**Appendix A**

**Input Instructions for the ATHENA Code**

**Appendix A Input Instructions for the FRAPCON-3 Code**

# Input Structure

The NAMELIST input is divided into four sections: case control integers (in $FRPCN); case design and operation descriptors (real and integer variables) located in ($FRPCON); evaluation model options (in $EMFPCN); and plutonium isotopic distributions (in $FRPMOX). The variables in the first group must be separated by commas and placed between the statement

$FRPCN and $END. Similarly, the variables in the second, third, and fourth groups must be placed between $FRPCON and $END, between $EMFPCN and $END, and between $FRPMOX and $END, respectively.

Before the NAMELIST input, the following lines must be included in the input file: FILE05='nullfile', STATUS='UNKNOWN', FORM='FORMATTED',

CARRIAGE CONTROL='NONE'

This line sets up a file called “nullfile” which is needed by FRAPCON-3.5. FILE06=’file.out', STATUS='UNKNOWN', CARRIAGE CONTROL='LIST'

This line specifies the name of the output file. In this case the output file would be called “file.out.”

FILE66='file.plot', STATUS='UNKNOWN', FORM='FORMATTED', CARRIAGE CONTROL='LIST'

This line is needed if a plot output file is being created. (see definition of variable NPLOT) In this case the plot file would be called “file.plot.”

FILE22=’file.restart', STATUS='UNKNOWN'

This line is needed if a FRAPTRAN restart file is being created (see definition of variable NTAPE). In this case the restart file would be called “file.restart.”

The above four lines should not exceed 72 spaces, and if they do, continue on the next line with no continuation symbols needed.

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* The line seen above, which is preceded by the character “/”, tells the code that the lines

specifying files are complete.

The line immediately after this line is reserved for the case description that will be displayed in the page headers in the output. Up to 72 characters can be inserted here to describe the case.

After this line the NAMELIST input can be entered. In the above section any line with a “\*” in column 1 is considered a comment and will not be read by the code. An example case input is given in Section 2 below.

The following tables describe the input variables to FRAPCON3.5. Unless otherwise noted in the Limitations/Default value column, the variables should be placed in the $frpcon data input block.

# Rod Size

**Input Variables Specifying Rod Design**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| dco (R) | Cladding outer diameter  包壳外径 | inches / meters | Required Input |
| thkcld  (R) | Cladding wall thickness  包壳壁厚 | inches / meters | Required Input |
| thkgap (R) | Pellet-cladding as-fabricated radial gap thickness  芯块包壳制造间隙径向宽度 | inches / meters | Required Input |
| totl (R) | The total (active) fuel column length  燃料棒（活性区）总长 | feet / meters | Required Input |
| cpl (R) | Cold plenum length  冷态气腔长度 | inches / meters | Required Input |

**Spring Dimensions**

(R) = real, (I) = integer

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| dspg (R) | Outer diameter of plenum spring  气腔弹簧外径 | inches / meters | Required Input  (*dgpg* should be less than the clad inner diameter) |
| dspgw (R) | Diameter of the plenum spring wire  气腔弹簧丝径 | inches / meters | Required Input |
| vs (R) | Number of turns in the plenum spring  气腔弹簧圈数 | Dimensionless | Required Input |

(R) = real, (I) = integer

# Pellet Shape

**Input Variables Specifying Pellet Fabrication**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| hplt (R) | Height (length) of each pellet  单一芯块高度（长度） | inches / meters | Required Input |
| rc (R) | The inner pellet radius  芯块内径  May input one value for entire pellet stack or input values as an array for each axial node starting at the bottom. | inches / meters | Default = 0.0 |
| hdish (R) | Height (depth) of pellet dish, assumed to be a spherical indentation  芯块碟形坑高度（深度） | inches / meters | Default = 0.0 |
| dishsd (R) | Pellet end-dish shoulder width  芯块碟形坑肩宽  (outer radius of fuel pellet minus radius of dish) | inches / meters | Default = 0.0 |
| chmfrh (R) | Chamfer height  倒角高度 | inches / meters | Default = 0.0 |
| chmfrw (R) | Chamfer width  倒角宽度 | inches / meters | Default = 0.0 |

**Pellet Isotopics**

(R) = real, (I) = integer

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name (type) | Description | Units British/SI | Limitations/Default Value |
| enrch (R) | Fuel pellet U-235 enrichment  燃料芯块U-235富集度  May input one value for entire  pellet stack or input values as  an array for each axial node starting at the bottom. | Atom % U-235 in total U | Required Input |
| imox (I) | Index for modeling MOX:  MOX模型种类  0 = UO2 fuel  >0 = mixed oxide fuel  1 = use Duriez/Ronchi/NFI Mod thermal conductivity correlation  2 = use Halden thermal conductivity correlation  (if *imox*>0, must include *comp*  and namelist $FRPMOX) | Dimensionless | Default = 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| comp (R) | Weight percent of plutonia in fuel  燃料内二氧化钚质量分数  (Must specify if *imox*>0) | Weight percent | Default = 0.0 |
| moxtype (I) | Type of Pu used in MOX  MOX燃料内钚的类型  moxtype = 1 reactor grade moxtype = 2 weapons grade | Dimensionless | Default = 1 (namelist frpmox) |
| enrpu39 (R) | Fuel pellet Pu-239 content  燃料芯块Pu-239含量 | Atom % Pu-239 in total Pu | Default = 0.0 (namelist frpmox) |
| enrpu40 (R) | Fuel pellet Pu-240 content  燃料芯块Pu-240含量 | Atom % Pu-240 in total Pu | Default = 0.0 (namelist frpmox) |
| enrpu41 (R) | Fuel pellet Pu-241 content  燃料芯块Pu-241含量 | Atom % Pu-241 in total Pu | Default = 0.0 (namelist frpmox) |
| enrpu42 (R) | Fuel pellet Pu-242 content  燃料芯块Pu-242含量 | Atom % Pu-242 in total Pu | Default = 0.0 (namelist frpmox) |
| fotmtl (R) | Oxygen-to-metal atomic ratio in the oxide fuel pellet  氧化物燃料芯块氧-金属原子比 | Dimensionless | Default = 2.0  (If MOX fuel is selected, *fotmtl* should be less than 2.0.) |
| gadoln (R) | Weight fraction of gadolinia in urania-gadolinia fuel pellets  含钆燃料芯块钆的质量份额  May input one value for entire pellet stack or input values as an array for each axial node starting at the bottom. | Dimensionless | Default = 0.0 |
| ifba (R) | Percent of IFBA rods in the core  堆芯IFBA（一体化燃料可燃吸收体）棒比例 | % | Default = 0.0 |
| b10 (R) | Boron-10 enrichment in ZrB2  ZrB2 内硼-10富集度 | Atom % | Default = 0.0 |
| zrb2thick (R) | ZrB2 layer thickness on pellets  芯块ZrB2 涂层厚度 | inches, meters | Default = 0.0 |
| zrb2den (R) | Percent theoretical density of ZrB2  ZrB2 理论密度占比  TD=6.08 g/cm³  TD：理论密度 | % theoretical density | Default = 90.0 |
| ppmh2o (R) | Parts per million by weight of moisture in the as-fabricated pellets  制造芯块内水汽质量百万分率 | ppm | Default = 0.0 |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| ppmn2 (R) | Parts per million by weight of nitrogen in the as-fabricated pellets  制造芯块内氮气质量百万分率 | ppm | Default = 0.0 |

# Pellet Fabrication

(R) = real, (I) = integer

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| den (R) | As-fabricated apparent fuel density  燃料制造密度 | % of theoretical density | Required Input (Theoretical density taken  as 10.96 g/cm3) |
| deng (R) | Open porosity fraction for pellets  芯块开孔份额 | % of theoretical density | Default = 0.0 |
| roughf (R) | The fuel pellet surface arithmetic mean roughness, peak-to-average  燃料芯块表面算术平均粗糙度，峰值因子 | inches / meters | Default = 7.87×10-5 in / 2.0×10-6 m |
| rsntr (R) | The increase in pellet density expected during in-reactor operation (determined from a standard re-sintering test per NUREG-0085 and Regulatory Guide 1.126)  堆内运行时芯块密度增长期望  *PNNL recommends 0.1 kg/m³ for UO2-Gd2O3 fuel* | kg/m3 | Required Input |
| tsint (R) | Temperature at which pellets were sintered  芯块烧结温度 | °F / K | Default = 2911° F |

(R) = real, (I) = integer

# Input Variables Specifying Cladding Fabrication

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| icm (I) | Cladding Type Indicator:  包壳类型  2 = Zircaloy 2  4 = Zircaloy 4  5 = M5  6 = ZIRLOTM  7 = Optimized ZIRLO™ | Dimensionless | Required Input |
| zr2vinage (I) | Flag to select Zircaloy-2 vintage  锆-2生产年代  zr2vintage= 0 older Zircaloy-2 prior to 1998  zr2vintage=1 newer Zircaloy-2 since 1998 | Dimensionless | Default = 1 |
| cldwks (R) | Cold-work of the cladding  包壳冷加工性能  (fractional reduction in cross- section area due to processing).  加工造成的截面积损失份额  PNNL recommends 0.5 for stress relief annealed cladding and 0.0 for fully re-crystallized cladding. | Dimensionless | Default = 0.2 |
| roughc (R) | The cladding surface arithmetic mean roughness, peak-to- average  包壳表面算术平均粗糙度，峰值因子 | inches / meters | Default = 1.97×10-5 in / 5.0×10-7 m |
| catexf (R) | Cladding texture factor; defined as the fraction of cladding cells with basal poles parallel to the longitudinal axis of the cladding tube  包壳织构因子，基极平行于包壳管轴向的包壳晶胞份额 | Dimensionless | Default = 0.05 |
| chorg (R) | As-fabricated hydrogen in cladding  包壳制造含氢量 | ppm wt. | Default = 10.0 |

(R) = real, (I) = integer

# Input Variables Specifying Rod Fill Conditions

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| fgpav (R) | Initial fill gas pressure (taken to be at room temperature)  初始充气压力（室温） | psia / Pa | Required Input |
| idxgas (I) | Initial fill gas type indictator:  初始充气种类  1 = helium  2 = air  3 = nitrogen  4 = fission gas 5 = argon  6 = user-specified mix, using the *amfxx* variables *amfair*, etc. | Dimensionless | Default = 1 |
| amfair (R) | Mole fraction of air; use only if  *idxgas* = 6.  空气摩尔份额 | Mole Fraction | Default = 0.0 |
| amfarg (R) | Mole fraction of argon; use only if *idxgas* = 6.  氩气摩尔份额 | Mole Fraction | Default = 0.0 |
| amffg (R) | Mole fraction of fission gas; use only if *idxgas* = 6 and if *amfxe* and *amfkry* = 0.0.  裂变气体摩尔份额 | Mole Fraction | Default = 0.0 |
| amfhe (R) | Mole fraction of helium; use only *idxgas* = 6.  氦气摩尔份额 | Mole Fraction | Default = 0.0 (note default on *idxgas* = 1 initializes pure He) |
| amfh2 (R) | Mole fraction of hydrogen; use only if *idxgas* = 6.  氢气摩尔份额 | Mole Fraction | Default = 0.0 |
| amfh2o (R) | Mole fraction of water vapor; use only if *idxgas* = 6.  蒸汽摩尔份额 | Mole Fraction | Default = 0.0 |
| amfkry (R) | Mole fraction of krypton; use only if *idxgas* = 6.  氪气摩尔份额 | Mole Fraction | Default = 0.0 |
| amfn2 (R) | Mole fraction of nitrogen; use only if *idxgas* = 6.  氮气摩尔份额 | Mole Fraction | Default = 0.0 |
| amfxe (R) | Mole fraction of xenon; use only if *idxgas* = 6.  氙气摩尔份额 | Mole Fraction | Default = 0.0 |

(R) = real, (I) = integer

# Input Variables Specifying Reactor Conditions

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| iplant (I) | Signal for which type of reactor:  反应堆类型  -2 = PWR  -3 = BWR  -4 = HBWR | Dimensionless | Default = -2 |
| nsp (I) | Signal for time-dependent input arrays for *p2*, *tw*, and *go*:  p2,tw和go的时变输入数组类型  If *nsp* = 0, single values for these three variables will be used for all time steps.  If *nsp* = 1, a value for each variable for each time step must be input. | Dimensionless | Required Input |
| p2(IT)  (R) | Coolant system pressure. Must be input for each time step if *nsp* = 1.  冷态系统压力 | psia / Pa | Required Input |
| tw(IT)  (R) | Coolant inlet temperature. Enter a value for every time step if *nsp* =1.  冷态入口温度 | °F / K | Required Input |
| go(IT)  (R) | Mass flux of coolant around fuel rod. Input a value for each time step if *nsp* = 1. Note that *go* input may have to be adjusted to yield both desired coolant and desired cladding surface temperatures. Concurrent adjustment of *pitch* may also be required.  环燃料棒冷却剂质量流量 | lb/hr-ft2 / kg/s-m2 | Required Input |
| pitch (R) | Center-to-center distance between rods in a square array  正方形排列时燃料棒中心间距 | inches / meters | Required Input  (Must be greater than *dco*) |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| icor (I) | Index for Crud Model:  积垢模型类型  *icor* = 0 or 1 yields constant crud thickness; 0.0 mil crud as default; input *crdt* as constant thickness. Maximum temperature rise permitted across this layer is 20 ºF.  *icor* = 2 yields time-dependent crud; growth rate is *crdtr*, starting from zero crud layer. There is no limit to the temperature rise across the crud when *icor*=2. The conductivity of the layer is 0.5 Btu/hr/ft-F. | Dimensionless | Default = 0 |
| crdt (R) | Initial thickness of crud layer on cladding outside surface  包壳外表面初始积垢层厚度 | mils/meters | Default = 0.0 |
| crdtr (R) | Rate of crud accumulation (used if *icor* = 2)  积垢形成速率 | mils/hr / meters/s | Default = 0.0 |
| crudmult(J-1) (R) | Axial array of multipliers on crud thickness or crud growth rate  积垢厚度或积垢生长速率轴向因子数组 | Dimensionless | Default = 1.0 (optional, must be input for each axial node if used) |
| flux(J) (R) | Conversion between fuel specific power (W/g) and fast neutron flux (n/m2/s, E>1MeV). Input as an axial array; the second value of the array corresponds to the first axial node, the *na*+1 value corresponds to the top axial node.  燃料功率系数和快中子通量的转化率 | neutrons per square meter per second per W/g of fuel | Default = 0.221x1017 (Maximum of 151 values) |

(R) = real, (I) = integer

IT = Time Step Index J = 1 + Axial Node Index

# Input Variables Specifying Power History

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| im (I) | Number of time steps  时间步长数 | Dimensionless | Greater than 1, less than or equal to 1000  Required Input (namelist frpcn) |
| ProblemTime(IT) (R) | Cumulative time at the end of each time step.  每一时间步末的累计时间  Note: Time steps greater than 50 days are not recommended. If steady- state operation is being modeled, use time steps greater than 1 day. Time steps less than 1 day should only be used when modeling a fast power ramp. | days | Required Input Limit 1000 steps |
| qmpy(IT) (R) | The linear heat generation rate at each time step.  每一时间步的线释热率  This equals the rod-average value if *iq* = 0 and the peak value if *iq* = 1. Note: Changes in local LHGR of greater than 1.5 kw/ft per time step are not recommended. Size *qmpy* accordingly. | kW/ft / kW/m | Required Input Limit 1000 steps |

(R) = real, (I) = integer

IT = Time Step Index

# Input Variables Specifying Axial Power Profile

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| iq (I) | Indicator for axial power shape:  轴向功率分布形状  0 = User-input power shapes,  with *qmpy* = rod-average  powers and power shapes defined by *qf*,*x*, and *fa* = 1.0.  1 = Chopped-cosine shape, with *fa* = Peak-to-average ratio and *qmpy* = peak power (use na=odd in order to have an axial node corresponding to the input peak power). | Dimensionless | Required Input |
| x(N)  (R) | The elevations in each *qf*,  （功率计算所用）节点高度  （N表示第几组，可以有多组）  *x* array defining a power shape. Note the first value should be  0.0 and the last value must =  *totl*. | feet / meters | Required Input if *iq*=0 Maximum number of *qf*, *x*  pairs is 150. |
| qf(N)  (R) | The ratio of the linear power at the *x*(N) elevation to the axially- averaged value for the M-th power shape.  节点相对线功率  The number of QF, X pairs for the Mth power shape is defined by *jn*(M). The code will automatically normalize to an average value of 1.0. | Dimensionless | Required Input if *iq* = 0 Maximum number of *qf*, *x*  pairs is 150. |
| jn(M)  (I) | The number of *qf*, *x* value pairs for each axial power shape;  节点总数  required input if *iq* = 0. Input in the same sequence as the *qf* and *x* arrays. | Dimensionless | Required Input if *iq*=0 Maximum number of shapes is 20.  Maximum number of *qf*, *x*  pairs is 40. |
| jst(IT) (I) | The sequential number of the power shape to be used for each time step.  每一时间步长所采用的功率分布序号  One value of *jst* is required per time step if *iq* = 0. | Dimensionless | Required Input if *iq*=0 Maximum number of power shapes is 20.  Maximum time steps is 1000. |
| fa  (R) | Peak-to-average power ratio for  cosine-type axial power distribution  余弦型轴向功率分布的峰值-平均功率比  ( = 1.0, unless *iq* = 1; see description of *iq*). | Dimensionless | Required Input |

(R) = real, (I) = integer

N = Axial Node Index for Input Power Profile M = Power Shape Number, IT = Time Step Index

# Input Variables Specifying Axial Temperature Distribution (Optional)

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| ifixedtsurf (I) | Indicator for using axial temperature distribution  轴向温度分布类型  0 = Cladding temperature will be calculated based on input power and coolant conditions.  1 = Cladding temperature will be specified by the user for certain time steps. Each time step where the temperature will be set by the user, the input variable, *go*, should be set equal to 0.0. | Dimensionless | Default Value = 0 |
| xt(N)  (R) | The elevations in each *cladt*, *xt* array defining a cladding temperature profile.  （温度计算所用）节点高度  Note the first value should be 0.0 and the last value must = *totl*.  Begin the input elevations for the second temperature profile at xt(n+1) where n is the number of values in the first profile. | feet / meters | Default Value = 0.0 |
| cladt(N) (R) | The cladding surface temperature *xt*(N) elevation for the M-th temperature profile.  包壳外表面节点温度  The number of *cladt*, *xt* pairs for the Mth power shape is defined by *jnsurftemp*(M). | °F / K | Default Value =0.0 Maximum number of *cladt*,  *xt* pairs is 150. |
| jnsurftemp(M) (I) | The number of *cladt*, *xt* value pairs for each axial temperature distribution; Input in the same sequence as the *cladt* and *xt* arrays.  节点总数 | Dimensionless | Default Value = 0 Maximum number of shapes is 20.  Maximum number of *cladt*, *xt* pairs is 150. |
| jstsurftemp(IT) (I) | The sequential number of the temperature profile to be used for each time step. One value of *jstsurftemp* is required per time step if *ifixedtsurf* = 1.  每一时间步采用的温度分布序号 | Dimensionless | Default Value = 0 Maximum number of shapes = 20. Maximum time steps is 1000. |

(R) = real, (I) = integer

N = Axial Node Index for Input Surface Temperature Profile

M = Surface Temperature Profile Number

IT = Time Step Index

# Input Variables Specifying Code Operation

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| nr (I) | Number of radial boundaries in the pellet (for temperature calculations and temperature distribution output). These are spaced by the code with greater fraction in the outer region to optimize definition of the heat generation radial distribution.  芯块径向节点数 | Dimensionless | Greater than 1, less than or equal to 50; suggested minimum number is 17.  Default = 17 (namelist frpcn) |
| ngasr (I) | Number of equal-volume radial rings in the pellet for gas release calculations  气体释放计算时芯块等体积环数 | Dimensionless | Greater than 6, less than or equal to 50; suggested number is 45.  Default = 45 (namelist frpcn) |
| ngasmod (I) | Flag to select fission gas release model  裂变气体释放模型类型  ngasmod=1 selects ANS5.4 model  ngasmod=2 selects Massih model  ngasmod=3 selects FRAPFGR model | Dimensionless | Default = 2 |
| na (I) | Number of equal-length axial regions along the rod, for which calculations are performed and output  燃料棒轴向段数 | Dimensionless | Greater than 1, less than or equal to 150  Default = 9 (namelist frpcn) |
| nunits (I) | Signal for units system to be used for input and output:  输入输出文件单位类型  1 = British units 0 = SI units  Note that input of *nunits* >10 will activate "debug" output, which is significant in volume. | Dimensionless | Default = 1 |
| crephr (R) | Subdivision for internal creep steps (should be set to a minimum of 10 creep steps per time step for smallest step)  蠕变时长细分数 | hours | Default = 10.0 |
| sgapf (R) | Number of fission gas atoms formed per 100 fissions  每100次裂变生成的裂变气体原子数 | Dimensionless | Default = 31.0 |

|  |  |  |  |
| --- | --- | --- | --- |
| slim (R) | Limit on swelling  肿胀限值 | Volume fraction | Default = 0.05 |
| qend (R) | Fraction of end-node heat that transfers to the plenum gas  底部节点热量传导至空腔气体的份额 | Dimensionless | Default = 0.3 |
| igas (I) | Time step to begin calculation of fission gas release. For all time steps prior to *igas*, the calculated gas release will not be included in the gas in the rod void volume. (Note: this option only is available when using the Massih fission gas release model.)  开始计算裂变气体释放的时间步 | Dimensionless | Default = 0 |
| mechan (I) | Option to select mechanical model  力学模型选择  mechan=1 selects FEA model mechan=2 selects FRACAS-I  model | Dimensionless | Default = 2 (namelist frpcn) |
| nce (I) | Number of radial elements in the cladding for FEA model  FEA模型包壳径向单元数 | Dimensionless | Default = 5 (namelist frpcn) |
| frcoef (R) | Coulomb friction coefficient between the cladding and the fuel pellet  包壳-芯块之间库伦摩擦系数 | Dimensionless | Default = 0.015 |
| igascal (I) | Internal pressure calculation for FEA model  FEA模型内压计算方法  igascal=1 normal pressure calculation  igascal=0 use prescribed pressure set by p1 | Dimensionless | Default = 1 |
| p1(IT)  (R) | Rod internal pressure for each time step for FEA model. Needed only if igascal = 0.  FEA模型每一时间步内的燃料棒内压 | psi / Pa | Variable must be specified if igascal=0 |
| ivardm (I) | Option to use equal length axial nodes or variable length axial nodes  选择使用等长轴向节点或不等长轴向节点  ivardm=0 equal length axial nodes  ivardm=1 variable length axial nodes. (Must specify node lengths in deltaz array.) | Dimensionless | Default = 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| deltaz(na) (R) | Array of axial node lengths starting at the bottom of the rod. The sum of all these lengths should be the same as *totl.*. Use only if ivardm =1.  轴向节点高度 | ft / m | Variable must be specified if ivardm=1 |

(R) = real, (I) = integer

IT = Time Step Index

# Model Uncertainty Variables for Sensitivity Analysis

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| sigftc  (I) | Bias on fuel thermal conductivity model. sigftc = 1 biases model up 1,  sigftc = -1.5 biases model down  1.5.  燃料热导率模型偏差 | Dimensionless | Default = 0 |
| sigftex  (I) | Bias on fuel thermal expansion model. sigftex = 1 biases model up 1, sigftex = -1.5 biases model down 1.5.  燃料热膨胀模型偏差 | Dimensionless | Default = 0 |
| sigfgr  (I) | Bias on fission gas release model. sigfgr=1 biases model up 1, sigfgr = -1.5 biases model down 1.5.  裂变气体释放模型偏差 | Dimensionless | Default = 0 |
| sigswell  (I) | Bias on fuel swelling model. sigswell=1 biases model up 1, sigswell = -1.5 biases model down 1.5.  燃料肿胀模型偏差 | Dimensionless | Default = 0 |
| sigcreep  (I) | Bias on cladding creep model. sigcreep=1 biases model up 1, sigcreep=-1.5 biases model down 1.5.  包壳蠕变模型偏差 | Dimensionless | Default = 0 |
| siggro  (I) | Bias on cladding axial growth model. siggro=1 biases model up 1, siggro=-1.5 biases model down 1.5.  包壳轴向生长模型偏差 | Dimensionless | Default = 0 |
| sigcor  (I) | Bias on cladding corrosion model. sigcor=1 biases model up 1, sigcor=-1.5 biases model down 1.5.  包壳腐蚀模型偏差 | Dimensionless | Default = 0 |
| sigh2  (I) | Bias on cladding hydrogen pickup model. sigh2=1 biases model up 1, sigh2=-1.5 biases model down 1.5.  包壳吸氢模型偏差 | Dimensionless | Default = 0 |

(R) = real, (I) = integer

# Input Variables for Modeling Refabrication (See Section 3.3.4)

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name (type) | Description | Units British/SI | Limitations/Default Value |
| irefab  (I) | Time step to start using  refabricated values | Dimensionless | Default = 10,000 (no  refabrication) |
| nrefab1  (I) | Lower axial node for  refabrication | Dimensionless |  |
| nrefab2  (I) | Upper axial node for  refabrication | Dimensionless |  |
| cplrefab  (R) | Refabricated upper plenum  length | in/m |  |
| vsrefab (R) | Number of spring turns in refabricated upper plenum | Dimensionless |  |
| dspgrefab  (R) | New plenum spring coil  diameter | in/m |  |
| dspgwrefab  (R) | New plenum spring wire  diameter | in/m |  |
| fgpavrefab  (R) | Fill gas pressure at time step of  refabrication | psi/MPa |  |
| airrefab  (R) | Fraction of air in refabricated  rod | Fraction | Default = 0.0 |
| n2refab (R) | Fraction of nitrogen in refabricated rod | Fraction | Default = 0.0 |
| arrefab  (R) | Fraction of argon in  refabricated rod | Fraction | Default = 0.0 |
| fgrefab  (R) | Fraction of fission gas in  refabricated rod | Fraction | Default = 0.0 |
| herefab  (R) | Fraction of helium in  refabricated rod | Fraction | Default = 1.0 |
| krrefab  (R) | Fraction of krypton in  refabricated rod | Fraction | Default = 0.0 |
| xerefab (R) | Fraction of xenon in refabricated rod | Fraction | Default = 0.0 |

(R) = real, (I) = integer

# Model Selection Variables for “Evaluation Models” (EM) not Recommended or Supported by PNNL

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| imswch (I) | Signal for EM models:  =1 All EM models  = 0 No EM models  = -1 Selected EM models, input signals in $EMFPCN | Dimensionless | Default = 0 |
| impowr (R) | EM Power requirement index;  = 0, not assumed to be required | Dimensionless | Default = 0 (namelist emfpcn) |

|  |  |  |  |
| --- | --- | --- | --- |
| imfuel (R) | Switch on dimensional changes: = 0, BE changes, =1, EM changes | Dimensionless | Default = 0 (namelist emfpcn) |
| imdens (R) | Switch on densification model | Dimensionless | Default = 0 (namelist emfpcn) |
| imrelo (R) | Switch on fuel relocation model | Dimensionless | Default = 0 (namelist emfpcn) |
| imclad (R) | Switch on cladding deformation; = 1, no permanent deformation | Dimensionless | Default = 0 (namelist emfpcn) |
| imgapc (R) | switch on gap conductance calculation | Dimensionless | Default = 0 (namelist emfpcn) |
| imenrg (R) | Switch on stored energy reference temperature: = 0 reference = 298 K  = 1, reference = 273 K | Dimensionless | Default = 0 (namelist emfpcn) |

(R) = real, (I) = integer

# Input Variables Specifying Code Output

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| jdlpr (I) | Output print control for each time step:  每一时间步内输出打印控制（是否打印每个节点）  0 = All axial nodes  1 = peak-power axial node  -1 = axial summary  for NO printout each step, see  *nopt* | Dimensionless | Default = 1  Note: The code sets *jdlpr* to 0 (full output) when *ntape* is greater than 0, to assure full axial array of permanent radial deformations is passed to FRAPTRAN. |
| nopt (I) | Control on printout  时间步打印输出控制（是否打印每一时间步）  = 0, printout each time step, controlled by *jdlpr*  =1, Case input and summary sheet only | Dimensionless | Default = 0 |
| nplot (I) | Control on output of plot file for excel plotting routine  = 0, No output plot file will be created.  =1, Plot output file will be created (File 66). Note: The name of the plot file should be specified in the input file below where the name of the ordinary output (File 06) is specified.  输出excel曲线文件控制 | Dimensionless | Default = 0 |
| ntape (I) | Signal for creating a start tape for FRAPTRAN, from subroutine RESTFS. If *ntape* > 0, RESTFS is called and a tape (file 22="restart") is incrementally written each time step. Note: The name of the restart file should be specified in the input file below where the name of the ordinary plot file (File 66) is specified.  是否为FRAPTRAN创建一个启动算例 | Dimensionless | Default = 0. |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name  (type) | Description | Units  British/SI | Limitations/Default Value |
| nread (I) | Signal to start up from a restart tape (File 13). The value of *nread* is the time step to start from. Note: User must switch the restart-write tape file number from 12 to 13 to make it a restart-read tape. Note that the restart tape does not currently contain complete restart information for the fission gas release models.  是否由一个启动算例开始 | Dimensionless | Default = 0 |
| nrestr (I) | Signal for writing a restart tape for FRAPCON-3. If *nrestr* not equal to 0, subroutine TAPEGEN generates a restart tape (file 12) at each time step. Note that the restart tape does not currently contain complete restart information for the fission gas release models.  是否为FRAPCON-3写入重启算例（上述3个参数如果输入文件没有建议不要列出来，或者写成备用参数 ） | Dimensionless | Default = 0 |

(R) = real, (I) = integer

# Example Case with MOX Fuel

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

* frapcon3, steady-state fuel rod analysis code

\*

\*----------------------------------------------------------------------

\*

\*

\*

* CASE DESCRIPTION: MOX example rod

\*

\*

\*

\*UNIT FILE DESCRIPTION

\*

\*---- -----------------------------------------------Output:

\*

* Output :

\*

* 6 STANDARD PRINTER OUTPUT

\*

\*

\*

* Scratch:

|  |  |  |
| --- | --- | --- |
| \* |  | |
| \* | 5 | SCRATCH INPUT FILE FROM ECH01 |
| \* |  |  |
| \* |  |  |
| \* |  |  |
| \* | Input: | FRAPCON3 INPUT FILE (UNIT 55) |
| \* |  |  |
| \* |  |  |
| \* |  |  |

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

* GOESINS:

FILE05='nullfile', STATUS='UNKNOWN', FORM='FORMATTED', CARRIAGE CONTROL='NONE'

\*

* GOESOUTS:

FILE06='MOXexample.out', STATUS='UNKNOWN', CARRIAGE CONTROL='LIST'

FILE66='MOXexample.plot', STATUS='UNKNOWN', FORM='FORMATTED', CARRIAGE CONTROL='LIST'

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* MOX Example Rod

$frpcn

im=50, na=4, ngasr = 45,

$end

$frpcon

cpl = 2., crdt = 0.0, thkcld = 0.0224, thkgap = 0.0033,

dco = 0.374, pitch = 0.5,nplot=1,

rc = 0.0453, fotmtl = 1.997,dishsd=0.06488, den = 94.43, dspg = 0.3,fa = 1.,

dspgw = 0.03, enrch = 0.229, fgpav = 382, hdish = 0.011,

hplt = 0.5, icm = 4, imox = 1, comp = 5.945,

idxgas = 1, iplant =-2, iq = 0, jdlpr = 0,

jn = 5,5,

totl = 1.31, roughc = 3.94e-5, roughf = 7.9e-5, vs = 10.0, nunits = 1, rsntr = 52., nsp = 1,

p2(1) = 44\*2250., p2(45) = 6\*2352,

tw(1) = 44\*570, tw(45) = 6\*590 go(1) = 50\*2.0e6,

jst = 44\*1, 6\*2

qf(1) = 1.0, 1.0, 1.0, 1.0, 1.0

x(1) = 0.0, 0.3275, 0.6650, 0.9925, 1.31

qf(6) = 0.9, 1.0, 1.1, 1.0, 0.9

x(6) = 0.0, 0.3275, 0.6650, 0.9925, 1.31

ProblemTime=

0.1, 0.2, 0.3, 0.4, 0.5,

0.6, 30., 60., 90., 120.,

150., 180., 210., 240., 270.,

300., 331., 360., 390., 420.,

450., 480., 510., 540., 570.,

600., 625., 650., 700., 750.,

800., 850., 900., 945., 990.,

1000., 1050., 1100., 1150., 1200.,

1250., 1300., 1350., 1400

1401., 1402., 1403., 1404., 1405.,

1406.

qmpy =

1,2,3,4,5,

6., 6.7, 6.7, 6.7, 6.7,

5\*6.7

6.7, 6.7, 7.0, 7.0, 7.0,

5\*7.0,

7.0, 7.0, 7.0, 5.8, 5.8,

5\*5.8,

5\*4.11,

4.11, 4.11, 4.11, 4.11,

4.0, 3.5, 3.0,

2.5, 2.0, 1.5

slim = .05,

$end

$frpmox

enrpu39 = 65.83, enrpu40 = 23.45, enrpu41 = 7.39,

enrpu42 = 3.33

$end

# Input Variables Arranged Alphabetically and by Input Block

**$frpcn input block**

|  |  |
| --- | --- |
| Variable Name | Page Number |
| im | A.11 |
| mechan | A.15 |
| na | A.14 |
| nce | A.15 |
| ngasr | A.14 |
| nr | A.14 |

**$frpmox input block**

|  |  |
| --- | --- |
| Variable Name | Page Number |
| enrpu39 | A.5 |
| enrpu40 | A.5 |
| enrpu41 | A.5 |
| enrpu42 | A.5 |
| moxtype | A.5 |

**$emfpcn input block**

|  |  |
| --- | --- |
| Variable Name | Page Number |
| imclad | A.18 |
| imdens | A.18 |
| imenrg | A.18 |
| imfuel | A.18 |
| imgapc | A.18 |
| impowr | A.17 |
| imrelo | A.18 |

**$frpcon input block**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name | Page Number | Variable Name | Page Number |
| airrefab | A.17 | icor | A.10 |
| amfair | A.8 | idxgas | A.8 |
| amfarg | A.8 | ifba | A.5 |
| amffg | A.8 | ifixedtsurf | A.13 |
| amfh2 | A.8 | igas | A.15 |
| amfh2o | A.8 | igascal | A.15 |
| amfhe | A.8 | imox | A.4 |
| amfkry | A.8 | imswch | A.17 |
| amfn2 | A.8 | iplant | A.9 |
| amfxe | A.8 | iq | A.12 |
| arrefab | A.17 | irefab | A.17 |
| b10 | A.5 | ivardm | A.15 |
| catexf | A.7 | jdlpr | A.19 |
| chmfrh | A.4 | jn | A.12 |
| chmfrw | A.4 | jnsurftemp | A.13 |
| chorg | A.7 | jst | A.12 |
| cladt | A.13 | jstsurftemp | A.13 |
| cldwks | A.7 | krrefab | A.17 |
| comp | A.5 | n2refab | A.17 |
| cpl | A.3 | ngasmod | A.14 |
| cplrefab | A.17 | nopt | A.19 |
| crdt | A.10 | nplot | A.19 |
| crdtr | A.10 | nread | A.20 |
| crephr | A.14 | nrefab1 | A.17 |
| crudmult | A.10 | nrefab2 | A.17 |
| dco | A.3 | nrestr | A.20 |
| deltaz | A.16 | nsp | A.9 |
| den | A.6 | ntape | A.19 |
| deng | A.6 | nunits | A.14 |
| dishd | A.4 | p1 | A.15 |
| dspg | A.3 | p2 | A.9 |
| dspgrefab | A.17 | pitch | A.9 |
| dspgw | A.3 | ppmh2o | A.5 |
| dspgwrefab | A.17 | ppmn2 | A.6 |
| enrch | A.4 | ProblemTime | A.11 |
| fa | A.12 | qend | A.15 |
| fgrefab | A.17 | qf | A.12 |
| fgpav | A.8 | qmpy | A.11 |
| flux | A.10 | rc | A.4 |
| fotmtl | A.5 | roughc | A.7 |
| frcoef | A.15 | roughf | A.6 |
| gadoln | A.5 | rsntr | A.6 |
| go | A.9 | sigcreep | A.16 |
| hdish | A.4 | sigcor | A.16 |
| herefab | A.17 | sigfgr | A.16 |
| hplt | A.4 | sigftc | A.16 |
| icm | A.7 | sigftex | A.16 |

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name | Page Number | Variable Name | Page Number |
| siggro | A.16 | tw | A.9 |
| sigh2 | A.16 | vs | A.3 |
| sigswell | A.16 | vsrefab | A.17 |
| sgapf | A.14 | x | A.12 |
| slim | A.15 | xerefab | A.17 |
| thkcld | A.3 | xt | A.13 |
| thkgap | A.3 | zr2vintage | A.7 |
| totl | A.3 | zrb2den | A.5 |
| tsint | A.6 | zrb2thick | A.5 |