
- Neutron capture correction factors CAPNEU(I), corresponding to times TIMDCH(I) in sensitivity coefficient 3202.

(default = values from Table 10 of the ANS standard, units = none, equiv = CAPNEU (1:56))

3205 – Parameters for actinide decay heat calculation

These sensitivity coefficients are the parameters in the ANS decay heat equation for the decay power from U-239 and Np-239 (see Section 3.2 of the DCH Package Reference Manual). The default for the first parameter is computed so that Equation 16 of the ANS standard matches the ORIGEN results for decay power from U-239 and Np-239. The other defaults are taken from the discussion of the equation on page 5 of the ANS standard.

(1) - Number of atoms of U-239 produced per second per fission per second at time of shutdown.
(default = 0.526, units = 1/fission, equiv = R)

(2) - Average energy from decay of U-239 atom.
(default = 0.474, units = MeV, equiv = E239U)

(3) - Average energy from decay of Np-239 atom.
(default = 0.419, units = MeV, equiv = E239NP)

(4) - Decay constant for U-239.
(default = 4.91E-4, units = s^{-1}, equiv = DCU)

(5) - Decay constant for Np-239.
(default = 3.41E-6, units = s^{-1}, equiv = DCNP)

3210 – Multiplier for all ORIGEN elemental decay heat curves

This sensitivity coefficient is a multiplier that will be applied to all elemental decay heat power curves stored as default data in MELCOR.

(1) - Multiplier for ORIGEN elemental decay heat power.
(default = 1.0, units = none, equiv = ORGMUL)

3211 – Multipliers for individual ORIGEN elemental decay heat curves

These sensitivity coefficients are multipliers for individual elemental decay heat power curves stored as default data in MELCOR. These multipliers will be applied in addition to the general multiplier ORGMUL. The list of relevant elements is core-model specific; the list given here is for the LWR COR package. Users of an alternate core package should consult the documentation for that package.

(1-29)

- Multiplier for individual elemental decay power. The indices for each element are:

1.	AS	2.	SE	3.	BR	4.	KR	5.	RB	6.	SR	7.	Y
8.	ZR	9.	NB	10.	MO	11.	TC	12.	RU	13.	RH	14.	PD
15.	AG	16.	SN	17.	SB	18.	TE	19.	I	20.	XE	21.	CS
22.	BA	23.	LA	24.	CE	25.	PR	26.	ND	27.	PM	28.	U
29.	NP												

(default = 1.0, units = none, equiv = ELMMUL(1:29))

3212 – Fraction of fuel equilibrium cycle elapsed

This sensitivity coefficient, which must have a value between 0.0 and 1.0, is used in determining the fission product mass inventory. 0.0 corresponds to the beginning of the fuel cycle (1/3 fresh fuel, 1/3 with one year in core, 1/3 with two years in core). 1.0 corresponds to the end of the fuel cycle (1/3 of fuel with one year in core, 1/3 with two years in core, 1/3 with three years in core). These data are used only if WCTYPE on card DCHDECPOW is 'ORIGEN.'

(1) - Fraction of fuel equilibrium cycle that has elapsed at beginning of problem (default = 1.0, units = none, equiv = TFLCYC)

4. Plot Variables and Control Function Arguments

The decay heat package's variables that may be used for plot variables and control function arguments are described below. The control function arguments are denoted by a 'c.' The plot variable arguments are denoted by 'p.' The 'c' or 'p' characters are inside slashes '/' following the variable name.

DCH-COREPOW.0	/cp/	Whole-core decay heat power. (units = W)
DCH-CLSPOW.n	/cp/	Decay heat power per unit mass for radionuclide class n. (units = W/kg)
DCH-TOTCLSPOW.0	/cp/	Total decay heat power for all radionuclide classes. (units = W)

5. Example Input

The following example input to MELCOR will input the default decay heat data set in MELCOR. The input will be in three sections; general, whole-core, and radionuclide class.

5.1 General Input

```
*
*          REQUEST PWR DEFAULT REACTOR POWER AND
*               RADIONUCLIDE INVENTORIES
*
DCHREACTOR PWR
*
*     SET REACTOR SHUTDOWN TIME TO DEFAULT - 0.0 S, NO SHUTDOWN FUNCTION.

*
DCHSHUT    0     0.0
*
```

5.2 Whole-Core Input

```
*     SELECT ANS DECAY CURVE FOR WHOLE-CORE DECAY HEAT
*
DCHDECPOW  ANS
*
*     SET REACTOR OPERATING TIME TO DEFAULT - 0.8 * 2 YEARS
*
DCHOPRTIME 5.05E7
*
*     SET TOTAL REACTOR FISSION POWER DUE TO:
*          U-235      2208.6 MW  (DEFAULT FOR PWR)
*          PU-239     1059.8 MW  (DEFAULT FOR PWR)
*          U-238      143.6 MW   (DEFAULT FOR PWR)
*
DCHFPOW    2.2086E9   1.0598E9   1.436E8
*
*
*     SET PSI IN NEUTRON CAPTURE CORRECTION EQUATION TO DEFAULT
*
DCHNCPSI   0.713
*
*
*     ANS DECAY HEAT SENSITIVITY COEFFICIENTS
*
*          SET ANS MULTIPLIER TO DEFAULT
SC00001    3200  1.00       1
*     SET ENERGY PER FISSION FOR U-235      DEFAULT - 199 MEV/FISSION
SC00002    3201  199.0      1
```

```
*     SET ENERGY PER FISSION FOR PU-239     DEFAULT - 210.2 MEV/FISSION
SC00003    3201  210.2      2
*     SET ENERGY PER FISSION FOR U-238      DEFAULT - 199.3 MEV/FISSION
SC0004     3201  199.3      3
*     SET TIME AT WHICH DECAY HEAT POWER AND NEUTRON
*     CAPTURE CORRECTION FACTOR GIVEN - FIRST POINT ONLY
*     TIME = 0.0 S AFTER SHUTDOWN
SC0005     3202  0.0        1
*     SET DECAY HEAT POWER FOR U-235 AT FIRST TIME POINT -
*     DEFAULT = 13.18 MEV/FISSION
SC0006     3203  13.18      1 1
*     SET DECAY HEAT POWER FOR PU-239 AT FIRST TIME POINT -
*     DEFAULT = 10.93  MEV/FISSION
SC0007     3203  10.93      1 2
*     SET DECAY HEAT POWER FOR U-238 AT FIRST TIME POINT -
*     DEFAULT = 16.23 MEV/FISSION
SC0008     3203  16.23      1 3
*     SET NEUTRON CAPTURE CORRECTION FACTOR GMAX AT FIRST TIME POINT
*     DEFAULT = 1.02
SC0009     3204  1.02       1
*
*     SET PARAMETERS FOR ACTINIDE DECAY HEATS
*
* ATOMS OF U-239 PRODUCED PER SECOND PER FISSION PER SECOND, DEFAULT
SC00010    3205  0.54       1
*     ENERGY FROM DECAY OF U-239 ATOM - MEV
SC00011    3205  0.474      2
*     ENERGY FROM DECAY OF NP-239 ATOM - MEV
SC00012    3205  0.419      3
*     DECAY CONSTANT FOR U-239 - INVERSE SECONDS
SC00013    3205  4.91E-4    4
*     DECAY CONSTANT FOR NP-239 - INVERSE SECONDS
SC00014    3205  3.41E-6    5
*
```

5.3 Radionuclide Class Input

```
*          DEFINE NEW ELEMENTS
*             NEW ELEMENT XX
*
*          NAME  MASS (KG)
DCHNEM0100 XX    0.100
*          TIME (S)   DECAY HEAT (W/KG)
DCHNEM0101 0.0        10.0
DCHNEM0102 5.0        0.01
*
*               NEW ELMENT YY
*
DCHNEM0200      YY         9.900
DCHNEM0201      0.0        0.1
DCHNEM0202      10.0       0.01
```

```
DCHNEM0203      100.0      0.001
*
*    ********** DEFINE CLASSES **********
*
*          DEFINE CLASS 16 - NEW ELEMENT XX
*
DCHCLS0160 'FIRST NEW CLASS'
DCHCLS0161 XX
*
*          DEFINE CLASS 17 - NEW ELEMENTS YY AND XX
*
DCHCLS0170 'SECOND NEW CLASS'
DCHCLS0171 YY   XX
*
*          DEFINE CLASS 18 - NEW ELEMENT YY + DEFAULT ELEMENT PM
*
DCHCLS0180 'THIRD NEW CLASS'
DCHCLS0181 YY   PM
*
*    SELECT ALL DEFAULT CLASSES
*
DCHDEFCLS0 ALL
*
*    SET ORIGEN SENSITIVITY COEFFICIENTS
*
*    SET MULTIPLIER FOR ALL ORIGEN DATA TO 1.0
SC00015    3210  1.0   1
*          SET MULTIPLIER FOR BROMINE TO 1.0
SC00016    3211  1.0   3
*
* SET FRACTION OF FUEL EQUILIBRIUM ELAPSED - DEFAULT = END OF CYCLE
*
SC00017 3212    1.0   1
*    TO NORMALIZE CLASS DECAY HEATS TO WHOLE-CORE DECAY HEAT,
*          INPUT NEXT CARD
*DCHCLSNORM     YES
```

Note that the fact that XX, YY, and PM each appear in two classes (PM is also in default class 9) does not mean that their decay heat will be double counted. Any mass that appears in any of the classes as a result of initialization or calculations in the RN package will have the specific power (W/kg) of a mixture of the elements it contains in proportion to their inventories at shutdown. Thus, any mass in class 16 will have the specific power of element XX, while mass in class 17 will have a specific power corresponding to a mixture of 0.1/(0.1+9.9) parts by mass of XX and 9.9/(0.1+9.9) parts of YY. Finally, any mass in class 18 will be treated as a mixture of YY and PM, in the proportions of 9.9 kg of YY to 9.8948 kg (the initial inventory) of PM. If the RN package calculates these masses in a way that conserves XX, YY, and PM, no double counting will occur.

6. Example Output

6.1 MELGEN Output

```
***** DECAY HEAT SETUP EDIT *****

For a PWR reactor with an operating power of 0.34120 x 10^10 watts, and
with an elapsed fraction of the equilibrium fuel cycle of 1.0, the
following default elements are defined for use in forming radionuclide
classes.

ELEMENT  MASS (KG)        DECAY HEAT AT SHUTDOWN (W/KG)
AS       0.78476D-02      0.14783D+9
SE       0.37532D+01      0.61818D+06
BR       0.14330D+01      0.47619D+07
KR       0.24908D+02      0.32877D+06
RB       0.23543D+02      0.63768D+06
SR       0.64828D+02      0.17895D+06
Y        0.32755D+02      0.55208D+06
ZR       0.22860D+03      0.34328D+05
NB       0.34120D+01      0.50000D+07
MO       0.19448D+03      0.33333D+05
TC       0.51180D+02      0.15333D+06
RU       0.12966D+03      0.13947D+05
RH       0.23543D+02      0.89855D+05
PD       0.58004D+02      0.22353D+04
AG       0.30026D+01      0.67045D+05
SN       0.26614D+01      0.56410D+06
SB       0.98948D+00      0.62069D+07
TE       0.26272D+02      0.27273D+06
I        0.13307D+02      0.12051D+07
XE       0.31732D+03      0.25806D+05
CS       0.16719D+03      0.89796D+05
BA       0.85300D+02      0.10400D+06
LA       0.75064D+02      0.20000D+06
CE       0.18084D+03      0.18868D+05
PR       0.68240D+02      0.70000D+05
ND       0.22178D+03      0.26154D+04
PM       0.98948D+01      0.41379D+05
U        0.85300D+05      0.48000D+02
NP       0.30026D+02      0.82955D+05

TIME-DECAY HEAT POWER DATA FOR USER-DEFINED ELEMENT XX WITH MASS = 0.1
KG

TIME (S)      DECAY HEAT POWER (W/KG)
0.00000D+00   0.10000D+02
0.50000D+01   0.10000D-01
```

```
TIME-DECAY HEAT POWER DATA FOR USER-DEFINED ELEMENT YY WITH MASS =
0.990D+01 KG
TIME (S)     DECAY HEAT POWER (W/KG)
0.00000D+00  0.10000D+00
0.10000D+02  0.10000D-01
0.10000D+03  0.10000D-02

TOTAL NUMBER OF DECAY HEAT F.P. CLASSES     =     18
TOTAL NUMBER OF DECAY HEAT ELEMENTS   =     107
TOTAL NUMBER OF DECAY HEAT CLASS TIMES=     456

EDIT OF ANS DECAY HEAT DATA
TYPE OF REACTOR = PWR
REACTOR OPERATING PERIOD = 0.50500D+08 SECONDS
REACTOR SHUTDOWN TIME = 0.00000D+00 SECONDS
NUMBER OF FISSIONING NUCLIDES = 3
NUMBER OF TIMES AT WHICH ANS DATA AVAILABLE = 56
OPERATING POWER FROM FISSIONING OF U235 = 0.22086D+10 WATTS
OPERATING POWER FROM FISSIONING OF PU239 = 0.10598D+10 WATTS
OPERATING POWER FROM FISSIONING OF U238 = 0.14360D+09 WATTS
TOTAL OPERATING POWER = 0.34120D+10 WATTS

TOTAL REACTOR DECAY HEAT POWER COMPUTED FROM ANS STANDARD
```

(The "TOTAL NUMBER OF DECAY HEAT ELEMENTS" counts each appearance of an element. Thus, there are two appearances of XX, two of YY, and an additional appearance of PM in addition to the default list of 102 elements, for a total of 107. The "POINTER TO FIRST ELEMENT IN CLASS" in the class edits on the following pages is the position of the first element in that class in a packed list of elements.)

```
** EDIT OF 18 FISSION PRODUCT CLASSES **

* 3 USER-DEFINED CLASSES *

EDIT OF DECAY HEAT FISSION PRODUCT CLASS - FIRST NEW CLASS
CLASS NUMBER = 16
CLASS MASS = 0.10000D+00 KG
NUMBER OF ELEMENTS IN CLASS = 1
POINTER TO FIRST ELEMENT IN CLASS = 1
ELEMENTS IN CLASS =
XX

TIME (S)     DECAY HEAT POWER (W/KG)

0.0000D+00   0.10000D+02
0.5000D+01   0.10000D-01

EDIT OF DECAY HEAT FISSION PRODUCT CLASS - SECOND NEW CLASS
CLASS NUMBER = 17
CLASS MASS = 0.10000D+02 KG
NUMBER OF ELEMENTS IN CLASS = 2
```

```
POINTER TO FIRST ELEMENT IN CLASS = 2
ELEMENTS IN CLASS =
YY
XX

TIME (S)      DECAY HEAT POWER (W/KG)

0.00000D+00  0.19900D+00
0.50000D+01  0.31407D-01
0.10000D+02  0.99001D-02
0.10000D+03  0.99000D-03

EDIT OF DECAY HEAT FISSION PRODUCT CLASS - THIRD NEW CLASS
CLASS MEMBER = 18
CLASS MASS = 0.19795D+02 KG
NUMBER OF ELEMENTS IN CLASS = 2
POINTER TO FIRST ELEMENT IN CLASS = 4
ELEMENTS IN CLASS =
YY
PM

TIME (S)      DECAY HEAT POWER (W/KG)

0.00000D+00  0.20684D+05
0.61200D+01  0.20684D+05
0.10000D+02  0.19507D+05
0.11880D+02  0.18961D+05
0.18000D+02  0.18961D+05
0.29880D+02  0.18961D+05
0.61200D+02  0.16720D+05
0.10000D+03  0.15297D+05
0.11880D+03  0.14651D+05
0.24120D+03  0.12583D+05
0.61200D+03  0.91355D+04
0.11880D+04  0.75842D+04
0.36000D+04  0.70671D+04
0.54000D+04  0.70671D+04
0.72000D+04  0.70671D+04
0.14400D+05  0.65500D+04
0.21600D+05  0.65500D+04
0.28800D+05  0.60329D+04
0.36000D+05  0.60329D+04
0.43200D+05  0.55158D+04
0.54000D+05  0.55158D+04
0.72000D+05  0.49987D+04
0.86400D+05  0.46539D+04
0.12960D+06  0.37921D+04
0.17280D+06  0.31026D+04
0.25920D+06  0.22408D+04
0.34560D+06  0.15686D+04
0.51840D+06  0.86184D+03
0.69120D+06  0.49987D+03
```

```
0.86400D+06  0.34474D+03
* 15 DEFAULT CLASSES *

EDIT OF DECAY HEAT FISSION PRODUCT CLASS - NOBLE GASES
CLASS NUMBER =  1
CLASS MASS = 0.34222d+03 KG
NUMBER OF ELEMENTS IN CLASS =  8
POINTER TO FIRST ELEMENT IN CLASS = 6
ELEMENTS IN CLASS =
XE
KR
RN
HE
NE
AR
H
N

TIME (S)     DECAY HEAT POWER (W/KG)

0.00000D+00  0.47856D+05
0.61200D+01  0.39880D+05
0.11880D+02  0.35892D+05
0.18000D+02  0.33898D+05
0.29880D+02  0.31904D+05
0.61200D+02  0.27916D+05
0.11880D+03  0.22931D+05
0.24120D+03  0.19043D+05
0.61200D+03  0.14855D+05
0.11880D+04  0.12861D+05
0.36000D+04  0.98704D+04
0.54000D+04  0.81755D+04
0.72000D+04  0.67797D+04
0.14400D+05  0.40977D+04
0.21600D+05  0.26122D+04
0.28800D+05  0.18544D+04
0.36000D+05  0.13958D+04
0.43200D+05  0.11067D+04
0.54000D+05  0.87737D+03
0.72000D+05  0.68495D+03
0.86400D+05  0.61615D+03
0.12960D+06  0.53340D+03
0.17280D+06  0.47178D+03
0.25920D+06  0.41167D+03
0.34560D+06  0.35184D+03
0.51840D+06  0.28205D+03
0.69120D+06  0.21226D+03
0.86400D+06  0.16241D+03
```

(Similar tables for the remaining default classes – 2 through 15 – follow.)

6.2 MELCOR Output

```
Edit for Decay Heat Package

POWER FROM FISSION PRODUCT CLASSES

CLASS                                          POWER/MASS   POWER
NUMBER     CLASS NAME                          W/KG         W

16         FIRST NEW CLASS                     0.10000D+02  0.10000D+01
17         SECOND NEW CLASS                    0.19900D+00  0.19900D+01
18         THIRD NEW CLASS                     0.20684D+05  0.40944D+06
1          NOBLE GASES                         0.47856D+05  0.16378D+08
2          ALKALI METALS                       0.15742D+06  0.30026D+08
3          ALKALINE EARTHS                     0.13636D+06  0.20472D+08
4          HALOGENS                            0.15509D+07  0.22860D+08
5          CHALCOGENS                          0.31591D+06  0.94854D+07
6          PLATINOIDS                          0.19192D+05  0.40535D+07
7          TRANSITION METALS                   0.12603D+06  0.31390D+08
8          TETRAVALENTS                        0.31289D+05  0.13750D+08
9          TRIVALENTS                          0.95314D+05  0.38863D+08
10         URANIUM                             0.48000D+02  0.40944D+07
11         MORE VOLATILE MAIN GRP ELEMENTS     0.73212D+07  0.73017D+07
12         LESS VOLATILE MAIN GRP ELEMENTS     0.30060D+06  0.17026D+07
13         BORON                               0.00000D+00  0.00000D+00
14         WATER                               0.00000D+00  0.00000D+00
15         CONCRETE                            0.00000D+00  0.00000D+00

TOTAL POWER FROM FISSION PRODUCT CLASSES = 0.20079D+09 WATTS
WHOLE REACTOR CORE DECAY HEAT POWER COMPUTED FROM ANS STANDARD WHOLE
REACTOR
CORE DECAY HEAT POWER AT TIME = 0.00000D+00 IS 0.21981D+09 WATTS
```

7. Diagnostics and Error Messages

An error message is printed if the decay heat package is asked to compute the decay heat for an invalid class ID number. The class number and calling package name are printed.

If the problem time is off the range of the decay heat tables, an error message is printed.