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FPFP_2: A Code for Following Airborne Fission Products in Generic Nuclear Plant Flow Paths

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ABSTRACT

This report describes the technical bases and use of the computer code FPFP_2 (Fission Product Flow Paths). FPFP_2 was developed to estimate the concentrations and flow rates of airborne fission products along a generic flow path following a transient or puff source of fission products at the beginning of the flow path. This report serves as a user's guide for FPFP_2. A complete code description, code operating instructions, code listing, and an example of the use of FPFP_2 support the use of the code.

SUMMARY

The software package FPFP_2 enables the user to follow fission product noble gases, molecular iodine, and particles along a flow path from a source to an end point. The user constructs the flow path consisting of a series arrangement of rooms, ducts, filters, or flow resistances. Parallel flow paths can be analyzed by studying each series element independently and superimposing the individual results. The user must supply flow path flow rates and fission product concentrations at the source as functions of time during the transient event and, as an option, supply the initial source term as a puff release in the farthest upstream room. FPFP_2 calculates the fission product concentrations and flow rates between or within the flow path components. These concentrations reflect dilution and transient time, deposition processes (iodine and particles), spray washout (particles), and filtration (iodine and particles) that fission products experience along the flow path.

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1.0 INTRODUCTION

In order to assure that a nuclear power plant control room remains habitable during certain types of postulated accidents, Pacific Northwest Laboratory (PNL) has undertaken a special study for the U.S. Nuclear Regulatory Commission. This purpose of this study is to develop software that can aid in the analyses of control room habitability during accidents in which airborne fission products could challenge internal air pathways to the control room. PNL has completed an initial version (FPFP) and final version (FPFP_2) of a software package that can estimate the unsteady-state invasion of quantities of fission products into the control room or any other destination within the nuclear plant via generic internal flow paths.

This report consists of three parts: Section 2.0, Technical Bases, describes the flow path components and mechanisms of natural fission product deposition; Section 3.0, FPFP_2 Code Description, describes code organization and the functions of the subroutines; and Section 4.0, Code Operation, discusses details of input requirements, code output, and a sample case demonstration. The appendices consist of an FPFP_2 Fortran code listing, a listing of a code for building input files, forms for building input files, and the sample case input and output files.

2.0 TECHNICAL BASES

This section discusses the technical aspects of the flow path components and the fission product deposition mechanisms. FPFP_2 allows the user to analyze only one flow path at a time, even if there are many parallel and cross-linked paths between the source and final sink of fission products. The user can analyze a complex network where the gas flow rates are known in all parts of this network by adding up all fission product concentrations and flow rates from each path analysis. FPFP_2 assumes that the fission products do not interact and that all deposition rates are linearly dependent on fission product airborne concentrations.

2.1 FLOW PATH COMPONENTS (SPACES)

The flow path components (referred to as spaces in the code) are designed to carry out various functions. A generic flow path in FPFP_2 is considered to be a series of N nodes and N-1 components (or spaces). The nodes are merely flow splitters or link points to other flow paths. Please see the sample case described in Section 4.3 to see the relationship between nodes and components. The most important components appear to be rooms, ducts, filters, and flow resistances.

2.1.1 Rooms

FPFP_2 assumes that the gases entering a room become well mixed in the room. Gases leave the room at the well-mixed concentration. Rooms not only dilute the incoming gases, they can remove iodine by surface deposition, particles by gravitational settling, and particles by liquid sprays. Spray washout of iodine is not modeled here.

2.1.2 Ducts

A duct is a flow path component where gases enter at one end of a long, constant cross-section system and proceed to an exit. There might be situations where it is difficult to decide whether a component is a room or duct. Situations where a duct has many turns or cross-section changes will require engineering judgment to arrive at an equivalent constant cross-section duct. Equivalent cross sections will be further discussed in Section 4.1.

FPFP_2 assumes that plug flow exists in a duct. This assumption precludes any diffusion in the flow direction and simplifies the FPFP_2 program. Iodine and particles are allowed to deposit on all surfaces and upward-facing surfaces, respectively. Turbulent diffusion, diffusiophoresis, thermophoresis, and Brownian diffusion of particles are not modeled in FPFP_2.

2.1.3 Filters

Gases passing through a filter experience some removal (decontamination) of fission products. FPFP_2 requires that the decontamination factors (DFs) be supplied by the user. Typical DFs are 2000 for particles, 20 for iodine and 1.0 for noble gases.

2.1.4 Flow Resistances

A flow resistance is a convenience for adjusting flow rates between two nodes. FPFP_2 treats flow resistance like a filter with all DFs = 1.

2.2 FISSION PRODUCT DEPOSITION

All fission products that can be removed by natural deposition processes are either vapor molecules or fine particles. Organic iodides are considered to be inert gases (like the noble gases), except when they pass through certain absorbers. Iodine vapors (as HI or I_2) are treated as though they were all I_2. Therefore, any exposed surface will be considered as a deposition surface for I_2. Since most well-aged accident aerosol particles are greater than 0.1 micron diameter (Gieseke et al. 1984; Denning et al. 1986) and since accident flow rates leading to control rooms are anticipated to be close to normal duct flow values (i.e., slow), only gravity settling is considered as a removal mechanism apart from filtration.

If a user would like to consider high flow-rate turbulent deposition, that mechanism could be easily added to the code. Diffusiophoretic and thermophoretic deposition mechanisms could be added, but these would require supporting heat transfer and condensation analyses as well.

2.2.1 Iodine Vapor

Iodine vapor reaches deposition surfaces through diffusion through a boundary layer. The deposition velocity (k, ft/min) is obtained from correlations for heat transfer coefficients using the Chilton-Colburn analogy for mass transfer coefficients (Bird, Stewart, and Lightfoot 1960). The Sherwood number (Sh) becomes a function of the Schmidt number (Sc), the Reynolds number (Re), and the friction factor (f):

$$Sh = Sc^{1/3}\, Re\, f/2 \ .$$

For turbulent duct flow, $f = 0.0791/Re^{1/4}$. Other definitions are

$$Sh = kd/D$$

$$Sc = \mu/rD$$

$$Re = rdv/\mu$$

$$r = \text{air density}$$

μ = air viscosity

v = air velocity

d = 4Rh

Rh = hydraulic radius

D = iodine diffusivity.

Because the above relationships do not account for surface roughness and bends in ducts, k values will be conservatively low. Values for k will also be conservative when these equations are used to estimate k in rooms. After introducing the deposition velocity for mass transfer, we now examine how it is used.

The differential equation for fission product concentration (c) in a well-mixed room is

$$V(dc/dt) = F_i c_i - (F_o + kA)c$$

where

V = room volume

F_i = actual inlet flow rate

c_i = inlet concentration

F_o = actual outlet flow rate

A = room surface area.

The partial differential equation for concentration in a duct along the x (flow) direction (neglecting diffusion) is

$$\partial c/\partial t = -v\partial c/\partial x - kPc/A_x$$

where

A_x = cross-sectional area

P = perimeter of A_x.

The above two differential equations are solved using a series of time steps over the duration of the transient accident. The noble gases and organic iodides follow the same equations except that k = 0.

The equations above assume that the I_2 vapor finds a deposition surface that readily adsorbs the iodine without reentrainment. Therefore, iodine deposition calculated by FPFP_2 is an upper-bound value. This ideal situation is probably realistic for clean metallic and painted surfaces. However, certain materials can become saturated and reentrain iodine in the presence of lower I_2 concentrations than the maximum observed during the accident. This reentrainment behavior is material-specific and cannot be easily generalized. The user of FPFP_2 should be aware that iodine can significantly reentrain in the days following deposition. [See Unrein et al. (1985) and Widner et al. (1985) for specific data where iodine reentrainment rates as high as 10^{-5} s^{-1} have been observed.] The user should not include surfaces in the area A for iodine deposition that cannot adsorb the iodine.

2.2.2 Particles

Particles can deposit on surfaces by a number of mechanisms. These are Brownian diffusion, gravity settling, electrophoresis, thermophoresis, diffusiophoresis, turbulent deposition, inertial impaction, and interception. For typical well-aged nuclear-accident-generated aerosols, with little water vapor present in the gas (i.e., no condensation on walls or particles), with small gas-to-wall temperature gradients, and with velocities that are not excessive, gravity becomes the dominant deposition mechanism. FPFP_2 uses gravity settling as the only particle deposition mechanism, and because the aerosols are well aged, particle agglomeration is ignored.

The differential equations in Section 2.2.1 hold for particle settling with the following changes: k becomes the particle settling velocity, A becomes A(floor), and P becomes duct width.

The equations for deposition velocities have been established in other documents (Owczarski, Schreck, and Winegardner 1985). These velocities are a strong function of particle diameter and a less strong function of particle density. FPFP_2 represents the nuclear aerosol at its source as having an aerodynamic mass median diameter (ammd) of 1 μm with a geometric standard deviation of 2. The aerosol particles are distributed into bins of five discrete particle sizes. FPFP_2 allows the user to apply a multiplier to the ammd value. The particle size distribution above is typical of well-aged aerosols found by calculation in severe reactor accidents analyses (Gieseke et al. 1984; Denning et al. 1986).

Reentrainment of particles is not considered in the models. This phenomenon is not important at the flow rates expected. A user could add models for this, if necessary. A reference for reentrainment is the Nuclear Fuel Cycle Accident Analyses Handbook, NUREG-1320 (Ayer et al. 1988).

3.0 CODE DESCRIPTION

FPFP_2 is a small "structured" program of less than 1100 lines. The main program is primarily a driver of subroutines. Each subroutine is a module that can be easily replaced or updated.

3.1 CODE ORGANIZATION

The main driver program initially calls for the input file. Then it controls the time-marching sequence over the whole transient event, calling the CALC and INTERP subroutines where appropriate. The structure of the whole code is depicted in Figure 1.

The input file is constructed by the user. To aid in this construction the user can employ the BLDINPT2.EXE software included with the FPFP_2 code. Details of the input file construction are found in Section 4.0.

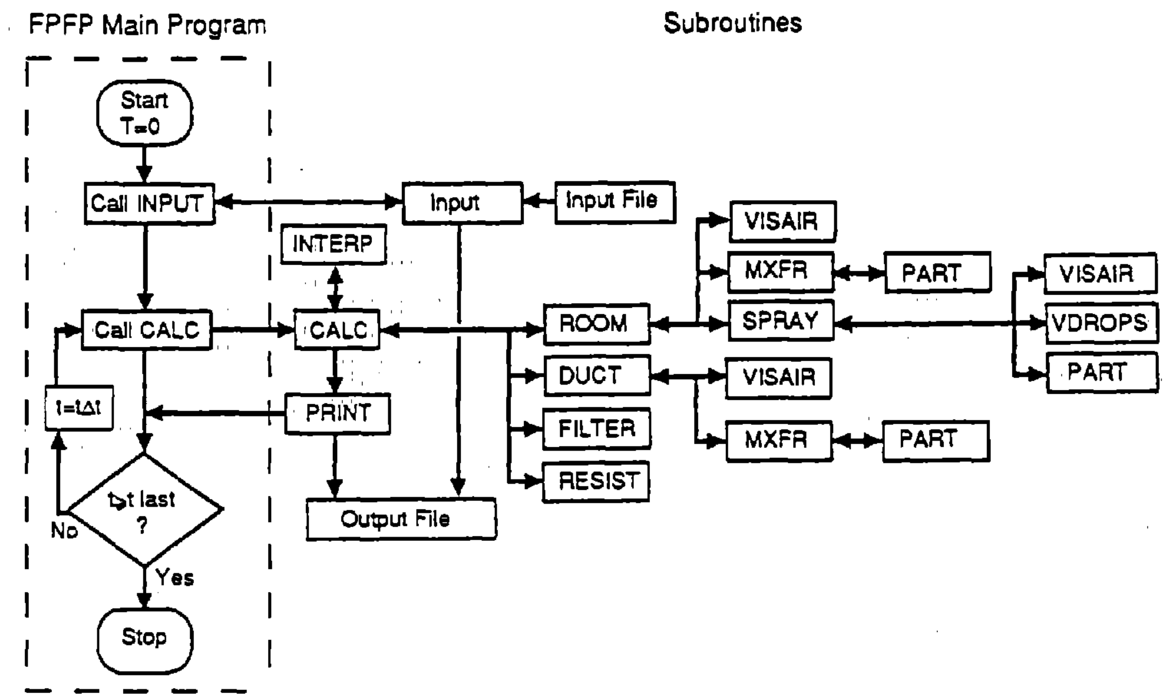

FIGURE 1. Schematic Diagram of FPFP_2 Showing Components and Information Flow

3.2 SUBROUTINES

The purpose of each of the subroutines is explained in the beginning of each subroutine. In summary, INPUT reads the input file and rewrites it in the output file; INTERP obtains (by interpolation) input data between input time values; CALC directs concentration calculations in the flow path; ROOM, DUCT, FILTER, and RESIST perform concentration calculations; and PRINT provides the output through the duration of the event.

Other subroutines that support those listed above include the following: MXFR computes mass transfer (deposition velocity) coefficients for rooms and ducts; PART calculates particle settling velocities; SPRAY computes washout coefficient for particles in spray compartments; VDROPS computes settling velocities for spray droplets; and VISAIR computes gas viscosities.

4.0 CODE OPERATION

Operating FPFP_2 requires establishing an input data file for each transient reactor accident case. Creating the input file is done by executing a code called BLDINPT2. This code prompts the user for all necessary input data and automatically creates an input file in the FPFP_2 format. The executable file, FPFP_2.EXE, which can be run on any IBM-compatible personal computer, uses the input files to calculate the desired output, and creates an output file designated by the user. The sections below describe the development of the necessary components of the input file and the output expected. Then a simple accident case demonstrates the use of the code.

4.1 BLDINPT2

Appendix A (pages A.1-A.2) defines the input and other variables. The listing of subroutine INPUT shows the order of the input variables. Using BLDINPT2 is probably the easiest way to develop an input file, even for experienced users. However, to make single variable changes from case to case, it is probably easier to change the variable in an already developed file.

4.1.1 Puff Release and Other Variables

Form 1 contains some initial naming requirements and requires defining the number of nodes, defining the puff release in space 1, if desired, and deciding whether the particle diameter as defined in the code is acceptable. The sample case in Section 4.3 will show examples of these choices.

4.1.2 Plant Variables

With Form 2, the user builds up a list of the consecutive series components of the flow path (spaces), and then establishes the dimensions of each as a rectangular parallelepiped.[a] If the space is a duct, the angle with the horizontal is required. Additional decontamination factors (DFs) are also requested for each fission product group. Usually DFs are 1.0 except when the component is a filter.

4.1.3 Other Fission Product Sources

Form 3 allows the user to have additional fission products enter node 1 as a function of time. These additional fission products are in concentrations suggested as core fractions/ft^3, but any mass unit/ft^3 is satisfactory if the user makes the appropriate adjustment in interpreting the output.

(a) For example, we suggest that a round duct of length L, volume V, and radius r, where $V = \pi r^2 L$, be represented by a duct of length L, volume V, and flow cross section l^2, such that $\pi r^2 = l^2$.

4.1.4 Gas Variables

Form 4 allows the user to develop the data file for gas flow rates and conditions. The gas temperature and pressure are used to calculate gas transport coefficients.

4.1.5 Spray Variables

Form 5 allows the addition of sprays to any room for removal of particles. The spray parameters are listed on the form. A decision is required to change the spray droplet diameters from 1 mm as coded.

4.2 OUTPUT DESCRIPTION

The output file consists of two parts. The first part of the output file is a printout of the input file, i.e., the input variable names and the input data. The second part is the output of transient accident scenario calculations.

This latter part presently consists of two sets of variables: the concentrations of fission products, in core fractions/ft^3, leaving each node and the flow rates of fission products leaving the nodes. The time values at which each calculation is completed and printed are determined by an input decision.

FPFP_2 can be easily modified to change the printing frequency and format. Other calculations can be introduced and printed, too. These might include cumulative amounts entering a room, cumulative amounts collecting on filters, and cumulative amounts settling or plating out; a breakdown of fission products by isotope; and calculation of radioactively decayed levels of these isotopes.

4.3 SAMPLE CASE

To demonstrate the use of FPFP_2, a simple Sample Puff Release Case has been set up and executed. The flow path consists of five nodes and four spaces (components). Figure 2 shows the order of the components and the flow rates, which were held constant during the transient accident. At t = 0, the transient accident was initiated by a sudden jump in fission product concentration in Space 1 as a puff release. Please refer to the completed BLDINPT2 forms in Appendix B.1 for the Sample Puff Release Case.

Figure 2 shows each node in its generalized form. It is probably clearer to interpret the flow schematic as constant flow of 15,000 acfm from the inlet at space 1 to node 3 where 10,000 acfm splits off to some unspecified destination. The remaining 5,000 acfm continues through the remaining part of the flow path and then exits to another unspecified destination.

The number of time steps was arbitrarily chosen to equal 3 with data entry times of 0, 100, and 200 minutes. This choice separates the calculating/printing intervals by 10 minutes.

The dimensions of the rooms and duct were chosen so that their identity could not be mistaken. Any resemblance of these dimensions to those of a nuclear power plant is purely coincidental. One could imagine that space 4 could be a control room, since it is the last component in the flow path. The dimensions of the filter of 1 ft x 1 ft x 1 ft are arbitrary; the READ statement expects each component to have dimensions regardless of identity. No calculations are made with the dimensions of a filter or flow resistance.

DFs were chosen as follows: in this sample case only the filter component had DFs = 1, 20, and 2000 for noble gases, I_2, and particles, respectively. The other components are assigned 1, 1, and 1.

The final input file is assembled in proper order in Appendix B.2. This file is read during the execution of FPFP.EXE and is reprinted with variable names in the first part of the output file found in Appendix B.2. When assembling an input file it could be useful to compare the input file with the corresponding part of the output file for this Sample Puff Release Case.

The remainder of the output is the sets of fission product concentrations and flow rates at 21 time points during the event. Three of these are reproduced in Appendix B.3, at t = 0, 10, and 200 minutes. Figure 3 is a plot of the concentrations of noble gases, I_2, and particles in space 4 over the 200-minute period. Some observations can be made in Figure 3. The pulse of the puff release builds to a maximum and then decays by dilution. The rate of decay depends primarily on the dilution time of the system. The dilution time of a single well-mixed room is equal to the volume of the room divided by the gas flow-through rate. For a series of flow path components, the dilution time is more complex. The ratios of the steady-state concentrations of I_2 and particles to noble gases with filtration alone should be 0.05 and 0.0005, respectively. Since these are 0.015 and 0.00045, respectively, some natural deposition of I_2 and particles has occurred.

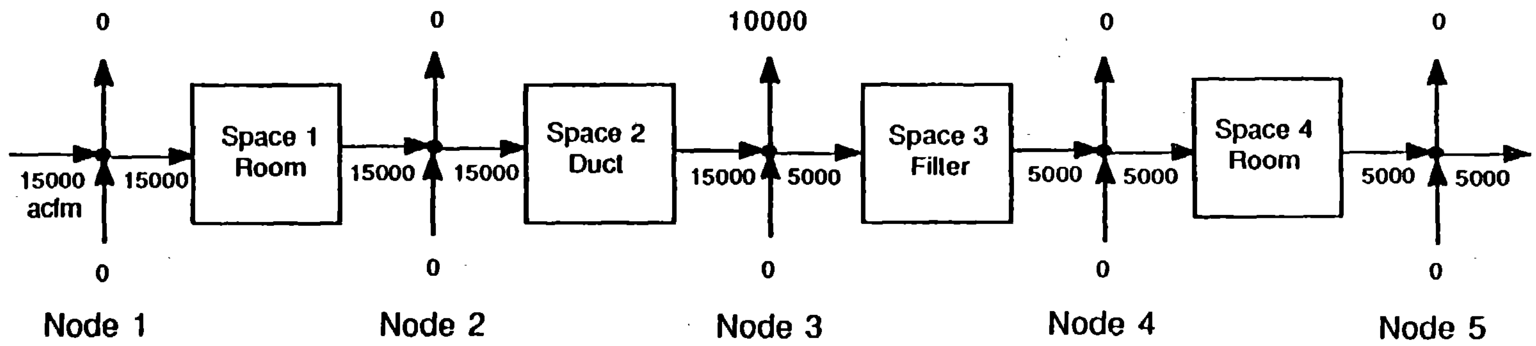

FIGURE 2. Sample Case Flow Path Showing Nodes, Components (Spaces), and Flow Rates

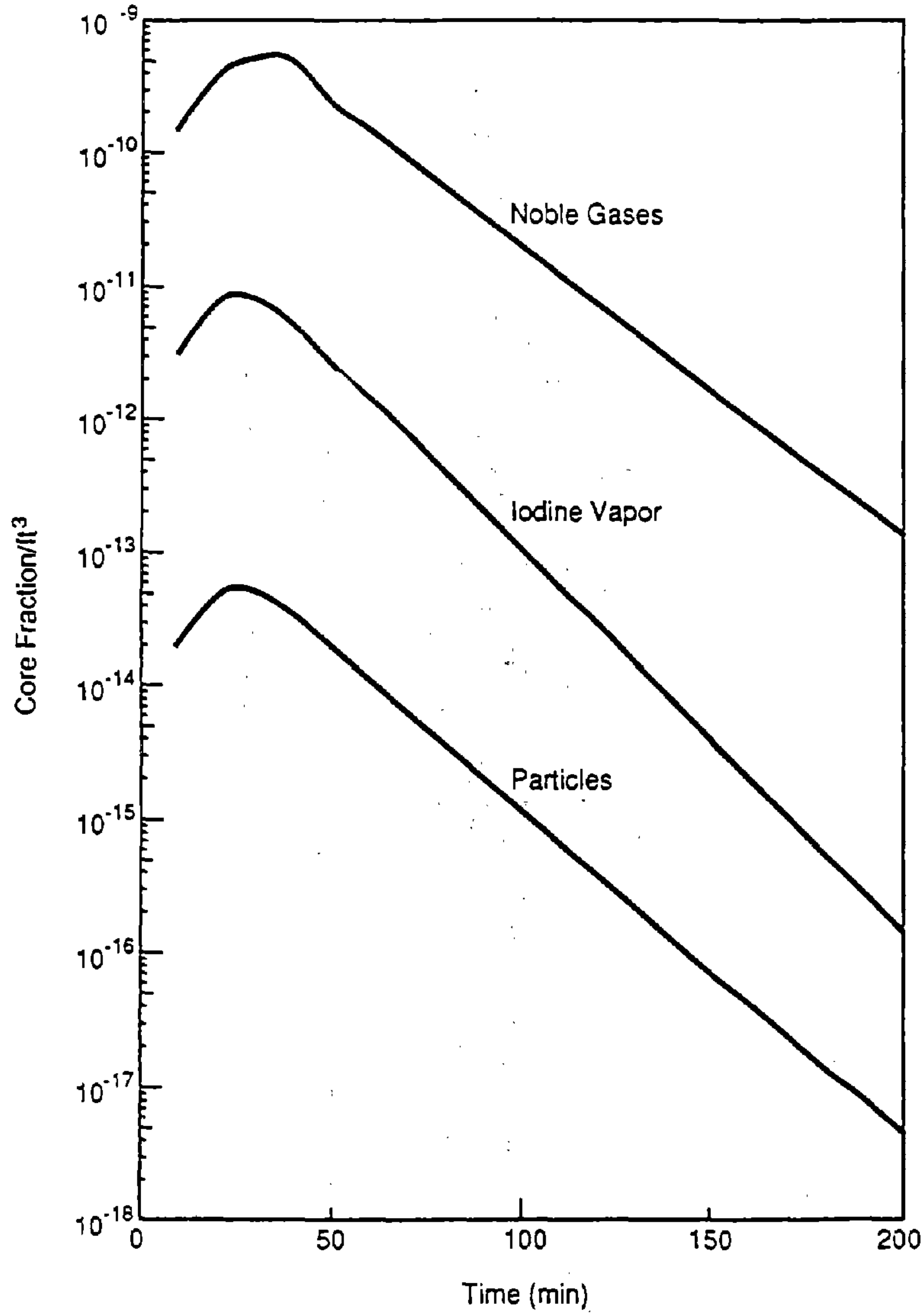

FIGURE 3. Concentration of Fission Products in Sample Case Space 4 as a Function of Time as Calculated by FPFP

5.0 REFERENCES

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APPENDIX A

FPFP 2 LISTING

APPENDIX A

FPFP 2 LISTING

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C*******************************************************************************
C
C                              XXXXX XXXXX XXXXX XXXXX
C                              XX    XX XX XX    XX XX
C                              XXXX  XXXXX XXXX  XXXXX
C                              XX    XX    XX    XX
C                              XX    XX    XX    XX   _2
C
C                           (Fission Product Flow Path)
C                             *       *       *    *
C
C     FPFP_2 IS A CODE UNDER DEVELOPEMENT FOR THE USNRC.  THE PURPOSE OF THE
C     CODE IS TO FOLLOW FISSION PRODUCTS VIA VARIOUS INTERNAL FLOW PATHS
C     FROM ONE POINT TO ANOTHER, E.G. FROM THE CONTAINMENT BUILDING TO THE
C     CONTROL ROOM.  SINCE THIS SOFTWARE IS UNVERIFIED AND UNVALIDATED, NO
C     ASSURANCE IS EXPRESSED OR IMPLIED AS TO ITS ACCURACY, COMPLETENESS,
C     OR USEFULNESS.
C
C     WITH FPFP_2 ONE CAN CONSTRUCT A TRANSIENT SCENARIO OF FISSION PRODUCT
C     MOVEMENT FROM A SOURCE TO AN END POINT IN A NUCLEAR REACTOR SYSTEM.  THE
C     CODE FOLLOWS NOBLE GASES, MOLECULAR IODINE, AND PARTICLES ALONG THE FLOW
C     PATH.  THIS PATH IS CONSTRUCTED BY THE USER.  INPUT REQUIREMENTS INCLUDE
C     SPECIFYING THE COMPONENTS OF THE PATH, COMPONENT DIMENSIONS, AND GAS
C     FLOW RATES THROUGH THESE COMPONENTS AND INTO OR OUT OF THE FLOW PATH.
C     PATH PRESSURES AND PRESSURES ARE REQUIRED INPUTS AS  WELL AS NOBLE GAS,
C     IODINE, AND PARTICLE CONCENTRATIONS AT THE SOURCE POINT AS A FUNCTION OF
C     TIME.  THE USER CAN ALSO INTRODUCE A PUFF RELEASE AT T=0 INTO A COMPART-
C     MENT BETWEEN NODES 1 & 2.  WATER SPRAYS CAN BE ACTIVATED IN FLOW PATH
C     ROOMS FOR THE REMOVAL OF PARTICLES ONLY.
C
      CHARACTER HEAD1*80
      REAL LENGTH(20)
C
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPUFF(7),DMULT(20)

      DIMENSION CNC(0:19,7,2), CNCP(20,7,2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
```

```
      COMMON/BLK2/T1,NSTEP
      COMMON/BLK6/TLAST
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
C                             DEFINITIONS
C
C     HEAD1=TITLE OF INPUT FILE
C     NDATA=2,.....,30 MAX, NO. OF TIME POINTS FOR DATA ENTRY
C     NODES=NO. OF NODES IN FLOW PATH, 20 MAX
C     NPUFF.NE.1, NO PUFF INTO SPACE 1 (ROOM) AT T=0; NPUFF=1 PLACES A PUFF
C     RELEASE INTO SPACE 1 WITH CONCENTRATIONS CPUFF(I), I=1,3, FOR NG, I2, AND
C     PARTICLES, RESPECTIVELY, IN CORE FRACTIONS/FT**3.
C     NPUFF = 0, NO PUFF RELEASE INTO SPACE 1 (ROOM) AT TNDATA(1); NPUFF = 1,
C     PUFF INTO SPACE 1 AT TNDATA(1) WITH CONCENTRATIONS CPUFF(1), CPUFF(2),
C     AND CPUFF(3), CORE FRACTIONS OF NG, I2, AND PARTICLES, RESPECTIVELY, IN
C     CORE FRACTIONS/FT**3.
C     DMULT=MULTIPLIER OF PARTICLE SIZE AMMD=1 MICROMETER.
C     TNDATA(J), J=1,NDATA, TIME VALUES AT EACH NDATA (MINUTES)
C     FP(I,J) = AVG FLOW RATE OF FISSION PRODUCT GROUP J FROM NODE I
C     INTO SPACE I.  J=1=NOBLE GASES, 2=VAPOR I2, 3-7=FIVE PARTICLE
C     SIZES.  UNITS OF FP ARE IN FRACTIONS OF CORE INVENTORY PER MINUTE.
C     CONC(I,J) = CONCENTRATION OF FISSION PRODUCTS AT NODE 1 AT TNDATA(I) FOR
C     FISSION PRODUCT GROUP J = 1,2, OR 3 AS ABOVE. FRACTION OF CORE INVENTORY
C     PER FT**3.
C     CNC(I,J,K) = CONCENTRATION OF FISSION PRODUCT J ENTERING NODE I AT TIME K
C     CNCP(I,J,K)= CONCENTRATION OF FISSION PRODUCT J LEAVING NODE I AT TIME K
C     FR(I,J) = FLOW RATE OF GASES (ACFM) FROM NODE J INTO SPACE J AT
C     TNDATA(I).
C     FRO(I,J) = FLOW RATE OF GASES FROM SPACE J INTO NODE J+1.
C     FROUT(I,J) = FLOW RATE OF GASES (ACFM) FROM NODE J OUT OF FLOW PATH
C     AT TNDATA(I).
C     FRIN(I,J) = FLOW RATE OF GASES (ACFM) INTO FLOW PATH AT NODE J AT
C     TNDATA(I).
C     PDATA(I,J) AND TDATA(I,J) ARE PSIG AND DEGREES C IN THE GAS IMMEDIATELY
C     DOWNSTREAM OF NODE J AT TNDATA(I).
C
C     NSPACE(J) = 1 = ROOM, = 2 = DUCT, = 3 = FILTER, = 4 = FLOW RESISTANCE (E.
C     G. A LEAKY DOOR).  IF NPUFF=1, NSPACE(1)=1.
C
C     DT(K) = TIME STEP, MINUTES, BETWEEN TNDATA(K) AND TNDATA(K+1)
C
C     VOL(K) = HEIGHT(K)*WIDTH(K)*LENGTH(K), FT**3
C     AXSXN(K) = HEIGHT(K)*WIDTH(K)
C     AFLOOR(K) = WIDTH(K)*LENGTH(K)
C     THETA(K) = ANGLE OF DUCT(K) WITH HORIZONTAL
C
C     THE FOLLOWING ARE OPTIONAL SPRAY PARAMETERS:
C
C     IF ROOM J HAS A SPRAY SYSTEM THAT OPERATES BETWEEN TIMES TSON AND TSOFF,
C     THEN NSPRAY(J)=1, AND DSPRAY(J)=MULTIPLIER OF DROPLET MMD RELATIVE TO 1.0
C     MILLIMETERS, HSPRAY(J)= SPRAY HEIGHT (FT), AND VSPRAY(J)=VOL FLOW RATE
```

```
C     (CFM).  SUBROUTINE SPRAY RETURNS WASHOUT PARAMETER LSPRAY(K) FOR EACH K
C     (K=1,7) FISSION PRODUCT TYPE TO SUBROUTINE ROOM.
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>
C
C                              FLOW SCHEMATIC DIAGRAM
C           FROUT(I,J)                                      FROUT(I,J+1)
C             /I\                  _______                     /I\
C              I                  I       I                     I
C       _______\I_______________\I  SPACE  I_______________\I_______\
C      FRO(I,J) /I\  FR(I,J)    /I    J    I  FRO(I,J+1)   /I\       / FR(I,J+1)
C               I                 I_______I                     I
C               I                                               I
C           FRIN(I,J)                                       FRIN(I,J+1)
C
C            NODE J                TNDATA(I)                NODE J+1
C
C   CNC(J-1,M,2)    CNCP(J,M,2)   CNC(J,M,2)   CNC(J,M,2)     CNCP(J+1,M,2)
C
C                             FISSION PRODUCT GROUP M
C
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>

      CALL INPUT
C
      WRITE(6,101)
101   FORMAT(//,5X,'BEGIN PROCESSING . . .',//)

      TT=0.
      NSTEP=1
C
C     TT = TIME OF CALCULATION, MIN
C
C<><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><><>.
C
C     PERFORM CALCULATIONS NOW
C
  100 CONTINUE

      CALL CALC
C
      IF(TT.GE.TLAST) GO TO 1000
C
      T1=TT
      NSTEP=NSTEP+1
      TT=TT+DTT
      GO TO 100
C
 1000 CONTINUE
```

```
WRITE(*,'(//,A)') ' PROGRAM SUCCESSFULLY COMPLETED'
STOP
END
```

```
C*******************************************************************************
C
C
      SUBROUTINE INPUT
C
C     THIS SUBROUTINE READS THE INPUT FILE FPFP.DAT AND PRINTS IT OUT IN
C     FPFP.OUT
C
      CHARACTER HEAD1*80
      CHARACTER*12  INFILE,OUTFILE,TEMP
C
      DIMENSION DIAM(5), DIAM1(5), FRAC(5), CNC(0:19,7,2), BONC(30)
C
      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPUFF(7),NSPRAY(20)

      DIMENSION DSPRAY(20),HSPRAY(20),VSPRAY(20),CNCP(20,7,2),TSON(20),
     +TSOFF(20)
      DIMENSION THETA(20)
C
      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
      COMMON/BLK6/TLAST
      COMMON/BLK10/CPUFF,NPUFF
      COMMON/BLK30/DIAM,VP,DIFUS,CM
      COMMON/BLK23/TSON,TSOFF
      COMMON/BLK24/NSPRAY
      COMMON/BLK25/DSPRAY,HSPRAY,VSPRAY
      COMMON/BLK90/THETA
C
      WRITE(6,1)
    1 FORMAT(/' Program Title:   FPFP.'//
     +  ' Developed For:   U.S. Nuclear Regulatory Commission'/
     +  '                  Office of Nuclear Regulatory Research'/
     +  '                  Division of Reactor Accident Analysis'//
     +  ' Date:            June 1990'//
     +  ' NRC Contact(s):  C. Ferrell         Phone: (FTS) 492-3944'/
     +  ' Code Developer:  P. C. Owczarcki    Phone: (509) 376-1701'/
     +  '                                            (FTS) 444-1701'//
     +  ' Code Documentation: '//
     +  ' The program was prepared for an agency of the United States',
     +  ' Government. Neither'/' the United States Government nor any',
     +  ' agency thereof, nor any of their'/' employees, makes any',
     +  ' warranty, expressed or implied, or assumes any legal'/
     +  ' liability or responsibilities for any third party''s use,',
     +  ' or the results of such'/' use, of any portion of this',
```

```
     +  ' program or represents that its use by such third'/' party',
     +  ' would not infringe privately owned rights. '/// )

      WRITE(6,2)
2     FORMAT(1X,'Hit RETURN to Continue   ',$)
      READ(5,'(I1)')I

      WRITE(6,600)
600   FORMAT(//,5X,'XXXXX XXXXX XXXXX XXXXX',/,
     *          5X,'XX    XX XX XX    XX XX',/,
     *          5X,'XXXX  XXXXX XXXX  XXXXX',/,
     *          5X,'XX    XX    XX    XX',/,
     *          5X,'XX    XX    XX    XX',//,
     *          3X,'(Fission Product Flow Path)',//)
      WRITE(6,601)
601   FORMAT(3X,'ENTER THE INPUT FILENAME > ',$)
      READ(5,'(A)')INFILE
699   OPEN(UNIT=1,FILE=INFILE,STATUS='OLD',IOSTAT=IER)
      IF(IER .EQ. 6416) THEN
        WRITE(6,602)INFILE
602     FORMAT(/,5X,'* * * ',A12,' DOES NOT EXIST * * *',/)
        WRITE(6,603)
603     FORMAT(3X,'ENTER NEW FILENAME, OR <RETURN> TO STOP > ',$)
        READ(5,'(A)')TEMP
        IF(TEMP(1:3) .EQ. '   ') THEN
          WRITE(6,604)
604       FORMAT(//,5X,'<<< TERMINATING EXECUTION >>>',//)
          STOP
        ENDIF
        INFILE = TEMP
        GOTO 699
      ENDIF
      WRITE(6,605)INFILE
605   FORMAT(//,5X,'OPENED ',A12,' AS INPUT',//)
      IND = INDEX(INFILE,'.') - 1
      OUTFILE = INFILE(1:IND)//'.OUT'
      WRITE(6,606)OUTFILE,OUTFILE
606   FORMAT(5X,'OUTPUT FILE WILL BE CALLED:  ',A12,//,
     *       3X,'ENTER ANOTHER FILENAME, OR <RETURN> TO USE ',A12,/,
     *       3X,'AS OUTPUT FILE > ',$)
      READ(5,'(A)')TEMP
      IF(TEMP(1:3) .NE. '   ') OUTFILE = TEMP
698   OPEN(UNIT=2,FILE=OUTFILE,STATUS='NEW',IOSTAT=IER)
      IF(IER .EQ. 6415) THEN
        CLOSE(2)
        WRITE(*,607)OUTFILE
607     FORMAT(/,5X,'* * * ',A12,' ALREADY EXISTS * * *',/)
        WRITE(*,608)
608     FORMAT(' ENTER A NEW FILENAME,',
     *         ' OR HIT <RETURN> TO OVERWRITE OLD FILE > ',$)
        READ(*,'(A)')TEMP
        IF(TEMP(1:3) .EQ. '   ') THEN
```

```
          WRITE(*,609)OUTFILE
609       FORMAT(/,5X,A12,' WILL BE OVERWRITTEN',/)
          OPEN(UNIT=2,FILE=OUTFILE,STATUS='UNKNOWN')
        ELSE
          WRITE(*,610)TEMP
610       FORMAT(/,5X,A12,' WILL BE OPENED',/)
          OUTFILE = TEMP
          GOTO 698
        ENDIF
      ENDIF

      OPEN(UNIT=3,FILE='CRHFPFP.OUT',STATUS='UNKNOWN')
C     ABOVE LINE REQUESTED BY H. GILPIN, SAIC, 2/13/90.
C
      WRITE(2,1)
      READ(1,'(A)')HEAD1
      WRITE(2,'(A)')HEAD1
      READ(1,*)NDATA,NODES,NPUFF,DMULT
      WRITE(2,501) 'NODES=',NODES
      WRITE(2,501) 'NDATA=',NDATA
      WRITE(2,501) 'NPUFF=',NPUFF
      WRITE(2,502) 'DMULT=',DMULT
501   FORMAT(3X,A6,1X,I4)
502   FORMAT(3X,A6,1X,F9.4)

      IF(NPUFF.EQ.1)THEN
        READ(1,*)(CPUFF(I),I=1,3)
        WRITE(2,503) 'CPUFF(I)= ',(CPUFF(I),I=1,3)
      END IF
      READ(1,*)(TNDATA(I),I=1,NDATA)
      WRITE(2,503) 'TNDATA(I)=',(TNDATA(I),I=1,NDATA)
      TLAST=TNDATA(NDATA)
      DO 10 K=1,NDATA
        READ(1,*)(CONC(K,J),J=1,3)
        WRITE(2,'(3X,A4,I3)')'K = ',K
        WRITE(2,503) 'CONC(K,J)=',(CONC(K,J),J=1,3)
10    CONTINUE
503   FORMAT(3X,A10,5(3X,1PE10.4),/,13X,5(3X,1PE10.4),/,
     *          13X,5(3X,1PE10.4),/,13X,5(3X,1PE10.4))

      DO 20 K=1,NODES-1
        READ(1,*)NSPACE(K),HEIGHT(K),WIDTH(K),LENGTH(K),DF1(K),DF2(K),
     +  DF3(K)
        WRITE(2,504)K,NSPACE(K),HEIGHT(K),WIDTH(K),LENGTH(K),
     *              DF1(K),DF2(K),DF3(K)
504     FORMAT(/,3X,'SPACE # K=',I3,3X,'NSPACE(K)=',I3,/,
     *            5X,'HEIGHT(K)=',F9.3,3X,'WIDTH(K)=',F9.3,
     *            5X,'LENGTH(K)=',F9.3,/,
     *            5X,'DF1(K)= ',1PE10.4,4X,'DF2(K)= ',1PE10.4,
     *            5X,'DF3(K)= ',1PE10.4)

        THETA(K) = 0.0
```

```
      IF(NSPACE(K) .EQ. 2) THEN
        READ(1,*)THETA(K)
        WRITE(2,505)K,THETA(K)
505     FORMAT(5X,'SPACE #',I2,' IS A DUCT, AND HAS AN ANGLE WITH',
     *            ' THE HORIZONTAL = ',F6.2,' DEGREES')
        THETA(K) = THETA(K) * ( 3.141592654 / 180.0 )
C       CONVERT THETA FROM DEGREES TO RADIANS
      ENDIF
   20 CONTINUE
      WRITE(2,*)
      DO 30 J=1,NODES
        WRITE(2,506)J,NDATA
506     FORMAT(3X,'NODE ',I2,'  NDATA = 1...',I2)
507     FORMAT(3X,A11,5(3X,F10.3),/,14X,5(3X,F10.3),/,
     *          14X,5(3X,F10.3),/,14X,5(3X,F10.3),/,
     *          14X,5(3X,F10.3),/,14X,5(3X,F10.3))
508     FORMAT(3X,A33)
        READ(1,*)(FR(K,J),K=1,NDATA)
        WRITE(2,507) 'FR(K,J)=    ',(FR(K,J),K=1,NDATA)
        READ(1,*)(FRO(K,J),K=1,NDATA)
        WRITE(2,507) 'FRO(K,J)=  ',(FRO(K,J),K=1,NDATA)
        READ(1,*)(FROUT(K,J),K=1,NDATA)
        WRITE(2,507) 'FROUT(K,J)=',(FROUT(K,J),K=1,NDATA)
        READ(1,*)(FRIN(K,J),K=1,NDATA)
        WRITE(2,507) 'FRIN(K,J)= ',(FRIN(K,J),K=1,NDATA)
        READ(1,*)(PDATA(K,J),K=1,NDATA)
        WRITE(2,507) 'PDATA(K,J)=',(PDATA(K,J),K=1,NDATA)
        READ(1,*)(TDATA(K,J),K=1,NDATA)
        WRITE(2,507) 'TDATA(K,J)=',(TDATA(K,J),K=1,NDATA)
   30 CONTINUE

      DO 40 K=1,NODES-1
        IF(NSPACE(K).LE.2)AXSXN(K)=HEIGHT(K)*WIDTH(K)
        IF(NSPACE(K).LE.2)AFLOOR(K)=WIDTH(K)*LENGTH(K)
        IF(NSPACE(K).LE.2)VOL(K)=AXSXN(K)*LENGTH(K)
        IF(NSPACE(K).EQ.1)READ(1,*) NSPRAY(K)
        IF(NSPRAY(K).EQ.1)THEN
          WRITE(2,*) 'SPACE # ',K,' HAS A SPRAY SYSTEM WHERE:'
          READ(1,*)DSPRAY(K),HSPRAY(K),VSPRAY(K),TSON(K),TSOFF(K)
          WRITE(2,*)' DSPRAY= ',DSPRAY(K),' DROPLET DIAMETER MULTIPLIER'
          WRITE(2,*)' HSPRAY= ',HSPRAY(K),' SPRAY HEIGHT, FT'
          WRITE(2,*)' VSPRAY= ',VSPRAY(K),' VOL. SPRAY RATE, GPM'
          WRITE(2,*)' TSON=   ',TSON(K),' TIME SPRAYS GO ON, MIN'
          WRITE(2,*)' TSOFF=  ',TSOFF(K),' TIME SPRAYS GO OFF, MIN'
        ENDIF
   40 CONTINUE
C
C     THE NEXT DO LOOPS ASSIGN PARTICLES TO FIVE BUCKETS REPRESENTING A
C     LOGNORMAL DISTRIBUTION AROUND ONE MICRON AMMD WITH GEOMETRIC STANDARD
C     DEVIATION OF 2.0.
C
```

```
      DATA DIAM1/.158489,.398107,1.,2.51189,6.30957/
      DATA FRAC/.0156896,.219259,.530103,.219259,.0156896/
      DO 50 J=1,NDATA
        BONC(J)=CONC(J,3)
        DO 50 K=3,7
          CONC(J,K)=FRAC(K-2)*BONC(J)
          DIAM(K-2)=DIAM1(K-2)*DMULT
   50 CONTINUE

      IF(NPUFF.EQ.1)THEN
        PUFFC=CPUFF(3)
        DO 60 K=3,7
          CPUFF(K)=PUFFC*FRAC(K-2)
   60   CONTINUE
      ENDIF

  800 FORMAT(1X,A,T15,7(2X,E11.5))
      RETURN
      END
```

```
C******************************************************************************
C
C
      SUBROUTINE INTERP

C     THIS SUBROUTINE PERFORMS LINEAR INTERPOLATIONS FOR TT BETWEEN TNDATA(K)
C     AND TNDATA(K+1).

      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7)

      DIMENSION CNC(0:19,7,2),CNCP(20,7,2)
      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP

C
      DO 10 J=1,NDATA-1
      IF(TT.GE.TNDATA(J).AND.TT.LE.TNDATA(J+1))INTER=J
   10 CONTINUE
C
      DEL=TNDATA(INTER+1)-TNDATA(INTER)
      DELT=TT-TNDATA(INTER)
      DTT=DEL/10.
      DO 20 K=1,NODES
      DFR=FR(INTER+1,K)-FR(INTER,K)
      FRI(K)=FR(INTER,K)+DFR*DELT/DEL
      DFRO=FRO(INTER+1,K)-FRO(INTER,K)
      FROI(K)=FRO(INTER,K)+DFRO*DELT/DEL
      DFROUT=FROUT(INTER+1,K)-FROUT(INTER,K)
      FROUTI(K)=FROUT(INTER,K)+DFROUT*DELT/DEL
      DFRIN=FRIN(INTER+1,K)-FRIN(INTER,K)
      FRINI(K)=FRIN(INTER,K)+DFRIN*DELT/DEL
      DTDATA=TDATA(INTER+1,K)-TDATA(INTER,K)
      TDATAI(K)=TDATA(INTER,K)+DTDATA*DELT/DEL
      DPDATA=PDATA(INTER+1,K)-PDATA(INTER,K)
      PDATAI(K)=PDATA(INTER,K)+DPDATA*DELT/DEL
   20 CONTINUE
C
      DO 30 K=1,7
      IF(TT.EQ.0.)THEN
       CONCI(K)=CONC(1,K)
       CNC(0,K,1)=CONCI(K)
       CNCP(1,K,1)=CNC(0,K,1)*FRO(1,1)/(FROUT(1,1)+FR(1,1))
       CNC(0,K,2)=CNC(0,K,1)
       CNCP(1,K,2)=CNCP(1,K,1)
       FP(1,K)=CNCP(1,K,2)*FRI(1)
       END IF
```

```
      IF(TT.GT.0.)THEN
       DCONC=CONC(INTER+1,K)-CONC(INTER,K)
       CONCP=CONCI(K)
       CONCI(K)=CONC(INTER,K)+DCONC*DELT/DEL
       CNC(0,K,1)=(CONCI(K)+CONCP)/2.
       CNCP(1,K,1)=CNC(0,K,1)*FROI(1)/(FROUTI(1)+FRI(1))
       CNC(0,K,2)=CONCI(K)
       CNCP(1,K,2)=CNC(0,K,2)*FROI(1)/(FROUTI(1)+FRI(1))
       END IF
   30 CONTINUE
C
      RETURN
      END


C**************************************************************************
C
C
      SUBROUTINE CALC

C
C     THIS SUBROUTINE DRIVES THE CALCULATION PROCESSES FOR THE TRANSPORT
C     AND DEPOSITION OF FISSION PRODUCTS
C
      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPUFF(7),NSPRAY(20)

      DIMENSION CNC(0:19,7,2),CNCP(20,7,2),cncr(20,7,2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
      COMMON/BLK2/T1,NSTEP
      COMMON/BLK3/ISPACE
      COMMON/BLK10/CPUFF,NPUFF
      common/blk60/cncr
C
      CALL INTERP

      DO 10 I=1,NODES-1
      ISPACE=I
      IF(TT.EQ.0.) GO TO 9
      IF(NSPACE(I).EQ.1)CALL ROOM
      IF(NSPACE(I).EQ.2)CALL DUCT
      IF(NSPACE(I).EQ.3)CALL FILTER
      IF(NSPACE(I).EQ.4)CALL RESIST
C
```

```
  9 CONTINUE
    IF(TT.EQ.0.)THEN
     DO 8 M=1,7
     CNC(ISPACE,M,2)=0.
     IF(ISPACE.EQ.1.AND.NPUFF.EQ.1)CNC(1,M,2)=CPUFF(M)
  8  CONTINUE
     END IF
C
    DO 11 M=1,7
    CAVGO=(CNC(I,M,2)+CNC(I,M,1))/2.
    IF(TT.EQ.0.)CAVGO=CNC(I,M,1)
    SPLIT=FROI(I+1)/(FROUTI(I+1)+FRI(I+1))
    CNCP(I+1,M,2)=CAVGO*SPLIT
    cncr(i+1,m,2)=cnc(i+1,m,2)*split
    FP(I+1,M)=CNCP(I+1,M,2)*FRI(I+1)
 11 CONTINUE
 10 CONTINUE
C
    CALL PRINT

C   RESET CNC & CNCP FOR NEXT TIME STEP.  ADD NON-ZERO DELC TO AVOID CRASH.
    DELC=1.E-20
    DO 20 M=0,NODES-1
    DO 20 N=1,7
    CNC(M,N,1)=CNC(M,N,2)+DELC
 20 CONTINUE
    DO 21 M=1,NODES
    DO 21 N=1,7
    CNCP(M,N,1)=CNCP(M,N,2)
 21 CONTINUE
C
C
    RETURN
    END
```

```
C***************************************************************************
C
C
      SUBROUTINE ROOM
C
C     THIS SUBROUTINE CALCULATES CNC(ISPACE,J,2) WITHIN A ROOM DESIGNATED AS
C     ISPACE IN SUBROUTINE CALC FOR FISSION PRODUCT GROUP J AT TIME = TT.
C     ALSO THE FISSION PRODUCT FLOW RATES FP(ISPACE,J) ARE ALSO CALCULATED.
C
      REAL LENGTH(20),KP(7),KMXFR(7),LSPRAY(7)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPUFF(7),NSPRAY(20)

      DIMENSION CNC(0:19,7,2),CNCP(20,7,2)
      DIMENSION DSPRAY(20),HSPRAY(20),VSPRAY(20),TSON(20),TSOFF(20)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP

      COMMON/BLK2/T1,NSTEP
      COMMON/BLK3/ISPACE
      COMMON/BLK5/KMXFR,KP,JMXFR
      COMMON/BLK15/DIAM
      COMMON/BLK23/TSON,TSOFF
      COMMON/BLK24/NSPRAY
      COMMON/BLK25/DSPRAY,HSPRAY,VSPRAY
      COMMON/BLK40/TB,VIS,PSPACE
      COMMON/BLK50/LSPRAY
C
C
C
      TB=TDATAI(ISPACE)+273.16
      PSPACE=(PDATAI(ISPACE)+14.7)/14.7
      CALL VISAIR

      DT1=TT-T1
C
      IF(TT.EQ.0.)GO TO 21
      DO 20 K=1,7
      JMXFR=K
      FP(ISPACE,K)=FRI(ISPACE)*CNCP(ISPACE,K,2)
      A1=FP(ISPACE,K)
      CALL MXFR
      B1=FROI(ISPACE+1)+KMXFR(K)
      IF(NSPRAY(ISPACE).NE.1) GO TO 40
      IF(TT.LT.TSON(ISPACE).OR.TT.GT.TSOFF(ISPACE)) GO TO 40
      CALL SPRAY
      B1=B1+LSPRAY(K)*VOL(ISPACE)
```

```
   40 CONTINUE
      C1=CNC(ISPACE,K,1)
C
      IF(B1.GT.0.)THEN
       C2=(A1-(A1-B1*C1)*EXP(-B1*DT1/VOL(ISPACE)))/B1
       CNC(ISPACE,K,2)=C2
       END IF
      IF(B1.LE.0.) CNC(ISPACE,K,2)=C1*(1.+A1*DT1)
   20 CONTINUE
C      WRITE(2,*) ' KMXFR= ',(KMXFR(K),K=1,7)
   21 CONTINUE

      RETURN
      END
```

```
C***********************************************************************
C
C
      SUBROUTINE DUCT
C
C     THIS SUBROUTINE CALCULATES CNC(ISPACE,J,2) EXITING A DUCT DESIGNATED AS
C     ISPACE IN SUBROUTINE CALC FOR FISSION PRODUCT GROUP J AT TIME = TT
C
      REAL LENGTH(20),KP(7),KMXFR(7)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CNCP(20,7,2)

      DIMENSION VEL(300,20),DZ(300,20),CO(300,20,7),ALPH(7),CNC(0:19,7,
     +2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
      COMMON/BLK2/T1,NSTEP
      COMMON/BLK3/ISPACE
      COMMON/BLK5/KMXFR,KP,JMXFR
      COMMON/BLK40/TB,VIS,PSPACE

      TB=TDATAI(ISPACE)+273.16
      PSPACE=(PDATAI(ISPACE)+14.7)/14.7
      CALL VISAIR
C
      VEL(NSTEP,ISPACE)=FRI(ISPACE)/AXSXN(ISPACE)
      DZ(NSTEP,ISPACE)=VEL(NSTEP,ISPACE)*DTT
C
      DO 1 JFP=1,7
      CO(NSTEP,ISPACE,JFP)=CNCP(ISPACE,JFP,2)
    1 CONTINUE
C
      SUMZ=0.
      DO 10 J=NSTEP,1,-1
      SUMZ=SUMZ+DZ(J,ISPACE)
      JUMP=J
      IF(SUMZ.GE.LENGTH(ISPACE)) GO TO 20
   10 CONTINUE
      IF(SUMZ.LT.LENGTH(ISPACE)) GO TO 30
   20 CONTINUE
      DTP=SUMZ-LENGTH(ISPACE)
C
      DO 40 JFP=1,7
      JMXFR=JFP
      CALL MXFR
C     CALL MXFR PRODUCES A MASS TRANSFER COEFFICIENT,AKP, IN 1/MIN
C
```

```
      ALPH(JFP)=DTP*KP(JFP)/VEL(JUMP,ISPACE)
      DO 40 NR=NSTEP,JUMP+1,-1
      CALL MXFR
      ALPH(JFP)=ALPH(JFP)+DZ(NR,ISPACE)*KP(JFP)/VEL(NR,ISPACE)
   40 CONTINUE
C
      DO 50 JFP=1,7
      EX=EXP(-ALPH(JFP))
      CNC(ISPACE,JFP,2)=CO(JUMP,ISPACE,JFP)*EX
   50 CONTINUE
      GO TO 70
   30 CONTINUE
      DO 60 JFP=1,7
      CNC(ISPACE,JFP,2)=0.
   60 CONTINUE
   70 CONTINUE
C
      RETURN
      END
```

```
C*****************************************************************************
C
C
      SUBROUTINE FILTER
C
C     THIS SUBROUTINE COMPUTES FISSION PRODUCT CONCENTRATIONS AFTER PASSAGE
C     OF GAS THROUGH A SPACE "I" DESIGNATED AS A FILTER IN SUBROUTINE CALC BY THE
C     CHOICE OF NSPACE(I)=3 IN THE INPUT DATA FILE FPFP.DAT.
C

      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7)

      DIMENSION CNC(0:19,7,2),CNCP(20,7,2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
      COMMON/BLK3/ISPACE


      CNC(ISPACE,1,2)=CNCP(ISPACE,1,2)/DF1(ISPACE)

      CNC(ISPACE,2,2)=CNCP(ISPACE,2,2)/DF2(ISPACE)

      DO 10 JFP=3,7
      CNC(ISPACE,JFP,2)=CNCP(ISPACE,JFP,2)/DF3(ISPACE)

   10 CONTINUE

      RETURN
      END
```

```
C*************************************************************************
C
C
      SUBROUTINE RESIST
C
C     THIS SUBROUTINE COMPUTES FISSION PRODUCT CONCENTRATIONS AFTER PASSAGE
C     OF GAS THROUGH A SPACE "I" DESIGNATED AS A FLOW RESISTANCE IN SUBROUTINE
C     CALC FOR THE CHOICE OF NSPACE(I)=4 IN THE INPUT DATA FILE FPFP.DAT.
C

      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7)

      DIMENSION CNC(0:19,7,2),CNCP(20,7,2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP
      COMMON/BLK3/ISPACE


      CNC(ISPACE,1,2)=CNCP(ISPACE,1,2)

      CNC(ISPACE,2,2)=CNCP(ISPACE,2,2)

      DO 10 JFP=3,7
      CNC(ISPACE,JFP,2)=CNCP(ISPACE,JFP,2)
   10 CONTINUE

      RETURN
      END
```

```
C***************************************************************************
C
C
      SUBROUTINE MXFR
C
C
C     THIS SUBROUTINE ESTIMATES MASS TRANSFER COEFFICIENTS FOR I2 VAPOR
C     DEPOSITION ON SURFACES AND PARTICLE SETTLING ON FLOORS.
C
      REAL LENGTH(20),KP(7),KMXFR(7)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7)
      DIMENSION CNC(0:19,7,2),DIAM(5),CNCP(20,7,2)
      DIMENSION THETA(20)
      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP

      COMMON/BLK3/ISPACE
C
      COMMON/BLK5/KMXFR,KP,JMXFR
      COMMON/BLK40/TB,VIS,PSPACE
      COMMON/BLK30/DIAM,VP,DIFUS,CM
      COMMON/BLK90/THETA
C
C     DEPOSITION VELOCITIES, VS, FT/MIN
C
C     THE VALUES OF VS BELOW ARE FOR FIXED CONDITIONS AND FIXED PARTICLE SIZES
      IF(JMXFR.EQ.1)VS=0.
      IF(JMXFR.EQ.2)VS=0.1732

      IF(JMXFR.GE.3)CALL PART
      IF(JMXFR.GE.3)VS=VP*1.9685 * COS(THETA(ISPACE))
C
      IF(NSPACE(ISPACE).EQ.1) GO TO 10
      F1=(WIDTH(ISPACE)+HEIGHT(ISPACE))/WIDTH(ISPACE)/HEIGHT(ISPACE)
      IF(JMXFR.LE.2)KP(JMXFR)=VS*2.*F1
      IF(JMXFR.GE.3)KP(JMXFR)=VS/HEIGHT(ISPACE)

   10 CONTINUE

      AWALL=HEIGHT(ISPACE)*LENGTH(ISPACE)
      ATOTAL=2.*(AXSXN(ISPACE)+AFLOOR(ISPACE)+AWALL)
      IF(JMXFR.LE.2)KMXFR(JMXFR)=VS*ATOTAL
      IF(JMXFR.GE.3)KMXFR(JMXFR)=VS*AFLOOR(ISPACE)

      RETURN
      END
```

```
C*************************************************************************
C
C
      SUBROUTINE PRINT
C
C     THIS SUBROUTINE PRINTS DESIRED CALCULATED OUTPUT TO FILE FPFP.OUT
C
      REAL LENGTH(20)
      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPRNTN(20,3)

      DIMENSION CPRINT(20,3),FPRINT(20,3),CNC(0:19,7,2),CNCP(20,7,2),
     +cncr(20,7,2),cprnt(20,3)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP

      common/blk60/cncr
C
      DO 10 I=1,NODES
      CPRINT(I,3)=CNC(I-1,3,2)+CNC(I-1,4,2)+CNC(I-1,5,2)+
     +CNC(I-1,6,2)+CNC(I-1,7,2)
      CPRNTN(I,3)=CNCP(I,3,2)+CNCP(I,4,2)+CNCP(I,5,2)+CNCP(I,6,2)+
     +CNCP(I,7,2)
      cprnt(i,3)=cncr(i,3,2)+cncr(i,4,2)+cncr(i,5,2)+cncr(i,6,2)+
     +cncr(i,7,2)
      DO 10 J=1,2
      CPRINT(I,J)=CNC(I-1,J,2)
      CPRNTN(I,J)=CNCP(I,J,2)
      cprnt(i,j)=cncr(i,j,2)
   10 CONTINUE
      DO 20 I=1,NODES
      FPRINT(I,1)=FP(I,1)
      FPRINT(I,2)=FP(I,2)
      FPRINT(I,3)=FP(I,3)+FP(I,4)+FP(I,5)+FP(I,6)+FP(I,7)
   20 CONTINUE
C
  299 FORMAT(5(5X,1PE10.4),/,5(5X,1PE10.4),/,
     *        5(5X,1PE10.4),/,5(5X,1PE10.4))

      WRITE(2,200)TT
  200 FORMAT(/,/,/,/,/,1X,T20,'CALCULATED OUTPUT AT ',F8.2,' MINUTES'
     +,/,/,/)
      WRITE(2,201)
  201 FORMAT(1X,'CONCENTRATIONS ENTERING NODES, CORE FRACTIONS/FT**3',/,
     +/,1X,'NOBLE GASES',/)
      WRITE(2,299)(CPRINT(I,1),I=1,NODES)
      WRITE(2,202)
```

```
  202 FORMAT(/,/,1X,'IODINE,I2',/)
      WRITE(2,299)(CPRINT(I,2),I=1,NODES)
      WRITE(2,203)
  203 FORMAT(/,/,1X,'PARTICLES',/)
      WRITE(2,299)(CPRINT(I,3),I=1,NODES)
      WRITE(2,205)
  205 FORMAT(/,/,/,1X,'CONCENTRATIONS LEAVING NODES, CORE FRACTIONS/
     +FT**3',/,/,1X,'NOBLE GASES',/)
      WRITE(2,299)(CPRNT(I,1),I=1,NODES)
      WRITE(2,206)
  206 FORMAT(/,/,1X,'IODINE,I2',/)
      WRITE(2,299)(CPRNT(I,2),I=1,NODES)
      WRITE(2,207)
  207 FORMAT(/,/,1X,'PARTICLES',/)
      WRITE(2,299)(CPRNT(I,3),I=1,NODES)
      WRITE(2,204)
  204 FORMAT(/,/,/,1X,'AVG RATES OF FISSION PRODUCTS LEAVING NODES, CORE
     + FRACTIONS/MIN',/,/,1X,'NOBLE GASES',/)
      WRITE(2,299)(FPRINT(I,1),I=1,NODES)
      WRITE(2,202)
      WRITE(2,299)(FPRINT(I,2),I=1,NODES)
      WRITE(2,203)
      WRITE(2,299)(FPRINT(I,3),I=1,NODES)

      WRITE(3,*)(CPRNT(NODES,I),I=1,3),TT
C     ABOVE LINE REQUESTED BY H. GILPIN, SAIC, 2/13/90
C

      RETURN
      END
```

```
C*******************************************************************************
C
      SUBROUTINE VISAIR
C
C
C     THIS SUBROUTINE COMPUTES THE VISCOSITY OF AIR AT TEMPERATURE TB, DEG K
C
      COMMON/BLK40/TB,VIS,PSPACE
      SIGAIR=3.617
      EPSAIR=97.
      OMAIR=0.765+0.82*EPSAIR/TB
      VIS=2.6693E-05*SQRT(29./TB)/((SIGAIR**2.)*OMAIR)
C
C     VIS IN POISES.  SEE REFERENCE BELOW:
C     BIRD, R.B., W.E. STEWART, AND E.N. LIGHTFOOT.  1960.
C      TRANSPORT PHENOMENA, JOHN WILEY & SONS, NEW YORK.
C
      RETURN
      END
```

```
C*******************************************************************************

      SUBROUTINE VDROPS

C     THIS SUBROUTINE CALCULATES THE VELOCITY OF FALLING WATER DROPS AS A
C     FUNCTION OF DROP SIZE AND TEMPERATURE.

      COMMON/BLK20/DROPDM,VDROP
      COMMON/BLK40/TB,VIS,PSPACE
      G=980.
      RHOGAS=29.*PSPACE/82.06/TB
      FDRE=1.3333*RHOGAS*G*DROPDM**3./VIS**2.
      IF(FDRE.LT.10700.)RE=(FDRE/15.71)**0.7027
      IF(FDRE.GE.10700.)RE=(FDRE/6.477)**0.6215

      VDROP=RE*VIS/RHOGAS/DROPDM

C     VDROP IN CM/S.  SEE REFERENCE BELOW:
C     U.S. NRC.  1975.  REACTOR SAFETY STUDY, WASH-1400 (NUREG-75/014),
C      APPENDIX VII, PP. VII-245.  U.S. NUCLEAR REGULATORY COMMISION,
C      WASHINGTON D.C.

      RETURN
      END
```

```
C*************************************************************************

      SUBROUTINE PART

C     THIS SUBROUTINE CALCULATES THE SETTLING VELOCITY, VP, DIFFUSIVITY, DIFUS,
C     CM, AND CUNNNINGHAM SLIP FACTOR FOR A PARTICLE

      DIMENSION DIAM(5),KMXFR(7),KP(7)

      COMMON/BLK30/DIAM,VP,DIFUS,CM
      COMMON/BLK40/TB,VIS,PSPACE
      COMMON/BLK5/KMXFR,KP,JMXFR

      G=980.
      RHOGAS=29.*PSPACE /82.06/TB

C     THE FOLLOWING ARE TAKEN FROM THE FOLLOWING REFERENCE:
C     OWCZARSKI, P.C., R.I. SHRECK, AND A.K. POSTMA. 1985.
C      TECHNICAL BASES AND USER'S MANUAL FOR THE PROTOTYPE OF A
C      SUPPRESSION POOL AEROSOL REMOVAL CODE (SPARC).
C      NUREG/CR-3317, U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON D.C.

C     ELAM = MEAN FREE PATH OF AIR MOLECULES

      PI=3.14159265
      ELAM=1.245E-02*((TB/29.)**0.5)*VIS/PSPACE
      DPA=DIAM(JMXFR-2)*1.E-04
      RATD=ELAM/DPA
      CM=1.+2.492*RATD+0.84*RATD*EXP(-0.435/RATD)
      DIFUS=4.6E-17*TB*CM/PI/VIS/DPA
C     DIFUS IN CM**2./S

      VP=1.0*G*CM*DPA**2./18./VIS

      FDRE=1.333333*1.0*RHOGAS*G*DPA**3./VIS**2.
      IF(FDRE.GT.9.6.AND.FDRE.LT.93.6)RE=(FDRE/27.)**(1./1.13)
      IF(FDRE.GE.93.6.AND.FDRE.LT.410.)RE=(FDRE/24.32)**(1./1.227)
      IF(FDRE.GE.410..AND.FDRE.LT.1.07E+04)RE=(FDRE/15.71)**(1./1.417)
      IF(FDRE.GE.1.07E+04.AND.FDRE.LT.2.4E+05)RE=(FDRE/6.477)
     +**(1./1.609)
      IF(FDRE.GE.2.4E+05)RE=(FDRE/1.194)**(1./1.867)
      IF(FDRE.GT.9.6)VP=RE*VIS/DPA/RHOGAS

C     VP IN CM/S

      RETURN
      END
```

```
C*****************************************************************************

      SUBROUTINE SPRAY

C     THIS SUBROUTINE COMPUTES SPAY WASHOUT OF PARTICLES IN A ROOM DESIGNATED
C     AS HAVING SPRAYS (NSPRAY(ISPACE)=1).  IT DELIVERS THE PARAMETER LSPRAY(K),
C     1/MIN, TO SUBROUTINE ROOM (K=1,7)

      REAL NDROP(5), LSPRAY(7),KP(7),KMXFR(7),LENGTH(20),LSPRY,LSP
      DIMENSION DIAM(5),FRAC(5),DROPD(5),FRACD(5)
      DIMENSION DSPRAY(20),HSPRAY(20),VSPRAY(20)

      DIMENSION CONC(30,7),FP(20,7),FR(30,20),FROUT(30,20),
     +FRO(30,20),FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     +NSPACE(20),HEIGHT(20),WIDTH(20),DT(30),VOL(20),AXSXN(20),
     +AFLOOR(20),DF1(20),DF2(20),DF3(20),FRI(20),FROUTI(20),FRINI(20),
     +TDATAI(20),PDATAI(20),FROI(20),CONCI(7),CPUFF(7),DMULT(20)
      DIMENSION CNC(0:19,7,2),CNCP(20,7,2)

      COMMON /BLK1/TT,DT,DTT,CNC,CONC,NDATA,NODES,TNDATA,TDATA,PDATA,
     +FP,FR,FRO,FROUT,FRIN,NSPACE,HEIGHT,WIDTH,LENGTH,VOL,AXSXN,AFLOOR,
     +DF1,DF2,DF3,FROUTI,FRINI,FRI,FROI,PDATAI,TDATAI,CONCI,CNCP

      COMMON/BLK3/ISPACE
      COMMON/BLK5/KMXFR,KP,JMXFR
      COMMON/BLK20/DROPDM,VDROP
      COMMON/BLK25/DSPRAY,HSPRAY,VSPRAY
      COMMON/BLK30/DIAM,VP,DIFUS,CM
      COMMON/BLK40/TB,VIS,PSPACE
      COMMON/BLK50/LSPRAY
C     NDROP(J), J=1,5, IS THE NUMBER OF SPRAY DROPLETS OF SIZE J IN THE ROOM

      IF(JMXFR.LT.3)LSPRAY(JMXFR)=0.
C     NO CREDIT IS GIVEN TO WASHOUT OF NG AND I2.
      IF(JMXFR.LT.3)GO TO 100

      CALL VISAIR
      PI=3.14159265
      DATA DROPD/158.489,398.107,1000.,2511.89,6309.57/
      DATA FRACD/0.0156896,0.219259,0.530103,0.219259,0.0156896/
C     ABOVE DATA STATEMENTS ARE FOR A LOG NORMAL SPRAY DROPLET DISTRIBUTION
C     OF MMD=1.0 MILLIMETERS AND GEOMETRIC STANDARD DEVIATION=2..

      LSPRY=0.

      DO 10 K=1,5

      DROPDM=DROPD(K)*DSPRAY(ISPACE)*1.E-04
C     DROPDM IS IN CM
      VD=PI*(DROPDM**3.)/6.
      CALL VDROPS
      TFALL=HSPRAY(ISPACE)*30.48/VDROP
```

```
      NDROP(K)=VSPRAY(ISPACE)*FRACD(K)*TFALL*(3785.412/60.)/VD
      CALL PART
      JM=JMXFR-2
      DP=DIAM(JM)*1.E-04
      DD=DROPDM
C     THE FOLLOWING IS TAKEN FROM:
C     GIESEKE, J.A., P. CYBULSKIS, R.S. DENNING, M.R. KUHLMAN,
C      K.W. LEE, AND H. CHEN. 1989.  RADIOACTIVE RELEASES UNDER SPECIFIC
C      LWR ACCIDENT CONDITIONS, VOL. IV.  BMI-2104, BATTELLE MEMORIAL
C      INSTITUTE, COLUMBUS OHIO.
C     PECLET NUMBER, PE
      PE=VDROP*DD/DIFUS
C     STOKES NUMBER, STK
      STK=DP*DP*1.*VDROP*CM/9./VIS/DD
      RAT=DP/DD
C     COLLECTION EFFICIENCIES EI, ER, AND ED FOR INERTIAL IMPACTION,
C     INTERCEPTION, AND BROWNIAN DIFFUSION, RESPECTIVELY.
      EI=STK*STK/(STK+0.35)**2.
      ER=1.5*RAT*RAT/(1.+RAT)**0.3333333
      ED=3.5/PE**0.6666667
      ETOT=EI+ER+ED
      DV=VDROP-VP
      IF(DV.LT.0.)THEN
       LSPRAY(JMXFR)=0.
       GO TO 100
      END IF
      VOLISP=28316.85*VOL(ISPACE)
      LSP=NDROP(K)*VDROP*ETOT*PI*(DD/2.)**2./VOLISP
      LSPRY=LSPRY+LSP
   10 CONTINUE
C     CONVERT 1/S TO 1/MIN.
      LSPRAY(JMXFR)=60.*LSPRY
  100 CONTINUE

      RETURN
      END
```

APPENDIX B

SAMPLE CASE INPUT AND OUTPUT FILES

APPENDIX B

SAMPLE CASE INPUT AND OUTPUT FILES

B.1 COMPLETED BLDINPT2 INPUT FORMS

**************************** FORM 1 ****************************

FILENAME TO BE CREATED: FPFP1A.DAT

HEADING FOR FILE (80 CHAR): Sample Puff Release Case

ENTER THE NUMBER OF SPACES: 5

COMPLETE ONE FORM 2 FOR EACH SPACE.

ENTER THE NUMBER OF TIME STEPS FOR DATA INPUT: 3

COMPLETE ONE FORM 3 FOR EACH TIME STEP.

COMPLETE ONE FORM 4 FOR EACH TIME STEP AT EACH NODE.

IS PUFF RELEASE IN SPACE 1 (ROOM) AT TIME(1) (0. MIN) ?: 1=YES 0=NO

ENTER PUFF CONCENTRATIONS IN CORE FRACTIONSS/FT**3
FOR EACH PRODUCT GROUP.

1) 1.000 E-08

2) 1.000 E-08

3) 1.000 E-08

ENTER PARTICLE DIAMETER MULTIPLIER: 1.000

COMPLETE ONE FORM 5 FOR EACH SPACE THAT IS A ROOM.

****

```
**************************** FORM 2 ****************************

SPACE NUMBER: _1_____

ENTER NUMBER DESCRIPTION OF SPACE: _1____
     1 = ROOM
     2 = DUCT
     3 = FILTER
     4 = RESISTANCE, e.g. leaky door
     5 = END DESCRIPTION

IF SPACE IS 1,2,3,4
                                 HEIGHT      WIDTH      LENGTH
     ENTER DIMENSIONS IN FEET:  ___50____  ___60____  ___100___

     IF SPACE IS 2
          ENTER DUCT ANGLE IN DEGREES: _NA______

     ENTER DECONTAMINATION FACTOR        DF1          DF2          DF3
      FOR EACH FISSION PRODUCT GROUP: ___1.0____  ___1.0____  ___1.0____

******************************************************************
```

```
**************************** FORM 2 ****************************

SPACE NUMBER: _2_____

ENTER NUMBER DESCRIPTION OF SPACE: _2____
     1 = ROOM
     2 = DUCT
     3 = FILTER
     4 = RESISTANCE, e.g. leaky door
     5 = END DESCRIPTION

IF SPACE IS 1,2,3,4
                                 HEIGHT      WIDTH      LENGTH
     ENTER DIMENSIONS IN FEET:  ___10____  ___10____  ___100___

     IF SPACE IS 2
          ENTER DUCT ANGLE IN DEGREES: _45______

     ENTER DECONTAMINATION FACTOR        DF1          DF2          DF3
      FOR EACH FISSION PRODUCT GROUP: ___1.0____  ___1.0____  ___1.0____

******************************************************************
```

```
****************************  FORM 2  ****************************

SPACE NUMBER: _3_____

ENTER NUMBER DESCRIPTION OF SPACE: _3_____
     1 = ROOM
     2 = DUCT
     3 = FILTER
     4 = RESISTANCE, e.g. leaky door
     5 = END DESCRIPTION

IF SPACE IS 1,2,3,4
                                          HEIGHT        WIDTH       LENGTH
     ENTER DIMENSIONS IN FEET:          ____1_____   ____1____   ____1____

     IF SPACE IS 2
          ENTER DUCT ANGLE IN DEGREES: _NA_______

     ENTER DECONTAMINATION FACTOR            DF1          DF2          DF3
      FOR EACH FISSION PRODUCT GROUP: ____1.0____  ___20.0____  __2000.0___

******************************************************************


****************************  FORM 2  ****************************

SPACE NUMBER: _4_____

ENTER NUMBER DESCRIPTION OF SPACE: _1_____
     1 = ROOM
     2 = DUCT
     3 = FILTER
     4 = RESISTANCE, e.g. leaky door
     5 = END DESCRIPTION

IF SPACE IS 1,2,3,4
                                          HEIGHT        WIDTH       LENGTH
     ENTER DIMENSIONS IN FEET:          ____12____   ____50___   ____60___

     IF SPACE IS 2
          ENTER DUCT ANGLE IN DEGREES: _NA_______

     ENTER DECONTAMINATION FACTOR            DF1          DF2          DF3
      FOR EACH FISSION PRODUCT GROUP: ____1.0____  ____1.0____  ____1.0____

******************************************************************
```

```
****************************  FORM 2  ****************************

SPACE NUMBER: _5______

ENTER NUMBER DESCRIPTION OF SPACE: _5_____
     1 = ROOM
     2 = DUCT
     3 = FILTER
     4 = RESISTANCE, e.g. leaky door
     5 = END DESCRIPTION

IF SPACE IS 1,2,3,4
                                      HEIGHT       WIDTH      LENGTH
     ENTER DIMENSIONS IN FEET:     ___NA____    ___NA___   ___NA___

     IF SPACE IS 2
          ENTER DUCT ANGLE IN DEGREES: _NA________

     ENTER DECONTAMINATION FACTOR          DF1          DF2          DF3
      FOR EACH FISSION PRODUCT GROUP: ____NA_____  ____NA_____  ____NA_____

******************************************************************
```

```
****************************  FORM 3  ****************************

CONCENTRATIONS ENTERING NODE 1.

TIME STEP: 1

ENTER DATA ENTRY TIME (MIN.): 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 1: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 2: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 3: 0.0

******************************************************************
```

```
****************************  FORM 3  ****************************

CONCENTRATIONS ENTERING NODE 1.

TIME STEP: 2

ENTER DATA ENTRY TIME (MIN.): 100.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 1: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 2: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 3: 0.0

******************************************************************
```

```
****************************  FORM 3  ****************************

CONCENTRATIONS ENTERING NODE 1.

TIME STEP: 3

ENTER DATA ENTRY TIME (MIN.): 200.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 1: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 2: 0.0

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 3: 0.0

******************************************************************
```

```
****************************  FORM 4  ****************************

TIME STEP: 1                  NODE NUMBER: 1

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

******************************************************************
```

```
****************************  FORM 4  ****************************

TIME STEP: 2                  NODE NUMBER: 1

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

******************************************************************
```

**************************** FORM 4 ****************************

TIME STEP: 3 NODE NUMBER: 1

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

**************************** FORM 4 ****************************

TIME STEP: 1 NODE NUMBER: 2

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

**************************** FORM 4 ****************************

TIME STEP: 2 NODE NUMBER: 2

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

**************************** FORM 4 ****************************

TIME STEP: 3 NODE NUMBER: 2

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 15000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 15000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

```
***************************** FORM 4 *****************************

TIME STEP: _1_____          NODE NUMBER: _3_____

ENTER DOWNSTREAM PRESSURE (PSIG): _0.0________

ENTER DOWNSTREAM TEMPERATURE (C): _25.0_______

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: _15000.0______

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : __5000.0______

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: _0.0__________

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: _10000.0______

******************************************************************
```

```
***************************** FORM 4 *****************************

TIME STEP: _2_____          NODE NUMBER: _3_____

ENTER DOWNSTREAM PRESSURE (PSIG): _0.0________

ENTER DOWNSTREAM TEMPERATURE (C): _25.0_______

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: _15000.0______

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : __5000.0______

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: _0.0_____________

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: _10000.0_________

******************************************************************
```

```
****************************  FORM 4  ****************************

TIME STEP: _3_____               NODE NUMBER: _3______

ENTER DOWNSTREAM PRESSURE (PSIG): _0.0_______

ENTER DOWNSTREAM TEMPERATURE (C): _25.0______

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: _15000.0_______

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : __5000.0_______

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: _0.0_________

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: _10000.0_______

******************************************************************


****************************  FORM 4  ****************************

TIME STEP: _1_____               NODE NUMBER: _4_____

ENTER DOWNSTREAM PRESSURE (PSIG): _0.0_______

ENTER DOWNSTREAM TEMPERATURE (C): _25.0______

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: __5000.0_______

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : __5000.0_______

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: _0.0_________

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: _0.0_________

******************************************************************
```

```
****************************  FORM 4  ****************************

TIME STEP: 2                     NODE NUMBER: 4

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 5000.0

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : 5000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

******************************************************************
```

```
****************************  FORM 4  ****************************

TIME STEP: 3                     NODE NUMBER: 4

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 5000.0

ENTER FLOW (ACFM) FROM NODE N  TO  SPACE  N : 5000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

******************************************************************
```

***************************** FORM 4 *****************************

TIME STEP: 1 NODE NUMBER: 5

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 5000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 5000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

***************************** FORM 4 *****************************

TIME STEP: 2 NODE NUMBER: 5

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 5000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 5000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

**************************** FORM 4 ****************************

TIME STEP: 3 NODE NUMBER: 5

ENTER DOWNSTREAM PRESSURE (PSIG): 0.0

ENTER DOWNSTREAM TEMPERATURE (C): 25.0

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: 5000.0

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : 5000.0

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: 0.0

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: 0.0

****

****************************** FORM 5 ******************************

SPACE NUMBER: ______

DOES ROOM HAVE ACTIVE SPRAYS: 1=YES <u>0=NO</u>

IF YES

ENTER DROP DIAMETER MULTIPLIER: NA

SPRAY FLOW RATE (GPM): NA

SPRAY HEIGHT (FT): NA

TIME SPRAYS GO ON (MIN): NA

TIME SPRAYS GO OFF (MIN): NA

****

****************************** FORM 5 ******************************

SPACE NUMBER: ______

DOES ROOM HAVE ACTIVE SPRAYS: 1=YES <u>0=NO</u>

IF YES

ENTER DROP DIAMETER MULTIPLIER: NA

SPRAY FLOW RATE (GPM): NA

SPRAY HEIGHT (FT): NA

TIME SPRAYS GO ON (MIN): NA

TIME SPRAYS GO OFF (MIN): NA

****

B.2 BLDINPT2 GENERATED INPUT FILE

```
SAMPLE PUFF RELEASE CASE
          3              5              1        1.000000
    1.000000E-08   1.000000E-08   1.000000E-08
    0.000000E+00     100.000000     200.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
          1      50.000000      60.000000     100.000000        1.000000
       1.000000       1.000000
          2      10.000000      10.000000     100.000000        1.000000
       1.000000       1.000000
      45.000000
          3       1.000000       1.000000       1.000000        1.000000
      20.000000    2000.000000
          1      12.000000      50.000000      60.000000        1.000000
       1.000000       1.000000
   15000.000000   15000.000000   15000.000000
   15000.000000   15000.000000   15000.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
      25.000000      25.000000      25.000000
   15000.000000   15000.000000   15000.000000
   15000.000000   15000.000000   15000.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
      25.000000      25.000000      25.000000
    5000.000000    5000.000000    5000.000000
   15000.000000   15000.000000   15000.000000
   10000.000000   10000.000000   10000.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
      25.000000      25.000000      25.000000
    5000.000000    5000.000000    5000.000000
    5000.000000    5000.000000    5000.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
      25.000000      25.000000      25.000000
    5000.000000    5000.000000    5000.000000
    5000.000000    5000.000000    5000.000000
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
    0.000000E+00   0.000000E+00   0.000000E+00
      25.000000      25.000000      25.000000
          0
          0
```

B.3 PART OF SAMPLE CASE OUTPUT FILE

```
SAMPLE PUFF RELEASE CASE
   NODES=     5
   NDATA=     3
   NPUFF=     1
   DMULT=     1.0000
   CPUFF(I)=     1.0000E-08   1.0000E-08   1.0000E-08
   TNDATA(I)=    0.0000E+00   1.0000E+02   2.0000E+02
   K =    1
   CONC(K,J)=    0.0000E+00   0.0000E+00   0.0000E+00
   K =    2
   CONC(K,J)=    0.0000E+00   0.0000E+00   0.0000E+00
   K =    3
   CONC(K,J)=    0.0000E+00   0.0000E+00   0.0000E+00

   SPACE # K=  1   NSPACE(K)=  1
     HEIGHT(K)=    50.000   WIDTH(K)=    60.000     LENGTH(K)=  100.000
     DF1(K)= 1.0000E+00     DF2(K)= 1.0000E+00     DF3(K)= 1.0000E+00

   SPACE # K=  2   NSPACE(K)=  2
     HEIGHT(K)=    10.000   WIDTH(K)=    10.000     LENGTH(K)=  100.000
     DF1(K)= 1.0000E+00     DF2(K)= 1.0000E+00     DF3(K)= 1.0000E+00
     SPACE # 2 IS A DUCT, AND HAS AN ANGLE WITH THE HORIZONTAL =  45.00 DEGREES

   SPACE # K=  3   NSPACE(K)=  3
     HEIGHT(K)=     1.000   WIDTH(K)=     1.000     LENGTH(K)=    1.000
     DF1(K)= 1.0000E+00     DF2(K)= 2.0000E+01     DF3(K)= 2.0000E+03

   SPACE # K=  4   NSPACE(K)=  1
     HEIGHT(K)=    12.000   WIDTH(K)=    50.000     LENGTH(K)=   60.000
     DF1(K)= 1.0000E+00     DF2(K)= 1.0000E+00     DF3(K)= 1.0000E+00

   NODE  1  NDATA = 1... 3
   FR(K,J)=         15000.000     15000.000     15000.000
   FRO(K,J)=        15000.000     15000.000     15000.000
   FROUT(K,J)=           .000          .000          .000
   FRIN(K,J)=            .000          .000          .000
   PDATA(K,J)=           .000          .000          .000
   TDATA(K,J)=         25.000        25.000        25.000
   NODE  2  NDATA = 1... 3
   FR(K,J)=         15000.000     15000.000     15000.000
   FRO(K,J)=        15000.000     15000.000     15000.000
   FROUT(K,J)=           .000          .000          .000
   FRIN(K,J)=            .000          .000          .000
   PDATA(K,J)=           .000          .000          .000
   TDATA(K,J)=         25.000        25.000        25.000
   NODE  3  NDATA = 1... 3
   FR(K,J)=          5000.000      5000.000      5000.000
   FRO(K,J)=        15000.000     15000.000     15000.000
   FROUT(K,J)=      10000.000     10000.000     10000.000
   FRIN(K,J)=            .000          .000          .000
```

```
PDATA(K,J)=          .000         .000         .000
TDATA(K,J)=        25.000       25.000       25.000
NODE  4  NDATA = 1... 3
FR(K,J)=         5000.000     5000.000     5000.000
FRO(K,J)=        5000.000     5000.000     5000.000
FROUT(K,J)=          .000         .000         .000
FRIN(K,J)=           .000         .000         .000
PDATA(K,J)=          .000         .000         .000
TDATA(K,J)=        25.000       25.000       25.000
NODE  5  NDATA = 1... 3
FR(K,J)=         5000.000     5000.000     5000.000
FRO(K,J)=        5000.000     5000.000     5000.000
FROUT(K,J)=          .000         .000         .000
FRIN(K,J)=           .000         .000         .000
PDATA(K,J)=          .000         .000         .000
TDATA(K,J)=        25.000       25.000       25.000
```

CALCULATED OUTPUT AT .00 MINUTES

CONCENTRATIONS ENTERING NODES, CORE FRACTIONS/FT**3

NOBLE GASES

0.0000E+00	1.0000E-08	0.0000E+00	0.0000E+00	0.0000E+00

IODINE,I2

0.0000E+00	1.0000E-08	0.0000E+00	0.0000E+00	0.0000E+00

PARTICLES

0.0000E+00	1.0000E-08	0.0000E+00	0.0000E+00	0.0000E+00

CONCENTRATIONS LEAVING NODES, CORE FRACTIONS/ FT**3

NOBLE GASES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

IODINE,I2

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PARTICLES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

AVG RATES OF FISSION PRODUCTS LEAVING NODES, CORE FRACTIONS/MIN

NOBLE GASES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

IODINE,I2

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PARTICLES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

CALCULATED OUTPUT AT 10.00 MINUTES

CONCENTRATIONS ENTERING NODES, CORE FRACTIONS/FT**3

NOBLE GASES

0.0000E+00	6.0653E-09	8.0327E-09	4.0163E-09	1.5074E-09

IODINE,I2

0.0000E+00	5.1600E-09	3.9705E-09	9.9263E-11	3.1914E-11

PARTICLES

0.0000E+00	3.8518E-09	2.7656E-09	6.9141E-13	2.0426E-13

CONCENTRATIONS LEAVING NODES, CORE FRACTIONS/ FT**3

NOBLE GASES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

IODINE,I2

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

PARTICLES

0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

AVG RATES OF FISSION PRODUCTS LEAVING NODES, CORE FRACTIONS/MIN

NOBLE GASES

0.0000E+00	1.2049E-04	2.0082E-05	1.0041E-05	3.7686E-06

IODINE,I2

0.0000E+00	1.1370E-04	9.9263E-06	2.4816E-07	7.9784E-08

PARTICLES

0.0000E+00	1.0389E-04	6.9141E-06	1.7285E-09	5.1066E-10

CALCULATED OUTPUT AT 200.00 MINUTES

CONCENTRATIONS ENTERING NODES, CORE FRACTIONS/FT**3

NOBLE GASES

0.0000E+00	4.5400E-13	6.0126E-13	7.9628E-13	1.3442E-12

IODINE,I2

0.0000E+00	1.7904E-14	1.3777E-14	1.0119E-15	1.4033E-15

PARTICLES

0.0000E+00	3.9231E-14	4.5597E-14	3.1125E-17	4.5841E-17

CONCENTRATIONS LEAVING NODES, CORE FRACTIONS/ FT**3

NOBLE GASES

0.0000E+00	9.9131E-13	1.3128E-12	2.2163E-12	0.0000E+00

IODINE,I2

0.0000E+00	2.6700E-14	1.9611E-15	2.7197E-15	0.0000E+00

PARTICLES

0.0000E+00	7.8902E-14	5.3880E-17	7.9237E-17	0.0000E+00

AVG RATES OF FISSION PRODUCTS LEAVING NODES, CORE FRACTIONS/MIN

NOBLE GASES

0.0000E+00	9.0189E-09	3.9814E-09	5.2728E-09	8.9013E-09

IODINE,I2

0.0000E+00	3.9452E-10	1.0119E-10	7.4325E-12	1.0308E-11

PARTICLES

0.0000E+00	8.0432E-10	3.1125E-10	2.1264E-13	3.1282E-13

APPENDIX C

BLANK BLDINPT2 FORMS

APPENDIX C

BLANK BLDINPT2 FORMS

**************************** FORM 1 ****************************

FILENAME TO BE CREATED: ____________________

HEADING FOR FILE (80 CHAR): ____________________________________

ENTER THE NUMBER OF SPACES: _____

COMPLETE ONE FORM 2 FOR EACH SPACE.

ENTER THE NUMBER OF TIME STEPS FOR DATA INPUT: _____

COMPLETE ONE FORM 3 FOR EACH TIME STEP.

COMPLETE ONE FORM 4 FOR EACH TIME STEP AT EACH NODE.

IS PUFF RELEASE IN SPACE 1 (ROOM) AT TIME(1) (0. MIN) ?: 1=YES 0=NO

ENTER PUFF CONCENTRATIONS IN CORE FRACTIONSS/FT**3
FOR EACH PRODUCT GROUP.

1) ________________________

2) ________________________

3) ________________________

ENTER PARTICLE DIAMETER MULTIPLIER: _________

COMPLETE ONE FORM 5 FOR EACH SPACE THAT IS A ROOM.

****

**************************** FORM 2 ****************************

SPACE NUMBER: _______

ENTER NUMBER DESCRIPTION OF SPACE: ______

1 = ROOM
2 = DUCT
3 = FILTER
4 = RESISTANCE, e.g. leaky door
5 = END DESCRIPTION

IF SPACE IS 1,2,3,4

	HEIGHT	WIDTH	LENGTH
ENTER DIMENSIONS IN FEET:	__________	__________	__________

IF SPACE IS 2
ENTER DUCT ANGLE IN DEGREES: __________

	DF1	DF2	DF3
ENTER DECONTAMINATION FACTOR FOR EACH FISSION PRODUCT GROUP:	__________	__________	__________

****

**************************** FORM 3 ****************************

CONCENTRATIONS ENTERING NODE 1.

TIME STEP: _______

ENTER DATA ENTRY TIME (MIN.): __________

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 1: __________

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 2: __________

ENTER CONCENTRATION OF FISSION PRODUCT GROUP 3: __________

****

***************************** FORM 4 *****************************

TIME STEP: _______ NODE NUMBER: _______

ENTER DOWNSTREAM PRESSURE (PSIG): ___________

ENTER DOWNSTREAM TEMPERATURE (C): ___________

ENTER FLOW (ACFM) INTO NODE N FROM SPACE N-1: ______________

ENTER FLOW (ACFM) FROM NODE N TO SPACE N : ______________

ENTER FLOW (ACFM) INTO NODE N FROM OUTSIDE FLOW PATH: ______________

ENTER FLOW (ACFM) FROM NODE N OUT OF FLOW PATH: ______________

****

***************************** FORM 5 *****************************

SPACE NUMBER: _____

DOES ROOM HAVE ACTIVE SPRAYS: 1=YES 0=NO

IF YES

ENTER DROP DIAMETER MULTIPLIER: ____________

SPRAY FLOW RATE (GPM): ____________

SPRAY HEIGHT (FT): ____________

TIME SPRAYS GO ON (MIN): ____________

TIME SPRAYS GO OFF (MIN): ____________

****

APPENDIX D

BLDINPT2 LISTING

APPENDIX D

BLDINPT2 LISTING

```
C***********************************************************************
C
C
      PROGRAM BLDINPUT
C
C     THIS PROGRAM BUILDS AN INPUT FILE FOR USE BY FPFP_2
C
C
C***********************************************************************
      CHARACTER HEAD1*80
      CHARACTER RESP*1

      REAL LENGTH(20)

      DIMENSION CONC(30,3),FR(30,20),FROUT(30,20),FRO(30,20),
     .   FRIN(30,20),TNDATA(30),PDATA(30,20),TDATA(30,20),
     .   NSPACE(20),HEIGHT(20),WIDTH(20),DF1(20),DF2(20),DF3(20),
     .   cpuff(7),nspray(20),dspray(20),hspray(20),vspray(20),
     .   tson(20),tsoff(20),THETA(20)

      CHARACTER*12 OUTFILE,NEWFILE
      CHARACTER*10 STYPE(4)

      DATA STYPE / '      ROOM','      DUCT','    FILTER','RESISTANCE'/


      WRITE(*,1)
    1 FORMAT(/' Program Title:   FPFP.'//
     + ' Developed For:   U.S. Nuclear Regulatory Commission'/
     + '                  Office of Nuclear Regulatory Research'/
     + '                  Division of Reactor Accident Analysis'//
     + ' Date:            June 1990'//
     + ' NRC Contact(s):  C. Ferrell       Phone: (FTS) 492-3944'/
     + ' Code Developer:  P. C. Owczarcki   Phone: (509) 376-1701'/
     + '                                          (FTS) 444-1701'//
     + ' Code Documentation: '//
     + ' The program was prepared for an agency of the United States',
     + ' Government. Neither'/' the United States Government nor any',
     + ' agency thereof, nor any of their'/' employees, makes any',
     + ' warranty, expressed or implied, or assumes any legal'/
     + ' liability or responsibilities for any third party''s use,',
     + ' or the results of such'/' use, of any portion of this',
     + ' program or represents that its use by such third'/' party',
     + ' would not infringe privately owned rights. '// )
```

```
      WRITE(*,2)
2     FORMAT(1X,'Press RETURN to Continue')
      READ(5,'(A)')RESP

      WRITE(*,'(/A)') ' ***********************************************'
      WRITE(*,'(A)')  ' ***********   PROGRAM BLDINPUT   **************'
      WRITE(*,'(A)')  ' ********   AN INTERACTIVE PROGRAM   ***********'
      WRITE(*,'(A)')  ' ********   TO CREATE AN INPUT FILE  ***********'
      WRITE(*,'(A)')  ' ***********   FOR PROGRAM FPFP   **************'
      WRITE(*,'(A)')  ' ***********************************************'

      WRITE(*,600)
600   FORMAT(//,' ENTER THE FILENAME TO BE CREATED > ',$)
      READ(*,'(A)')OUTFILE
699   OPEN(UNIT=1,FILE=OUTFILE,STATUS='NEW',IOSTAT=IER)
      IF(IER .EQ. 6415) THEN
        WRITE(*,601)OUTFILE
601     FORMAT(/,5X,'* * * ',A12,' ALREADY EXISTS * * *',/)
        WRITE(*,602)
602     FORMAT(' ENTER A NEW FILENAME,',
     *         ' OR HIT <RETURN> TO OVERWRITE OLD FILE > ',$)
        READ(*,'(A)')NEWFILE
        IF(NEWFILE(1:3) .EQ. '   ') THEN
          WRITE(*,603)OUTFILE
603       FORMAT(/,5X,A12,' WILL BE OVERWRITTEN',/)
          OPEN(UNIT=1,FILE=OUTFILE,STATUS='UNKNOWN')
        ELSE
          WRITE(*,604)NEWFILE
604       FORMAT(/,5X,A12,' WILL BE OPENED',/)
          OUTFILE = NEWFILE
          GOTO 699
        ENDIF
      ENDIF

   10 WRITE(*,'(/A)') ' ENTER A HEADING -- 80 CHARACTERS MAXIMUM '
      READ(*,'(A)',ERR=10) HEAD1
      WRITE(*,'(A)') HEAD1
      WRITE(1,'(A)') HEAD1

C     BUILD FLOW PATH

      WRITE(*,'(/A)') ' DESCRIBE FLOW PATH '

      NODES = 1

  100 CONTINUE

      WRITE(*,'(/A,I2)') ' ENTER NUMBER DESCRIPTION OF SPACE ', NODES
      WRITE(*,'(A)')     '   1 == ROOM'
      WRITE(*,'(A)')     '   2 == DUCT'
      WRITE(*,'(A)')     '   3 == FILTER'
      WRITE(*,'(A)')     '   4 == RESISTANCE, e.g. leaky door'
```

```
      IF( NODES .GT. 1 )
     .   WRITE(*,'(A)')      '    5 == DONE WITH DESCRIPTION'
      READ(*,'(BN,I2)',ERR=100) KOPT

      IF( KOPT .LT. 1 .OR. KOPT .GT. 5 ) THEN
        GOTO 100
      ELSE IF ( KOPT .NE. 5 ) THEN
        WRITE(*,'(A,I2,A,A)') '    SPACE',NODES,' IS A ',STYPE(KOPT)
        NSPACE(NODES) = KOPT
  110   WRITE(*,'(A,A,I2,/A)') '    ENTER HEIGHT, WIDTH AND LENGTH IN FT'
     .         ,' FOR SPACE ',NODES,'    SEPARATED BY COMMAS'
        READ(*,'(BN,3F10.0,)',ERR=110) HEIGHT(NODES),WIDTH(NODES),
     .                              LENGTH(NODES)
        WRITE(*,'(5X,3(A,1PE10.2))') 'HEIGHT =',HEIGHT(NODES),' WIDTH ='
     .          , WIDTH(NODES), ' LENGTH =', LENGTH(NODES)
        IF(KOPT .EQ. 2) THEN
          WRITE(*,'(/,A,A,I2,/,A,A)')'    ENTER ANGLE OF DUCT WITH',
     .          ' HORIZONTAL FOR SPACE ',NODES,'.  ENTER ANGLE',
     .          ' IN DEGREES, 0 = HORIZONTAL'
          READ(*,'(F8.0)')THETA(NODES)
          WRITE(*,'(5X,A,1PE10.2)') 'DUCT ANGLE = ',THETA(NODES)
        ENDIF

C     SET DECONTAMINATION FACTORS FOR SPACE

        IF( KOPT .NE. 3 ) THEN
          DF1(NODES) = 1.0
          DF2(NODES) = 1.0
          DF3(NODES) = 1.0
        ELSE
  120     WRITE(*,'(A,A,/A)')'    ENTER DECONTAMINATION FACTOR FOR EACH'
     .      ,' FISSION PRODUCT GROUP -- ','    SEPARATED BY COMMAS'
          READ(*,'(BN,3F10.0)',ERR=120) DF1(NODES),DF2(NODES),DF3(NODES)
          WRITE(*,'(A,3F10.1)') '    DECONTAMINATION FACTORS ARE:',
     .         DF1(NODES), DF2(NODES), DF3(NODES)
        ENDIF

        NODES = NODES + 1
        IF( NODES .LT. 21 ) THEN
          GOTO 100
        ELSE
          WRITE(*,'(//A)') ' TOO MANY SPACES '
          STOP
        ENDIF
      ENDIF

C     ENTER TIMES AND CONCENTRATIONS AT THE INITIAL FLOW PATH NODE

  200 WRITE(*,'(/A,A)')' ENTER THE NUMBER OF TIME STEPS FOR DATA INPUT',
     .      ', MAX = 30 '
      READ(*,'(BN,I4)',ERR=200) NDATA
      WRITE(*,'(2X,I4,A)') NDATA,' DATA ENTRY TIMES '
```

```
      WRITE(*,'(/A,A)')' ** ENTER TIME AND CORRESPONDING ',
     .   'CONCENTRATIONS AT INITIAL FLOW PATH NODE **'

      DO 240  I = 1,NDATA
  210   WRITE(*,'(/A,I3)') ' ENTER DATA ENTRY TIME IN MIN ',I
        READ(*,'(BN,F10.0)',ERR=210) TNDATA(I)
        WRITE(*,'(A,I2,A,F7.1)')' DATA ENTRY TIME ', I, ' = ',TNDATA(I)

        DO 230  J = 1,3
  220     WRITE(*,'(A,A,I2,A)')'   ENTER CONCENTRATION OF FISSION',
     .          ' PRODUCT GROUP ',J,' IN CORE FRACTION/FT**3'
          READ(*,'(BN,F15.0)',ERR=220) CONC(I,J)
          WRITE(*,'(A,I2,A,1PE10.2)') '   FISSION PRODUCT GROUP',J,
     .          ' CONCENTRATION = ', CONC(I,J)
  230   CONTINUE
  240 CONTINUE

C     DEFINE FLOWS, PRESSURES AND TEMPERATURES AT NODES AS FUNCTIONS
C        OF TIME

      WRITE(*,'(A,A)') ' DEFINE PRESSURES, TEMPERATURES AND FLOWS AT ',
     .                 'NODES AS FUNCTIONS OF TIME'

      DO 370 I = 1,NODES
        DO 360 J = 1,NDATA

          WRITE(*,'(/A,I2,A,F7.1)') ' NODE = ', I,' TIME = ',TNDATA(J)
  300     WRITE(*,'(A)') ' ENTER DOWNSTREAM PRESSURE, PSIG '
          READ(*,'(BN,F10.0)',ERR=300) PDATA(J,I)
  310     WRITE(*,'(A)') ' ENTER DOWNSTREAM TEMPERATURE, C'
          READ(*,'(BN,F10.0)',ERR=310) TDATA(J,I)
  320     WRITE(*,'(A,I2,A,I2)') ' ENTER FLOW (ACFM) INTO NODE ',I,
     .          ' FROM SPACE ',I-1
          READ(*,'(BN,F10.0)',ERR=320) FRO(J,I)
  330     WRITE(*,'(A,I2,A,I2)') ' ENTER FLOW (ACFM) FROM NODE ',I,
     .          ' TO SPACE ',I
          READ(*,'(BN,F10.0)',ERR=330) FR(J,I)
  340     WRITE(*,'(A,I2,A)') ' ENTER FLOW (ACFM) INTO NODE ',I,
     .          ' FROM OUTSIDE FLOW PATH'
          READ(*,'(BN,F10.0)',ERR=340) FRIN(J,I)
  350     WRITE(*,'(A,I2,A)') ' ENTER FLOW (ACFM) FROM NODE ',I,
     .          ' OUT OF FLOW PATH'
          READ(*,'(BN,F10.0)',ERR=350) FROUT(J,I)
          WRITE(*,'(A,/6(1PE12.2))') ' PRESSURE, TEMPERATURE & FLOWS',
     .          PDATA(J,I),TDATA(J,I),FRO(J,I),FR(J,I),FRIN(J,I),
     .          FROUT(J,I)

  360   CONTINUE
  370 CONTINUE
```

```
c     DEFINE PUFF RELEASE

  380 write(*,'(/a,a)')  ' PUFF RELEASE IN SPACE 1 = ROOM AT',
     .                   '  TNDATA(1)=0.?  YES = 1, NO = 0'
      read(*,'(bn,i4)',ERR=381) npuff
 381  IF(NPUFF .NE. 1 .AND. NPUFF .NE. 0) GOTO 380

  500 write(*,'(a,a,a)') ' ENTER PUFF CONCENTRATIONS IN',
     .' CORE FRACTIONSS/FT**3 FOR EACH PRODUCT GROUP.',
     .' SEPARATE BY COMMAS.'
      read(*,'(bn,3f10.0)',err=500)(cpuff(i),i=1,3)
  540 continue

c     DEFINE PARTICLE DIAMETER MULTIPLIER

  550 write(*,'(a)')' ENTER PARTICLE DIAMETER MULTIPLIER'
      read(*,'(bn,f10.0)',err=550)dmult

c     DEFINE SPRAY USAGE

      do 400 i=1,nodes-1
      if(nspace(i).ne.1) go to 390
  430 write(*,'(a,i2,a)') ' DOES SPACE(',I,') HAVE ACTIVE SPRAYS?'
      write(*,'(a)') ' ENTER 1 IF YES, 0 IF NO'
      read(*,'(bn,i4)',err=430) nspray(i)
      if(nspray(i).ne.1)go to 390
  440 write(*,'(a,/,a,/,a)') ' ENTER DROP DIAM MULTIPLIER; SPRAY FLOW
     .RATE, GPM; SPRAY HEIGHT, FT','TIME SPRAYS GO ON, MIN; AND
     .TIME SPRAYS GO OFF, MIN.','  SEPARATE BY COMMAS.'
      read(*,'(bn,5f10.0)',err=440)dspray(i),vspray(i),hspray(i),
     .tson(i),tsoff(i)
  390 continue
  400 continue

C     WRITE DATA TO FILE FPFP_2.DAT

      WRITE(1,*) NDATA,NODES,npuff,dmult
      if(npuff.eq.1)then
       write(1,*)(cpuff(i),i=1,3)
      end if
      WRITE(1,*) (TNDATA(I), I=1,NDATA)

      DO 405 K=1,NDATA
        WRITE(1,*)(CONC(K,J),J=1,3)
  405 CONTINUE

      DO 410 K=1,NODES-1
        WRITE(1,*)NSPACE(K),HEIGHT(K),WIDTH(K),LENGTH(K),DF1(K),DF2(K),
     +  DF3(K)
        IF(NSPACE(K) .EQ. 2) WRITE(1,*)THETA(K)
  410 CONTINUE
```

```
      DO 420 J=1,NODES
        WRITE(1,*)(FR(K,J),K=1,NDATA)
        WRITE(1,*)(FRO(K,J),K=1,NDATA)
        WRITE(1,*)(FROUT(K,J),K=1,NDATA)
        WRITE(1,*)(FRIN(K,J),K=1,NDATA)
        WRITE(1,*)(PDATA(K,J),K=1,NDATA)
        WRITE(1,*)(TDATA(K,J),K=1,NDATA)
420   CONTINUE

      do 450 k=1,nodes-1
      if(nspace(k).eq.1)write(1,*)nspray(k)
      if(nspray(k).ne.1)go to 445
      write(1,*)dspray(k),hspray(k),vspray(k),tson(k),tsoff(k)
445   continue
450   continue

      RETURN
      END
```

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