



International Agreement Report

Implementation of the Control Rod Movement Option by means of Control Variables in RELAP5/PARCS v2.7 Coupled Code

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ABSTRACT

The objective of this work is to introduce an improvement in best estimate coupled neutronic-thermalhydraulic 3D codes simulations, by adding a model for the control rod movement in the coupled code RELAP5/PARCS v2.7, by means of control variables, with the aim of being able to dynamically analyze asymmetric transient accidents, as the reactivity insertion accidents (RIA) in a nuclear reactor, reproducing all the reactors control systems.

The modification developed in this work permits the automatic movement of the control rods, activated by the RELAP5 code control system, and also they can depend on signals related to the reactor reactivity, like pressure, fuel temperature or moderator temperature, etc., improving the realism of the calculation and increasing the simulation capabilities.

This report was prepared by the Nuclear Engineering Group belonging to the Institute for Industrial, Radiophysical and Environmental Safety (ISIRYM) at the Universitat Politècnica de València (UPV), which collaborates in the simulation area with the Spanish company Centrales Nucleares Almaraz-Trillo (CNAT). The Asociación Española de la Industria Eléctrica (UNESA, Electric Industry Association of Spain), equivalent to the American EPRI sponsored this work.

FOREWORD

This report represents one of the assessment or application calculations submitted to fulfill the bilateral agreement for cooperation in thermal-hydraulic activities between the Consejo de Seguridad Nuclear (CSN) and the U.S. Nuclear Regulatory Commission (NRC) in the form of a Spanish contribution to the NRC's Code Assessment and Management Program (CAMP), the main purpose of which is to validate the TRAC/RELAP Advanced Computational Engine (TRACE) code.

CSN and the Asociación Española de la Industria Eléctrica (UNESA, Electric Industry Association of Spain), together with some relevant universities, have established a coordinated framework (CAMP-Spain) with two main objectives: to fulfill the formal CAMP requirements and to improve the quality of the technical support groups that provide services to the Spanish utilities, CSN, research centers, and engineering companies.

The AP-28 Project Coordination Committee has reviewed this report: the contribution of one of the Spanish utilities to the above-mentioned CAMP-Spain program, for submission to CSN.

UNESA

June 2010

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EXECUTIVE SUMMARY

The objective of this project is to introduce an improvement in simulations with coupled neutronic-thermalhydraulic 3D best estimate system codes, by adding a model for control rod movement in coupled code RELAP5/PARCS v2.7, by means of control variables, with the aim of being able to analyze asymmetric transient accidents, like the reactivity insertion accidents (RIA) in a nuclear reactor, reproducing all the reactors control systems.

In the neutronic simulation codes developed up to now, the control rods have not much movement versatility during a simulation. The commands for their movements are simply instructions which have to be introduced before the beginning of the calculation, and they are not related to the core characteristics and the control systems at any time of the simulation. Figure 1 shows an example of the conditions that are used until now:

```
Scram      F  1000.0  0.0  1048.0
move_bank 14  2.0  0.1  2.1  335.625
! The above values need checking
!!!!  theta      0.5  0.5  0.5
```

Figure 1 Fragment of PARCS v2.7 input file

Figure 1 shows the order for the movement of control rod bank number 14: the movement begins in second 2.0, so that in 0.1 seconds that bank moves from totally inserted position to 335.625, position that means totally withdrawn in this example (*move_bank* command).

In this work many changes are introduced in RELAP5/PARCS v2.7 codes in order to achieve that control rods become a more dynamic component in these kind of simulators.

With the modification developed in this work, control rods can be moved automatically, activated by the RELAP5 code control system, and they can also depend on signals related to the reactor activity, like pressure, fuel temperature or moderator temperature, etc., improving the realism of the calculation and widening the simulation possibilities.

The environment of work chosen have been the graphic programming environment Compaq Visual Fortran 6.6A (CVF 6.6A). The fundamental reasons have been, on one hand the facility of programming and versatility of the debugger of this environment, and on the other hand the fact that PARCS v2.7 source code already came prepared for this environment. RELAP5 distribution did not come prepared for this programming environment, its compilation used to be made with *shell script* files for UNIX or CYGWIN operating systems, being all the process hidden for the user. Therefore, it was necessary to adapt the RELAP5 source code to the CVF 6.6A.

ABBREVIATIONS

BWR	Boiling Water Reactor
CAMP	Code Assessment and Management Program
CSN	Consejo de Seguridad Nuclear (Spanish Nuclear Regulatory Commission)
ID	Identification Number
NRC	U.S. Nuclear Regulatory Commission
PARCS	Purdue Advance Reactor Core Simulator
PVM	Parallel Virtual Machine
PWR	Pressurized Water Reactor
SCRAM	Safety Control Rod Axe Man (Emergency Reactor Shutdown)
SNAP	Symbolic Nuclear Analysis Package
VVER	Voda-Vodyanoi Energetichesky Reaktor (Russian Pressurized Water Reactor)

1. INTRODUCTION

The coupled code RELAP5/PARCS v2.7 is a neutronic-thermalhydraulic code that can be used to simulate transient accidents considering neutronic phenomena in 3D geometry and thermalhydraulic processes in 1D multiple channels geometry.

As thermalhydraulic module, it uses the optimal estimation code RELAP5, which implements a two fluid and six-equations model to simulate the thermalhydraulic phenomena. This computer code has models for normal components of regular Light Water Reactors (LWR), like valves, pumps, heat sources, etc.

The fuel elements in the reactor core are modeled with multiple channel components. For modeling the heat transfer in the fuel, an axial-radial heat transfer equation is used. The thermalhydraulic processes are solved with six equations: mass balance, moment and energy for the both liquid phase and steam.

As a neutronic module, it uses the nodal core simulator PARCS v2.7, which simulates the dynamic response of the reactor to reactivity disturbances solving the neutron diffusion equation in steady and transient states. This code is applicable to PWR, BWR and VVER, with rectangular or hexagonal fuel elements. PARCS v2.7 solves the neutron diffusion equation with the two energy groups approach for rectangular geometries and with any number of energy groups for hexagonal geometries. With this code it is possible to obtain the 3D space distribution of neutron flux and power, as well as its time evolution.

RELAP5 and PARCS v2.7 can be executed in a stand-alone way as well as coupled.

Coupled code RELAP5/PARCS v2.7 uses an internal integration scheme in which the thermalhydraulic solution is obtained from RELAP5 and the kinetic space solution is obtained from PARCS v2.7. PARCS uses the data from the thermalhydraulic solution (moderator temperature and density and fuel temperature) calculated by RELAP5 to incorporate the effects of the feedback through the cross sections. RELAP5 also solves the heat conduction in the heat structures of the core using the power distribution calculated by PARCS.

The temporal coupling of both codes is explicit. Essentially, the advance of time steps begins with RELAP5, which obtains the solution of the hydrodynamics field equations using the power of the previous time step. Later, the power in the time step in process is calculated by PARCS with the data provided by RELAP5.

The coupling between these two codes is obtained through a communication protocol between both processes (Parallel Virtual Machine - PVM). Both processes are executed in parallel and PARCS transfers the data of nodal power to RELAP5. After that, RELAP5 gives back the information of temperature (of fuel and moderator) and the moderator density to PARCS.

The coupling is made in an external form via PVM (Parallel Virtual Machine) (see Appendix B). Daemon *pvm3d* has to be working prior in all the machines that are going to share their computing resources with the virtual parallel machine, that is, it connects the execution of our programs with PVM: the administration of communication mechanisms between machines, the automatic conversion of data and the hiding of the network to the programmer.

The neutron nodal structure is generally different from the nodal structure of the thermalhydraulic model. This difference is solved with a nodal mapping written in a file called MAPTAB, where the fractions of the different thermalhydraulic nodes associated with each neutron node are specified.

The MAPTAB file allows the neutron and thermalhydraulic nodes association and also allows the definition of the reflector properties and the election of the calculation method for the Doppler temperature.

2. ACTION CRITERIA FOR THE CODE MODIFICATION

The adopted criteria to approach the implementation the modifications in the codes are the following:

- RELAP5 Control Variables will be used to move the control rod banks of the reactor core.
- The variables have to be introduced in the MAPTAB file, using the card %CRSIG.
- The Control Variables' identification numbers will be introduced by order, so that the first will move control rod bank number 1, and so on. If a position is left with a "0" value, this will indicate that the corresponding control bank will not be moved, and therefore it will maintain its initial position during the whole transient.

```
*   MAPTAB FILE FOR TRILLO_15
*
%DOPL
*
LINC  0.15
*
*
%TRIP
700
*
*
%CRSIG
521  0  522  523
*
*
%REFLPROP
```

Figure 2 Data entry in MAPTAB file

- Each control rod bank will be controlled only by one control variable. For each time step, the position of the control rod bank will be equal to the value of the corresponding RELAP5 Control Variable in that time step.
- User can opt for moving the control rods with the original method or using this new option, though this new option dominates over the previous one. Thus, if user implements the card %CRSIG in the MAPTAB file, control rods will be moved using the new option, although in the PARCS input deck the standard movement commands were also implemented (as in the normal case up to now).
- It is recommendable that the initial positions of the control rods in RELAP5 correspond with the initial positions indicated in the PARCS input file, but again, the initial values introduced in RELAP5 will dominate the situation.

3. DEVELOPMENT OF THE INTRODUCED MODIFICATIONS

Subsequently, the modifications carried out in RELAP5 and PARCS v2.7 codes are detailed in order to obtain the goal of the work. The modifications are explained step by step, in the same order in which they were introduced in the programs.

The behavior of both programs in a coupled calculation is explained step by step, for a given time step. That is, during a coupled calculation, the program will execute repeatedly the actions that are going to be described, once for each time step, until the end of the calculation is reached.

3.1 First time step: ID's reading from MAPTAB and the sending to RELAP5

The first goal to reach is the acceptance from RELAP5 of the Control Variables identification numbers (ID's) introduced in the MAPTAB file. This modification can only be achieved introducing changes in the source codes of both programs. Otherwise, there would be more information than the needed in the MAPTAB file and the program would not be able to function correctly or simply do not carry out the calculation on having errors detected during this file processing.

In order to achieve that, PARCS v2.7 source code has been modified first, specifically, routines **pdmr_varM.f** and **pdmr_mapM.f**, that take charge of the following:

- **pdmr_varM.f**: It collects the statement of PARCS v2.7 variables, that is, this file contains the declaration of the most important variables of PARCS v2.7. New variables **var_leidas(1000)** and **n_var** have been introduced here. The former serves to store the read data, to a maximum of 1000 numbers, while the latter, is only used to know how many data have been stored in total (see the following figure).

```
! Miscellaneous Computational Control Variables:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
INTEGER(4) :: var_leidas(1000), n_var, mov_cr_relap
real(8)    :: var_cntrl(1000)
integer(4) :: contador
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
INTEGER(4) :: itrip, idopl
INTEGER(4) :: ncrctl
REAL(8)    :: wdopl
REAL(8)    :: tppm, ppmratio, corepow
LOGICAL    :: crctl
LOGICAL    :: automap, lis3d, lisVsslByp, lisWaterRod
CHARACTER(6), ALLOCATABLE :: hsdscr(:)
INTEGER(4), ALLOCATABLE  :: isgv(:), sgvbank(:)
REAL(8), ALLOCATABLE     :: newcrp(:), initcrp(:)
```

Figure 3 Declaration of variables in PARCS v2.7 subroutine **pdmr_varM.f**

variable is multidimensional and is used, among others things, for storing and transfer to RELAP5 the ID's of the RELAP5 *TRIP* that activates the PARCS SCRAM option.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPW
CALL pvmfpack( INTEGER4, var_leidas, 1000, 1, info)
CALL pvmfpack( INTEGER4, n_var, 1, info)
IF (info .LT. 0) CALL gi_error_chkpvm(fpack,sendbuf,info)
IF (errpvm_gi) GOTO 999
CALL pvmfpack( REAL4, pneut%r4buf, dimbuf_neut(5), 1, info)
IF (info .LT. 0) CALL gi_error_chkpvm(fpack,sendbuf,info)
IF (errpvm_gi) GOTO 999
CALL pvmfpack( REAL8, pneut%r8buf, dimbuf_neut(6), 1, info)
IF (info .LT. 0) CALL gi_error_chkpvm(fpack,sendbuf,info)
IF (errpvm_gi) GOTO 999

```

Figure 6 Data transfer to RELAP5, routine gi_commM.f

To achieve that changes previously introduced work correctly, it should be made a series of additional modifications in both PARCS v2.7 and RELAP5 codes.

For the neutronic code PARCS v2.7, a new declaration should be added in the routine **gi_commM.f** (see the following figure), otherwise, inside this routine, the program would not recognize the variables that it intends to send. It can be said, that it is a new declaration of variables **var_leidas** and **n_var** (the same had also to be done for variable **contador** and **var_cntrl**, just as it will be explained further on).

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPW
USE pdmr_commM, Only: var_leidas, n_var,
& contador, var_cntrl
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 7 Variables declaration in PARCS v2.7 routine gi_commM.f

In the thermalhydraulic code RELAP5, it is necessary to introduce changes to correctly receive these variables from PARCS v2.7, without causing errors neither any problem on the program run. Some modifications have been made in the following routines:

- **r-var.f:** This routine contains the declaration of the most important variables of RELAP5. Here, two new variables have been declared, one to store the values of the Control Variables ID's and other to store the total number of transmitted ID's. These two variables store the information that comes from PARCS v2.7, for that it has been determined to call them in the same way they were declared in the neutronic code: **var_leidas** and **n_var** (see the following figure). Variables **var_cntrl(1000)**, **guardar_cntrlv(1000)** and **contador** have been also declared here, but its function will be explained further on.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
integer(4) :: var_leidas(1000)
real(8)    :: var_cntrl(1000), guardar_cntrlv(1000)
integer(4) :: contador
integer(4) :: n_var
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 8 Variables declaration in RELAP5 subroutine r-var.f

- Subroutine **RDMR_Recv_PARCS_Buf()**, from file **r-commu.f**: This subroutine is responsible for receiving the information from PARCS. The information sent by PARCS with variable **pneut%i4buf** is received with a different name, **i4bufn**, though the value of these variables is the same (figure 9).

```

#ifdef INT16
call pvmfunpack( INTEGER2, i2bufn, dimbuf(3), istride, info)
#else
c SUN F90 Compiler V.1.2 maps integer*2 to integer*4.
call pvmfunpack( INTEGER4, i2bufn, dimbuf(3), istride, info)
#endif
if (info .lt. 0) then
errcode = 6
goto 999
endif
call pvmfunpack( INTEGER4, i4bufn, dimbuf(4), istride, info)
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
call pvmfunpack( INTEGER4, var_leidas, 1000, istride, info)
call pvmfunpack( INTEGER4, n_var, 1, istride, info)
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
if (info .lt. 0) then
errcode = 6
goto 999
endif

```

Figure 9 Data reception in RELAP5 routine r-commu.f

Once here, RELAP5 knows the value of variables **var_leidas** and **n_var**, which will facilitate the following step.

3.2 Second step: Storage of the Control Variables' ID's in RELAP5 and transfer of the variables' values in each time step to PARCS v2.7

Once the information has been received from PARCS v2.7, it can be passed to the following step, which consists of the storage of the Control Variables values for each time step. We now remark that, the ID's of the control variables which will move the control rods in PARCS v2.7 from RELAP5, are stored in variable **var_leidas**.

These ID numbers should be introduced according to the order explained previously, that is, the variable whose ID is written first, will be the responsible for controlling control rod bank number 1, the second variable will control bank number 2, and so on. If it the user wants to act on the

banks 1 and 3, for example, then among the ID of variables 1, 3 and 4, a “0” should be written. This can be understood better with the example shown in the following figure:

```
*   MAPTAB FILE FOR TRILLO_15
*
%DOPL
*
LINC  0.15
*
*
%TRIP
700
*
*
%CRSIG
521  0  522  523
*
*
%REFLPROP
```

Figure 10 Fragment of MAPTAB file

In this example, the ID of control variables 521, 522 and 523 have been introduced. Variable 521 will control to the number rod bank 1, the bank number 2 will not suffer perturbations and will conserve its initial position, while variables 522 and 523 will move banks number 3 and number 4. The remainder control rod banks will conserve their initial position during all the calculation.

The following step consists of locating and storing the value of the RELAP5 Control Variables involved, for each time step. The locating is carried out by means of a simple search, using the CVF 6.6A *debugger* for going line by line during the debugging of the program process and locating the important variables.

Once realized the follow-up of the variables, the following modifications were implemented:

- Changes in the routine **r-var.f**: This routine gathers the declaration of the RELAP5 variables, reason why a new variable has been declared here, **var_ctrl()** that takes charge of storing, for each time step, the values of the Control Variables that move the control rod banks (see the following figure). As in the previous cases, in this figure more introduced variables appear, which will be explained later.

```

#ifdef WIN32
  INTEGER(4), ALLOCATABLE      :: c2ibufn(:)
#endif
  logical, allocatable        :: lbufn(:)
  integer(2), allocatable      :: i2bufn(:)
  integer(4), allocatable      :: i4bufn(:)
  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
  !!!!! Pablo Ana / rmiro - UPV
  integer(4)                   :: var leidas(1000)
  real(8)                       :: var_cntrl(1000) guardar_cntrlv(1000)
  integer(4)                   :: contador
  integer(4)                   :: n_var
  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
  real(4), allocatable         :: r4bufn(:)
  real(8), allocatable         :: r8bufn(:)
  real(8), allocatable         :: vecnp(:)
  integer(4)                   :: nvecnp

```

Figure 11 Declaration of the variable `var_cntrl(1000)` in RELAP5 routine `r-var.f`

- Changes in the subroutine `convar.f`: More auxiliary variables have to be declared (see the following figure) before loop in figure 13 can to be introduced. Specifically, the variable `z` has been declared, that is an auxiliary variable that will take the values for every step of calculation of the in figure 13, between 1 and the number of variables that are introduced in MAPTAB (`n_var`). This way, if `n_var = 2`, `z` will be equal to 1 for the first step of calculation of the loop and 2 for the second step of calculation.

```

  real*8 hold,var(4)
  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
  !!!!! Pablo Ana / rmiro - UPV
  integer i,ii,ir,ityp,j,l,m,z
  integer i,ii,ir,ityp,j,l,m
  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
  logical tfail

```

Figure 12 Declaration of the variable `z`

Working of Control Variables position storing loop in figure 13:

The program performs a sweep along all the Control Variables introduced in RELAP5 input, so that for each of these variables, the corresponding instructions of the subroutine `convar.f` are processed.

The sweep is done by means of a loop, which maximum value is the total number of Control Variables. Thanks to the follow-up realized with the *debugger*, it can be known that variable `cnvpm(1,i)` stores the ID of the Control Variable that is being processed for each value of `i`, and the variable `cnvarn(i)` stores the value of the variable `i` for the time step in which we are.

With all this information, the implemented loop realizes a comparison between the above mentioned variable and `var_leidas`, in this way it is possible to separate the variables entrusted to move the control rods of those that have some another function, and in this way the efforts are centered on these variables.

This way, for each value of *i*, the loop will compare the values stored in *var_leidas*, using the counter *z*. If the value coincides, then the value of the control variable “ith” is stored in the position “zth” (that corresponds to the control bank number that moves the variable “ith”), of the variable *var_cntrl(z)*.

```

!!!! Pablo Ana / rmiro - UPV
do z=1, n_var
  if (cnvpm(1,i)==var_leidas(z)) then
    var_cntrl(z) = cnvarn(i)
  endif
enddo

```

Figure 13 Storage loop for the control variables values in convar.f

The following scheme explains this process:

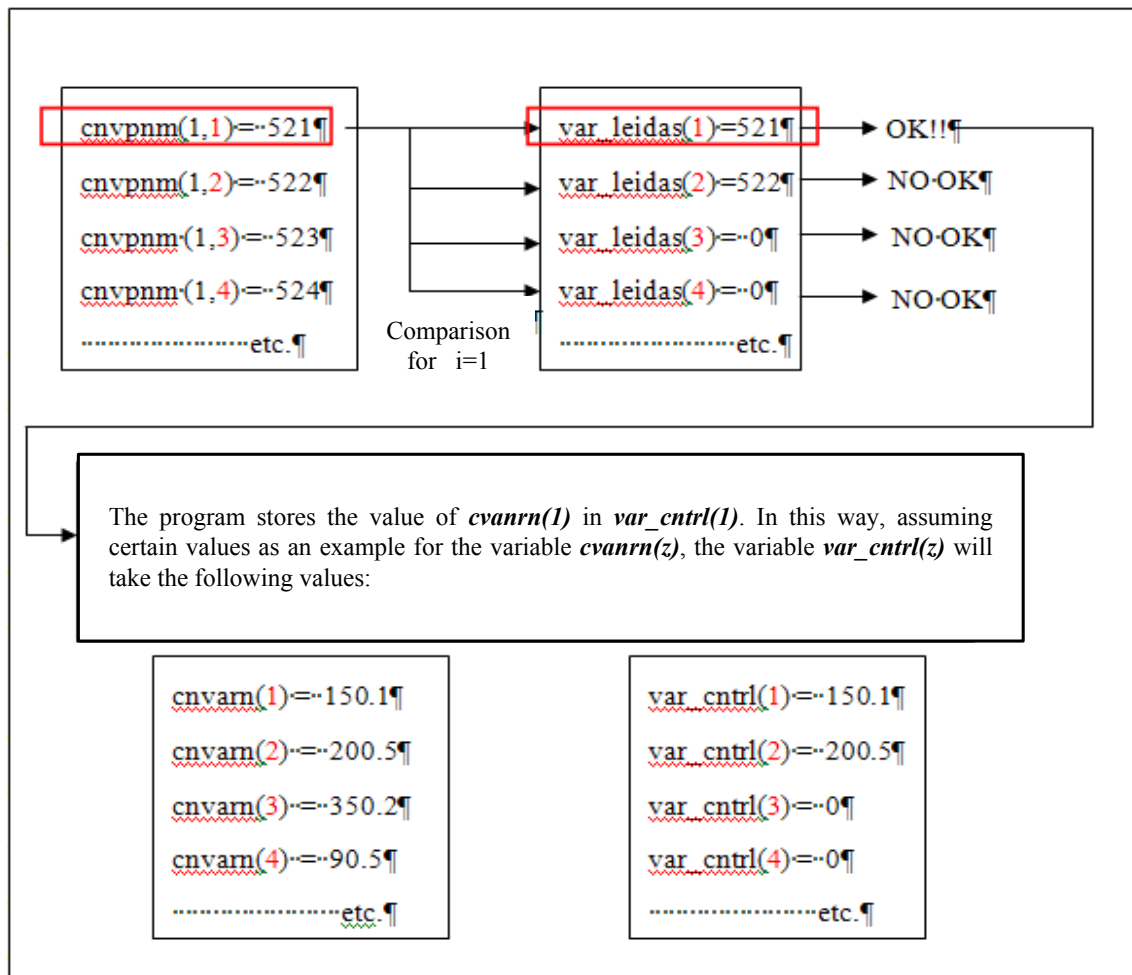


Figure 14 Working diagram of the loop shown in figure 13

Once here, all the information has to be sent to the neutronic code, which will be the one who finally uses these instructions to move the control rod banks.

In order to transfer of the information from RELAP5 to PARCS v2.7, the same steps have been followed that in the transfer of information from PARCS v2.7 to RELAP5 (that was explained previously). Studying a SCRAM activated by a RELAP *TRIP*, we found variable *lbufth* of RELAP5 and variable *pth%lbuf* of PARCS v2.7. These variables take charge of storing the same information, but each one do it in the corresponding program only.

These variables are those that use each code “to be informed” about if it is necessary or not to activate the SCRAM. The thermalhydraulic code is the one which decides if the *trip* is activated or not, depending on the calculation and the characteristics of the *trip*. If the *trip* is activated, then it will change its condition from “DEACTIVATED” to “ACTIVATED”, i.e. from “0” to “1”. The variable *lbufth* takes this logical value and then it is sent to PARCS v2.7.

The signal is then received by the neutron kinetics code by means of variable *pth%lbuf*, and activates or not the SCRAM depending on the value that has received from RELAP5. The knowledge of how this process works, has been of great help for the development of this work, since this variables have been used as a “guide” to transfer the new commands to the program. It is an easy form to assure that the information is sent in the correct calculation moment.

The commands to transfer the variable under study, *var_cntrl*, which contains the positions that must have the control rod banks in every time step, were implemented just before the transfer of the variable *lbufth*. In this way, the reception remains determined in PARCS v2.7 just before the reception of the above mentioned variable.

The following figure presents the fragments of the source code where these transfer and reception information commands have been implemented. Here, it can be remembered that it is important the rules of the programming language are accomplished in order that everything works correctly, that is, the information has to be of the same nature (real, integer), the dimension must be the same, etc., this is specified in the same command that transfers the information. In this figure, it can be also seen a loop that will be commented later on.

```

■      Enull
!!!!  Pablo Ana / rmiro - UPV
      if (contador==0) then
        do contador2=1,1000
          var_cntrl(contador2)=0
        end do
        contador2=1
        do contador2=1,n_var
          if (var_leidas(contador2).gt.0) then
            var_cntrl(contador2)=guardar_cntrlv(var_leidas(contador2))
          end if
        end do
      endif
      contador=contador+1
      call pvmfpack(real8, var_cntrl, 1000, 1stride, info)
!!!!  call pvmfpack( INTEGER4, lbufth, dimbuf(2), 1stride, info)

```

Figure 15 Fragment of modified RELAP5 routine r-commu.F

In the following figure, the implemented commands in PARCS v2.7's routine `gi_commM.f` for the reception of the information are shown. The above mentioned information reception command must respect also the rules of the programming language.

```

      IF (info .LT. 0) CALL gi_error_chkpvm(funpack,recvbuf,info)
      IF (errpvm_gi) GOTO 999
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
      CALL pvmfunpack( real8, var_cntrl, 1000, istride, info)
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      CALL pvmfunpack( INTEGER4, pth%lbuf, dimbuf_th(2), istride
& info)

```

Figure 16 Fragment of modified PARCS v2.7 routine `gi_commM.f`

3.3 Third step: control rod movement in PARCS v2.7 according to RELAP5 instructions

The last step consists of moving the control rod banks inside PARCS v2.7, following the directions received from RELAP5 for each time step.

The first thing that it is necessary to do, as in previous steps, is to perform a step by step tracking of PARCS v2.7 behavior using the debugger tool, to find the routine and variables that take care of the control rod movement.

This way, subroutine `perturb.f` was found. This subroutine processes all the control rod positions during the transient. Inside this subroutine, it is located the loop responsible for performing the control rods movement (figure 17):

```

endif
! determine current crbank positions
if (.not. scram) then
  do ib=1,npbanks
    id=idpbank(ib,1)
    nptb=idpbank(ib,2)
    do i=1,nptb
      if(tsgl.lt.tbank(i,1,id)) go to 200
    enddo
    iptbp1=i
    iptb=i-1
    if(iptb.lt.nptb) then
      crbpos(id)=fintp(tsgl,tbank(iptb,1,id),tbank(iptb,2,id))
    else
      crbpos(id)=tbank(iptb,2,id)
    endif
    if(crbpos(id).lt.0) crbpos(id)=0
  enddo
else

```

Figure 17 Original loop for the control rod movement in PARCS v2.7 subroutine `perturb.f`

PARCS v2.7 carries out a loop over all the control rod banks, placing each of them in the correct position in each time step, according to the predefined movements included in the input file. If

the time step in the calculation do not coincide with the predefined times in the input deck, then an interpolation scheme is used to calculate the intermediate position of the corresponding bank in each moment.

In this loop, the variable *crbpos(id)* stores the position for bank “*id*” in time step *tsgl* (variable that stores the calculation time). Variable *tbank(i,1,d)* is the responsible for storing the control rod positions that the user indicated in the PARCS v2.7 input file for each control rod bank.

For the implementation of the new loop, several calculation options must be taken into account, doing possible that the user executes any of them. The three calculation options are:

- WITHOUT MODIFICATIONS. Those cases in which the control rods do not move, or they move using the original way, that is, using the commands from PARCS v2.7 input file to define the positions of the rods in each moment.
- WITH MODIFICATIONS. In this case the rods will be moved receiving instructions from RELAP5; this option is the aim of this work.
- SCRAM WITH TRIP. This option can be used with any of the two previous ones, but with one more condition. In this case the transient is executed normally but can be SCRAMed by activating a trip from RELAP5.

To choose between these options, a new variable was introduced: *mov_cr_relap*. The following figures present the declaration of variable in *pdmr_varM.f*, and the needed modifications for using this variable in the subroutine *perturb.f*:

```

! Miscellaneous Computational Control Variables:
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
INTEGER(4) :: var_leidas(1000), n_var, mov_cr_relap
real(8)    :: var_cntrl(1000)
integer(4) :: contador
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
INTEGER(4) :: itrip, idopl
INTEGER(4) :: ncrctl
REAL(8)    :: wdopl

```

Figure 18 Declaration of the variable *mov_cr_relap* in *pdmr_varM.f*

```

subroutine perturb
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
USE pdmr_commM, Only: var_leidas, n_var,
& contador, var_cntrl, mov_cr_relap
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 19 Modifications introduced in *perturb.f*

The function of the variable *mov_cr_relap* is simple. The possible values of *mov_cr_relap* will be “0” or “1”, depending on if the user has implemented (1) or not (0) card %CRS/G in the MAPTAB file. This control on the introduced information is obtained by setting the condition of the following figure in the subroutine *pdmr_mapM.f*.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
! Read control rod position control variables for RELAP.
ELSEIF (table(1:5) .EQ. 'CRSIG' .AND. icode .EQ. RELAP5) THEN
  IF (iread .EQ. 2) THEN
    READ(line,*,err=900,end=900)
    n_var=nfields(line)
    READ(line,*,err=900,end=900) (var_leidas(i),i=1,n_var)
  ENDIF
  mov_cr_relap=1
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! Read control rod position signal variable for TRAC-M.

```

Figure 20 Condition for calculation mode selection in PARCS v2.7 subroutine pdmr_mapM.f

If during the processing of the MAPTAB file, card %CRSIG is detected, the value of variable *mov_cr_relap* will change to “1”. This information will be also used for selecting the execution option inside subroutine *perturb.f*.

If the value of this variable is “0”, the program executes the original control rod movement PARCS v2.7 loop, without taking into account all the modifications implemented in the code, as can be seen in the following figure.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
!!!! Original control rod movement
!!!! IF (MOV_CR_RELAP==0) THEN !MOV_CR
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
if (.not. scram) then !scram
  do ib=1,npbanks
    id=idpbank(ib,1)
    nptb=idpbank(ib,2)
    do i=1,nptb
      if(tsgl.lt.tbank(i,1,id)) go to 200
    enddo
200  iptbp1=i
    iptb=i-1
    if(iptb.lt.nptb) then
      crbpos(id)=fintp(tsgl,tbank(iptb,1,id),tbank(iptb,2,id))
    else
      crbpos(id)=tbank(iptb,2,id)
    endif
    if(crbpos(id).lt.0) crbpos(id)=0
  enddo
else !scram
  if (tscrmbeg .eq. 0.0) then !scram
    tscrmbeg = time - delt !scram
    print * !scram
    print *, " *****" !scram
    print *, " *** Scram Signal Received ***" !scram
    print *, " *****" !scram
    print * !scram
    write(ioutp,*) !scram
    write(ioutp,*) " *****" !scram
    write(ioutp,*) " *** Scram Signal Received ***" !scram
    write(ioutp,*) " *****" !scram
    write(ioutp,*) !scram
    do id=1,ncrb !scram
      pscrmbeg(id) = crbpos(id) !scram
    enddo !scram
    pscrmend = 0.0 !scram
  endif !scram

```

```

do id=1,ncrb                                     !scram
  tsum=0.0                                       !scram
  do k=1,nz                                       !scram
    tsum=tsum+hz(k)                              !scram
  enddo                                           !scram
  if(isvel) then
! tony's test for pbtt
! use scramdelt as a cr insertion velocity
    crbpos(id) = pscrbeg(id) - scramvel*(time-tscrbeg)  !scram
  else
    scramstep = ((tsum-crbpos0)/crbstep)*delt/scramdelt  !scram
    tscrmend = tscrbeg+scramdelt                        !scram
    crbpos(id) = crbpos(id) - scramstep                 !scram
  endif

  if (crbpos(id).lt.0) crbpos(id)=0.0                !scram
enddo                                             !scram
endif

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV                                                                !MOV_CR
END IF                                                                                         !MOV_CR
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 21 Condition for loop selection in PARCS v2.7 subroutine perturb.f

If the value of the variable *mov_cr_relap* is “1”, this means that the user has introduced the card %CRSIG in MAPTAB file, and therefore the loop that moves the rods will be the new one implemented in PARCS v2.7 (figure 22).


```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! IF (MOV_CR_RELAP==1) THEN
!
! if (.not. scram) then !scram
!   do i_mov_cb=1,n_var
!     if (var_leidas(i_mov_cb) .ne. 0) then
!       crbpos(i_mov_cb)=var_cntrl(i_mov_cb)
!     endif
!     if(crbpos(i_mov_cb).lt.0) crbpos(i_mov_cb)=0
!   enddo
!
! else
!
!   if (tscrmbeg .eq. 0.0) then !scram
!     tscrmbeg = time - delt !scram
!     print * !scram
!     print *, " *****" !scram
!     print *, " *** Scram Signal Received ***" !scram
!     print *, " *****" !scram
!     print * !scram
!     write(ioutp,*) !scram
!     write(ioutp,*) " *****" !scram
!     write(ioutp,*) " *** Scram Signal Received ***" !scram
!     write(ioutp,*) " *****" !scram
!     write(ioutp,*) !scram
!     do id=1,ncrb !scram
!       pscrmbeg(id) = crbpos(id) !scram
!     enddo !scram
!     pscrmend = 0.0 !scram
!   endif !scram
!   do id=1,ncrb !scram
!     tsum=0.0 !scram
!     do k=1,nz !scram
!       tsum=tsum+hz(k) !scram
!     enddo !scram
!     if(isvel) then
!       ! tony's test for pbtt
!       ! use scramdelt as a cr insertion velocity
!       crbpos(id) = pscrmbeg(id) - scramvel*(time-tscrmbeg) !scram
!     else
!       scramstep = ((tsum-crbpos0)/crbstep)*delt/scramdelt !scram
!       tscrmend = tscrmbeg+scramdelt !scram
!       crbpos(id) = crbpos(id) - scramstep !scram
!     endif
!     if (crbpos(id).lt.0) crbpos(id)=0.0 !scram
!   enddo !scram
! endif
!
! END IF !MOV_C
!!!!
!!!! end Pablo Ana / rmiro - UPV
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 22 New loop for the control rod movement in PARCS v2.7 subroutine perturb.f

The third calculation mode is the PARCS v2.7 original option. This option allows the activation of a SCRAM controlled by a RELAP5 *trip*. This option continues available for the user, that is, it is possible to move the rods using Control Variables, and at the same time a SCRAM is allowed when the corresponding RELAP5 *trip* indicates it.

To use this option it is necessary to proceed like PARCS v2.7 manual indicates. In MAPTAB file, it can be implemented a *%TRIP* card with the *trip* ID of RELAP5 that activates the SCRAM. The calculation will continue its normal course until this *trip* activates a total SCRAM.

4. RESOLUTION OF THE CONTROL ROD INITIAL POSITION PROBLEM

Once finished the previous steps, it was detected some mistakes in the implemented procedure. The first error was related to the control rod bank initial position.

The value that Control Variables take for each time step, and therefore the position that control rods must have, is obtained from the RELAP5 routine **cnvar.f**. The problem found was that this routine is processed since the first time step, so it is not possible to load the Control Variables initial values.

To obtain these initial values, routine **iconvr.f** was modified. This routine processes the Control Variables initial values. Variable **cnvarn(i)** was used for that purpose, it stores the initial values of all the Control Variables introduced in RELAP5. This information is passed to another variable, **guardar_cntrlv()**, that can be manipulated with more freedom without concerning to normal behavior of the code (see figure 23).

```

31  cnvarn(i) = max(min(cnvarn(i),cnvmax(i)),cnvmin(i))
!!!!
!!!! Pablo Ana / rmiro - UPV
29  guardar_cntrlv(cnvpnm(1,i))=cnvarn(i)
!!!!
!!!! 29   i = i + cnvlen(1,i)
!!!!   i = i + cnvlen(1,i)
30  continue
c   Restore cnvpck values.
!!!!   i = filndx(27)

```

Figure 23 Initial values storing instructions in iconvr.f

The variable that stores these values is **guardar_cntrlv()**, declared in the general variables declaration routine **r-var.f**, see the following figure, close to other variables that have been explained previously. The values are stored using the indexes in **cnvpnm(1, i)**. This variable makes a sweep over all of the control variables introduced in RELAP5 input deck, depending on the values of **i**. Variable **guardar_cntrlv(1000)** has also been declared here.

```

!!!!
!!!! Pablo Ana / rmiro - UPV
integer(4) :: var_leidas(1000)
real(8)    :: var_cntrl(1000), guardar_cntrlv(1000)
integer(4) :: contador
integer(4) :: n_var
!!!!
real(4), allocatable :: r4bufn(:)
real(8), allocatable :: r8bufn(:)
real(8), allocatable :: vecnp(:)
integer(4)           :: nvecnp

```

Figure 24 Declaration of the variable **guardar_cntrlv(1000)** in the RELAP5 subroutine **r-var.f**

In this way, the initial values of all the introduced Control Variables will be stored, up to a maximum of 1000, arranged according to the ID control variable number. For instance, the initial value of the Control Variable 521, let's suppose that it is 300.625, will be in position "521" of the information storage variable, keeping **guardar_cntrlv(521)** = 300.625.

To be able to use the declared variable (**guardar_cntrlv()**) in routine **iconvr.f**, one more line of code had to be added, see the following figure, since the declared variable is not a global variable which can be recognized in all the routines of the program in a predefined form.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!  Pablo Ana / rmiro - UPV
      use RDMR_Var_Decl
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      implicit none
      include 'cmpdat.h'
      include 'comctl.h'
      include 'contrl.h'
      include 'convarc.h'
      include 'fast.h'
      include 'gentblc.h'
      include 'machas.h'
      include 'machss.h'
      include 'pumpblk.h'
      include 'trpblk.h'
      include 'turbin.h'
      include 'ufiles.h'

```

Figure 25 Fragment of the subroutine **iconvr.f**

Once the values of the Control Variables have been stored, a new loop has been programmed. This loop is entrusted to transfer the information from the new variable **guardar_cntrlv()** to the variable that will be sent to PARCS v2.7 with the position of each control rod bank: **var_cntrl()**, which declaration can also be seen in the figure 24.

With all these variables and the implemented modifications the new loop has been coded.

Two new variables **contador** and **contador2** have been also declared at the beginning of subroutine **r-commu.f**.

```

#ifdef WIN32
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!  Pablo Ana / rmiro - UPV
      integer(4):: l, i, j, m, n, contador, contador2
!!!!!!!!!!!!integer(4):: l, i, j
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
#endif

```

Figure 26 Declaration of variable **contador** in RELAP5 routine **r-commu.f**

Contador has the mission to assure that loop on figure 27 is only processed once, that is, the first time step of the run. During the following time steps the assignment of values will be realized in the routine **convar.f**.

Variable **contador** takes by default an initial value of “0”, so, when it arrives to the position of the outer loop in figure 27, it fulfills the initial condition and the loop is processed. At the end of the loop variable **contador** is incremented one unit, so in the following time step the initial condition will not be fulfilled, and the loop will not be processed again.

The loop commands are simple: first, variable **var_cntrl()** is set to “0”. The following step consists of assigning to this variable the initial values of each Control Variable. For that, the code performs a sweep over all the positions in variable **var_leidas()**, that stores the ID’s of the Control Variables introduced in the MAPTAB file that will move the control rods groups.

Afterwards, it will make a comparison and, for those positions which their values are not zero, will assign the Control Variable initial value. Here it is possible to figure out why the zeros in the file MAPTAB have to be introduced.

```

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!! Pablo Ana / rmiro - UPV
      if (contador==0) then
        do contador2=1,1000
          var_cntrl(contador2)=0
        end do
        contador2=1
        do contador2=1,n_var
          if (var_leidas(contador2).gt.0) then
            var_cntrl(contador2)=guardar_cntrlv(var_leidas(contador2))
          end if
        end do
      endif
      contador=contador+1
      call pvmfpack(real8, var_cntrl, 1000, istride, info)
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Figure 27 Loop in r-commu.f

The process is explained graphically in figure 28’s scheme, where it is summarized a simple case in which two control variables ID’s have been used in MAPTAB file.

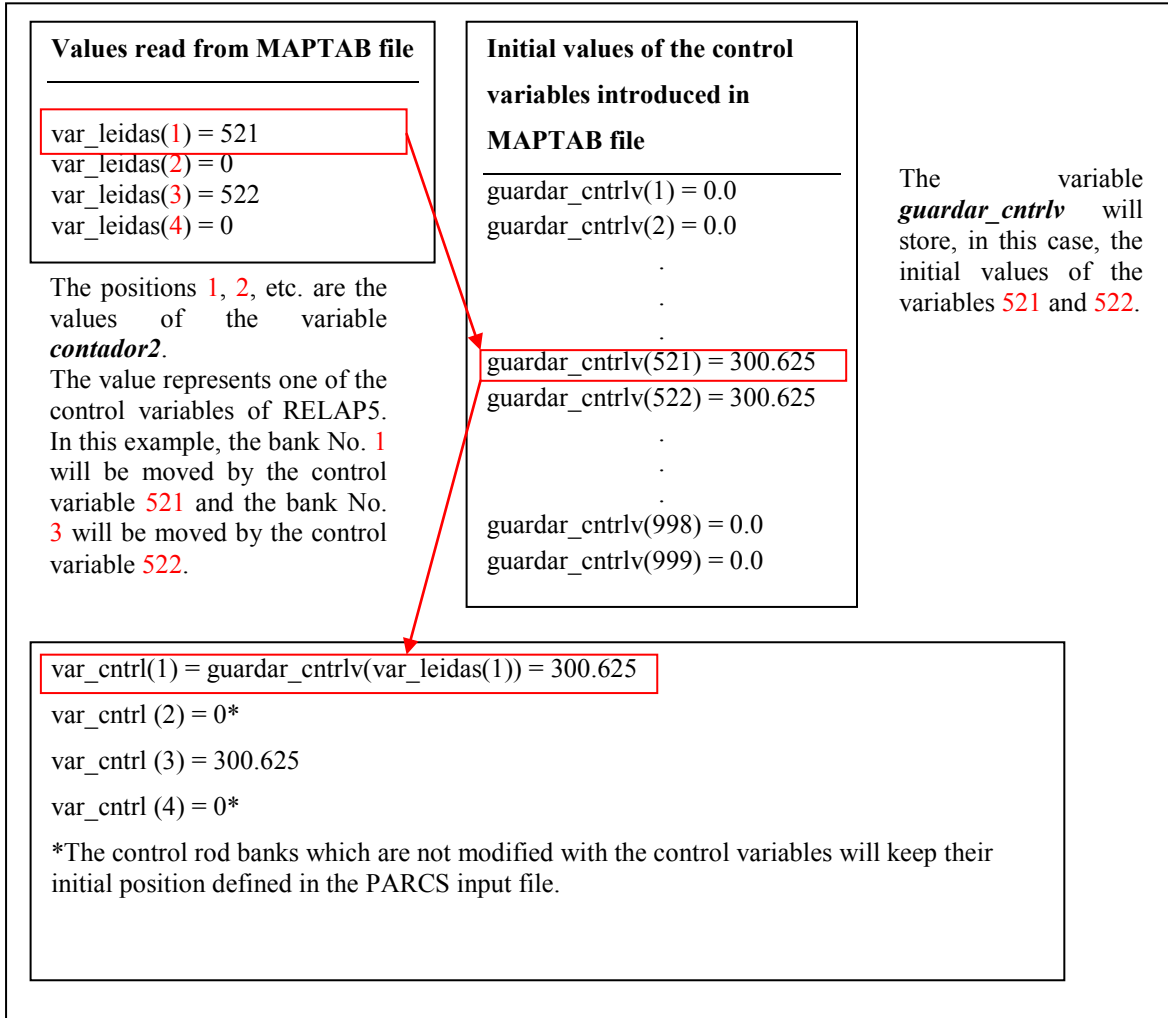


Figure 28 Working sequence of the initial values loop

5. RESOLUTION OF THE TIME SHIFT PROBLEM

With all these introduced changes it was realized that the program moves correctly the control rods, following the instructions indicated by user, but with a shift in the time step. The position of the control rods was always set one time step after the desired step.

To correct this behavior, the program was analyzed with the *debugger*. It was enough to put the calling to subroutine **convar** before the calling to **rdmr** in subroutine **tran.f**, to solve the problem. With the new configuration, the values of the Control Variables are updated before sending the information to PARCS v2.7, for what the lag between the programs disappears, see the following figure:

```
!!!! Pablo Ana / rmiro - UPV
c Call control system advancement.
  if (filid(27) .ne. 0.0d0) call convar 1
c Advance reactor kinetics.
cww
*if def.parcS
  if (.not. fail .and. chngno(88)) then 2
    call rdmr(.false.)
  else
*endif
  if (filid(21) .ne. 0.0d0) call rkin
*if def.parcS
  endif
*endif
c Call post-hydro scdap routines.
*if def.selap
*   if (scntrl(1)) call scdpsH
*endif
!!!! Pablo Ana / rmiro - UPV
!!!!c Call control system advancement.
!!!!  if (filid(27) .ne. 0.0d0) call convar 3
```

Figure 29 Fragment of the subroutine tran.f

In the original source code the line No. 3 was in use and was processed by the program. In line No. 2, a call to the routine **rdmr** transfers the information between both codes using the *pvm* library. Due to the former calling sequence the transfer of information was done first, i.e., line No. 2 was processed before the calling to **convar** (line No. 3).

Line No. 3 has been changed to position No. 1, obtaining thus the update of the Control Variables values before its transfer to PARCS v2.7. With this simple modification, and after the necessary checking to assure that these changes were not concerning the results of the original programs, the final aim of this work was achieved.

6. QUALIFICATION OF THE MODIFICATIONS INTRODUCED

In order to test that the modifications have been introduced properly, a Rod Ejection Accident (REA) transient to test the control rod movement modifications.

The Rod Ejection Accident (REA) belongs to the RIA category of accidents and it is part of the licensing basis accident analyses required for pressurized water reactors (PWR). The REA at hot zero power (HZP) is characterized by a single rod ejection from a core position with a very low power level. The evolution consists of a continuous reactivity insertion. The main feature limiting the consequences of the accident in a PWR is the Doppler Effect.

The reactor core studied is composed of 177 fuel elements, being the number of fuel rods per fuel element equal to 236 with 20 guide tubes. The neutronic model represents the whole core: the nodal discretization consists of 177 x 32 active nodes, considering 20 different fuel elements with 611 neutronic compositions. The cross-sections tables are generated with the SIMTAB methodology from CASMO4-SIMULATE3 code, developed at Universitat Politècnica de València, together with Iberdrola.

The model uses two prompt neutron groups and six delayed neutron groups, while the boundary condition for the neutron diffusion equation is zero-flux at the outer reflector surface.

Radially, the core is divided in 23 cm x 23 cm cells, each corresponding to one fuel assembly, plus a radial reflector. There are 177 fuel assemblies and 64 reflector assemblies.

Axially, the core is divided into 34 layers (32 fuel layers plus top and bottom reflector) with 10.625 cm height each one, with a total active core height of 340 cm.

The Doppler temperature (T_f) calculated by PARCS v2.7 code is found from the fuel temperature at the fuel rod center T_{fc} and at the fuel rod surface T_{fs} by the relation:

$$T_f = (1 - \alpha) \cdot T_{fc} + \alpha \cdot T_{fs}$$

where α is taken as equal to 0.7.

The thermalhydraulic model has been performed using RELAP5-MOD3.3 code. The reactor core has been modeled with 10 thermalhydraulic channels connected with a multiple junction (MTPLJUN) and the by-pass has been modeled as an independent channel (figures 30 and 31). Each one of the channels has 34 axial nodes. The axial nodes 1 and 34 represent the non-active core region. A time dependent volume (TMDPVOL) and a time dependent junction (TMDPJUN) simulate the boundary conditions at the entrance and exit of the reactor core. Each thermalhydraulic channel representing the core is connected to a heat structure.

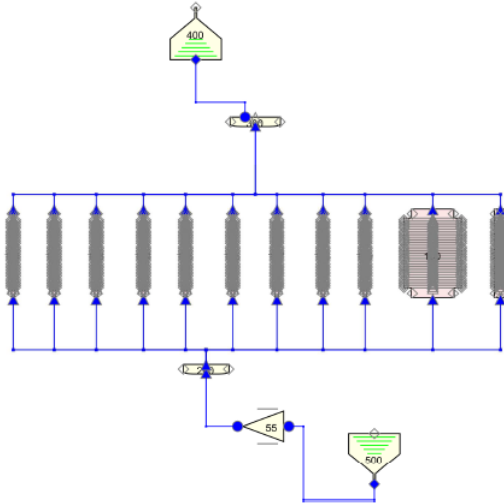


Figure 30: SNAP representation of the thermalhydraulic model

	Q	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	100	100	100	100	100	0	0	0	0	0	2
3	0	0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	0	3
4	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	0	0	4
5	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	5
6	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	6
7	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	7
8	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	8
9	0	100	100	100	100	100	100	100	100	100	100	100	100	102	103	104	100	9
10	0	100	100	100	100	100	100	100	100	100	100	100	100	105	101	106	100	10
11	0	100	100	100	100	100	100	100	100	100	100	100	100	107	108	109	100	11
12	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	12
13	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0	13
14	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	0	0	14
15	0	0	0	0	100	100	100	100	100	100	100	100	100	100	0	0	0	15
16	0	0	0	0	0	100	100	100	100	100	100	0	0	0	0	0	0	16
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17

Figure 31: Thermalhydraulic channels

Previous analysis determined that the control rod with the maximum worth belongs to the bank number 6 and it is located at position D-10. The thermalhydraulic channels surrounding the ejected control rod have been modeled as independent channels, while the others have been grouped in a unique channel (figure 31).

Control rods are grouped in 13 banks: initially banks 1, 5 and 6 are totally inserted and the other ones are out of the core. Figure 32 shows the control rods banks and the ejected rod D-10 is highlighted in red.

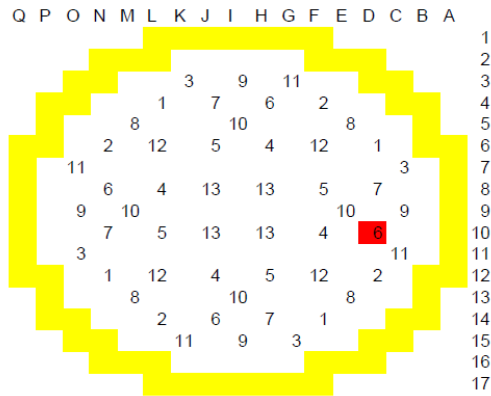


Figure 32: Control rods banks

RELAP5 and PARCS v2.7 input decks are provided in the annex for running this example, for both the original option and the new capability.

To compare the results using the older and the new option for the control rod movement, two parameters has been chosen: power and enthalpy. The results obtained are shown in Figures 33 and 34.

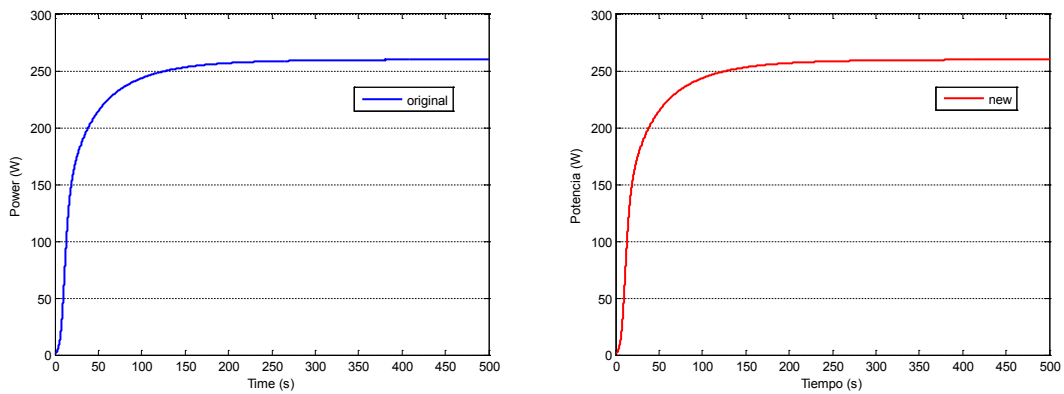


Figure 33: Comparison of the power evolution

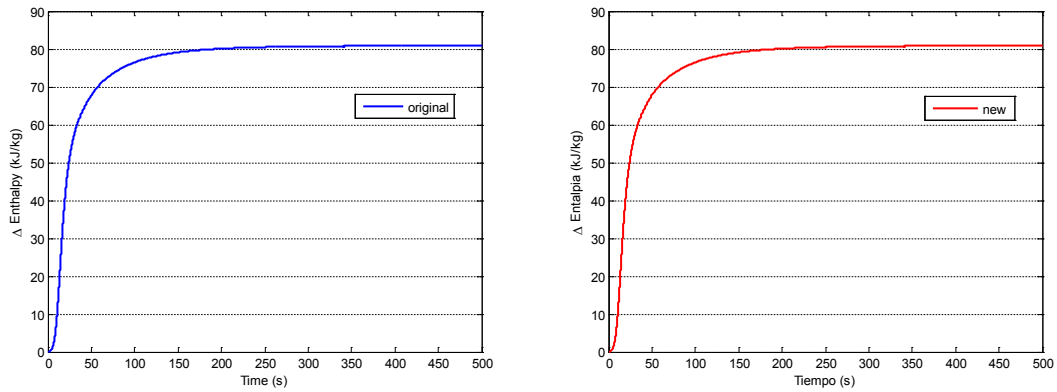


Figure 34: Comparison of the enthalpy evolution

This figures show that there is no difference between the two options, as can be seen also in the numerical results of the output files supplied in the annex. The obtained results show that the introduced modifications work properly, as the results obtained with the new methodology are identical to the ones obtained with the original.

7. CONCLUSIONS

The variables that have been introduced in the changes performed to the subroutines are summarized in the following table:

Table 1 Summary of the declared new variables in PARCS v2.7 and RELAP5 codes

Variable	Meaning	Code	File
<i>n_var</i>	Total stored data: total number of RELAP5 Control Variables that will move PARCS control rod banks	PARCS v2.7	pdmr_varM.f
<i>var_leidas(1000)</i>	It stores the read data, that is, the ID's for the RELAP5 Control Variables which will move the control rod banks in PARCS v2.7.	PARCS v2.7	pdmr_varM.f
<i>mov_cr_relap</i>	It is used to choose between one type of calculation option and another, i.e., between the former CR movement option and the new one.	PARCS v2.7	pdmr_varM.f
<i>var_cntrl(1000)</i>	It takes charge of storing, in each time step, the value of the Control Variables which will move the control rod banks.	RELAP5	r-var.f
<i>guardar_cntrlv(1000)</i>	It stores the initial values of the Control Variables which will move the control rod banks.	RELAP5	r-var.f
<i>contador</i>	It assures that the loop used to read the initial values of the control rod position is done only once.	RELAP5	r-commu.f
<i>contador2</i>	Auxiliary variable.	RELAP5	r-commu.f

The table 2 shows a summary of PARCS v2.7 and RELAP5 modified routines:

Table 2 Summary of the modified subroutines in PARCS V2.7 and RELAP5 codes

File	Function	Changes	Code
<i>pdmr_varM.f</i>	Declaration of PARCS v2.7 variables.	Declaration of the new variables: var_leidas , n_var , mov_cr_relap	PARCS v2.7
<i>pdmr_mapM.f</i>	It processes the MAPTAB file.	New loop for reading the information from the %CRSIG card	PARCS v2.7
<i>gi_commM.f</i>	Sending and reception of the data from and to RELAP5 code.	Sending of the variables var_leidas and n_var and reception of the variable var_cntrl through the PVM	PARCS v2.7
<i>perturb.f</i>	Processes the perturbations that occur during the transient.	With variable mov_cr_relap the control rod banks are moved following the orders from RELAP5	PARCS v2.7
<i>r-var.f</i>	Declaration of RELAP5 variables.	Declaration of the new variables: var_leidas , n_var , guardar_cntrlv , var_cntrl	RELAP5
<i>r-commu.f</i>	Sending and reception of the data from and to PARCS v2.7 code.	Sending of the variable var_cntrl and reception of the variables: var_leidas , n_var , through the PVM	RELAP5
<i>iconvr.f</i>	Processes the Control Variables initial values.	It stores the initial values in the variable guardar_cntrlv	RELAP5
<i>tran.f</i>	It controls the advancement of the transient simulations: for each time step, it calls to the processing subroutine of the	It updates first the values by calling to the subroutine convar and after that it sends them to the subroutine rdmr .	RELAP5

File	Function	Changes	Code
	hydraulic components, heat structures and reactor kinetics (0D or PARCS).		

The main conclusions of this work are the following:

- In this project a new capability has added to RELAP5/PARCS v2.7 that converts it to a more real 3D simulator.
- Previous input files of both RELAP5 and PARCS v2.7 does not need to be modified, and they continue working without any modification.
- RELAP5 manual do not need to be modified.
- PARCS v2.7 manual only needs to incorporate the explanation of the new capability.
- Integration with the graphical environment SNAP.
- It permits the interactivity, both from SNAP and without graphical environment.

8. REFERENCES

1. Compaq Visual Fortran. Programmer's Guide. Compaq Computer Corporation, Houston, Texas, August, 2001.
2. RELAP5/MOD3.3 Code Manual Volume VIII: Programmers Manual. Information Systems Laboratories, Inc., Rockville, Maryland, NUREG/CR-5535/Rev 1-Vol VIII, December, 2001.
3. PARCS v2.7 US NRC Core Neutronics Simulator. T. Downar, Y. Xu, T. Kozlowski, D. Carlson, School of Nuclear Engineering, Purdue University, W. Lafayette, Indiana, 2006.
4. PVM: Parallel Virtual Machine. A Users' Guide and Tutorial for Networked Parallel Computing. MIT Press Scientific and Engineering Computation, Janusz Kowalik, Editor, Massachusetts Institute of Technology, 1994.
5. O. Roselló, Desarrollo de una metodología de generación de secciones eficaces para la simplificación del núcleo de reactores de agua ligera y aplicación en códigos acoplados neutrónicos termohidráulicos. PhD Thesis. UPV, Valencia, Spain (2004).

ANNEX 1: INPUT DECKS FOR RELAP5 AND PARCS V2.7 CODES

In order to test that the modifications have been introduced properly, input decks for RELAP5 and PARCS v2.7 codes are provided. The transient simulated is a Rod Ejection Accident (REA), and the control rod movement is implemented in both codes.

For PARCS v2.7 code, *GEOM_LWR* file is needed. This file contains the reactor geometry data, and the control rod bank position. The file is provided in this annex.

For coupled simulation, *MAPTAB_RP* file is also needed. This file contains the correspondence between neutronic and thermalhydraulic nodes, and is the file where the card %CRSIG is implemented. This file is also provided in this annex.

Cards and comments referring to the control rod movement capability are shaded in grey.

INPUT DECK FOR RELAP5 STAND ALONE SIMULATION:

```
=PWR R5M3.3 beta (INPUT FOR RIA TEST)
* PWR REACTOR RELAP5 INPUT FILE0
*
*-----
* Problem Options
*-----
*
*****
100 new   stdy-st
101 run
102 si si
* remaining cpu time
105 5. 6.
*
*           Min mj re
201 100.0 .1e-05 0.10 07003 5 4000 4000
202 500.0 .1e-05 0.10 07003 100 5000 5000
*
*-----
* T/H Volumes
*-----
*-----
* Core Inlet Boundary Conditions
*-----
5000000 inlet tmdpvol
5000101 100.0 .1e+9 0. 0. 0. 0. 0. 00
5000200 113
5000201 0.0 0.1552e+08 567.922 0.131e-02
5000202 .1e+07 0.1552e+08 567.922 0.131e-02
*
* tmdpjun feedwater
*
0550000 feedwate tmdpjun
0550101 500010000 200000000 3.048
0550200 1
550201 0.0 16000.0000 0.0 0.0
550202 .1e+07 16000.0000 0.0 0.0
*
* lower plenum part 0
*
2000000 lwpt0   branch
2000001 4      1
2000101 3.0000 0.5 0.0 0.0 90.0 0.5 0 0.013083 0000000
2000200 113 0.1552e+08 567.922 0.131e-02
2001101 200010000 201000000 0.20 0.0 0.0 0000000
2002101 200010000 202000000 2.70 0.0 0.0 0000000
2003101 200010000 203000000 0.10 0.0 0.0 0000000
2004101 200010000 204000000 0.05 0.0 0.0 0000000
2001201 420.0 0.0 0.0
2002201 15000.0 0.0 0.0
2003201 500.0 0.0 0.0
2004201 260.0 0.0 0.0
*
*
```

```

*lower plenum
*
2010000 lw201 branch
2010001 1 1
2010101 0.20 0.5 0.0 0.0 90.0 0.5 0 0.013083 0000000
2010200 113 0.1552e+08 567.922 0.131e-02
2011101 201010000 250000000 0.20 0.0 0.0 0000000
2011201 420.0 0.0 0.0

```

```

*lower plenum
*
2020000 lw202 branch
2020001 1 1
2020101 2.5 0.5 0.0 0.0 90.0 0.5 0 0.013083 0000000
2020200 113 0.1552e+08 567.922 0.131e-02
2021101 202010000 100000000 2.70 0.0 0.0 0000000
2021201 15000.0 0.0 0.0

```

```

*lower plenum
*
2030000 lw203 branch
2030001 6 1
2030101 0.1 0.5 0.0 0.0 90.0 0.5 0 0.013083 0000000
2030200 113 0.1552e+08 560.0 0.131e-02
2031101 203010000 101000000 0.0150 0.0 0.0 0000000
2032101 203010000 102000000 0.0150 0.0 0.0 0000000
2033101 203010000 103000000 0.0150 0.0 0.0 0000000
2034101 203010000 104000000 0.0150 0.0 0.0 0000000
2035101 203010000 105000000 0.0150 0.0 0.0 0000000
2036101 203010000 106000000 0.0150 0.0 0.0 0000000
2031201 90.0 0.0 0.0
2032201 90.0 0.0 0.0
2033201 90.0 0.0 0.0
2034201 90.0 0.0 0.0
2035201 90.0 0.0 0.0
2036201 90.0 0.0 0.0

```

```

*lower plenum
*
2040000 lw204 branch
2040001 3 1
2040101 0.05 0.5 0.0 0.0 90.0 0.5 0 0.013083 0000000
2040200 113 0.1552e+08 567.922 0.131e-02
2041101 204010000 107000000 0.0150 0.0 0.0 0000000
2042101 204010000 108000000 0.0150 0.0 0.0 0000000
2043101 204010000 109000000 0.0150 0.0 0.0 0000000
2041201 90.0 0.0 0.0
2042201 90.0 0.0 0.0
2043201 90.0 0.0 0.0

```

```

*****Internal Bundles*****

```

* Channel 100

*

```
1000000 inb100 pipe
1000001      34
1000101 2.70      1
1000102 4.85      33
1000103 2.60      34
1000301 0.4670     1
1000302 0.1067     33
1000303 0.4540     34
1000601 90.0       34
1000701 0.4670     1
1000702 0.1067     33
1000703 0.4540     34
1000801 .60e-05 0.013083 34
1000901 1.4 1.4      1
1000902 0.0 0.0      4
1000903 1.8 1.8      5
1000904 0.0 0.0     10
1000905 1.8 1.8     11
1000906 0.0 0.0     15
1000907 1.8 1.8     16
1000908 0.0 0.0     21
1000909 1.8 1.8     22
1000910 0.0 0.0     26
1000911 1.8 1.8     27
1000912 0.0 0.0     32
1000913 0.70 0.70    33
1001001 0000100     34
1001101 00001000   33
1001201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1001202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1001203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1001204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1001205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1001206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1001207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1001208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1001209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1001210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1001211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1001212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1001213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1001214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1001215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
1001216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
1001217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
1001218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
1001219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
1001220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
1001221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
1001222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
1001223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
1001224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
1001225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
```

1001226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
 1001227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
 1001228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
 1001229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
 1001230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
 1001231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
 1001232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
 1001233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
 1001234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
 1002001 .1308e-02 34
 1001300 1
 1001301 15000.0 0.0 0.0 33

*

* Channel 101

*

1010000 inb101 pipe
 1010001 34
 1010101 0.0150 1
 1010102 0.0290 33
 1010103 0.0150 34
 1010301 0.4670 1
 1010302 0.1067 33
 1010303 0.4540 34
 1010601 90.0 34
 1010701 0.4670 1
 1010702 0.1067 33
 1010703 0.4540 34
 1010801 .60e-05 0.013083 34
 1010901 1.4 1.4 1
 1010902 0.0 0.0 4
 1010903 1.8 1.8 5
 1010904 0.0 0.0 10
 1010905 1.8 1.8 11
 1010906 0.0 0.0 15
 1010907 1.8 1.8 16
 1010908 0.0 0.0 21
 1010909 1.8 1.8 22
 1010910 0.0 0.0 26
 1010911 1.8 1.8 27
 1010912 0.0 0.0 32
 1010913 0.70 0.70 33
 1011001 0000100 34
 1011101 00001000 33
 1011201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
 1011202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
 1011203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
 1011204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
 1011205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
 1011206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
 1011207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
 1011208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
 1011209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
 1011210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
 1011211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
 1011212 113 0.1552e+08 567.874 0.0 0.0 0.0 12

1011213	113	0.1552e+08	567.874	0.0	0.0	0.0	13
1011214	113	0.1552e+08	567.874	0.0	0.0	0.0	14
1011215	113	0.1552e+08	567.874	0.0	0.0	0.0	15
1011216	113	0.1552e+08	567.874	0.0	0.0	0.0	16
1011217	113	0.1552e+08	567.874	0.0	0.0	0.0	17
1011218	113	0.1552e+08	567.874	0.0	0.0	0.0	18
1011219	113	0.1552e+08	567.874	0.0	0.0	0.0	19
1011220	113	0.1552e+08	567.874	0.0	0.0	0.0	20
1011221	113	0.1552e+08	567.874	0.0	0.0	0.0	21
1011222	113	0.1552e+08	567.874	0.0	0.0	0.0	22
1011223	113	0.1552e+08	567.874	0.0	0.0	0.0	23
1011224	113	0.1552e+08	567.874	0.0	0.0	0.0	24
1011225	113	0.1552e+08	567.874	0.0	0.0	0.0	25
1011226	113	0.1552e+08	567.874	0.0	0.0	0.0	26
1011227	113	0.1552e+08	567.874	0.0	0.0	0.0	27
1011228	113	0.1552e+08	567.874	0.0	0.0	0.0	28
1011229	113	0.1552e+08	567.874	0.0	0.0	0.0	29
1011230	113	0.1552e+08	567.874	0.0	0.0	0.0	30
1011231	113	0.1552e+08	567.874	0.0	0.0	0.0	31
1011232	113	0.1552e+08	567.874	0.0	0.0	0.0	32
1011233	113	0.1552e+08	567.874	0.0	0.0	0.0	33
1011234	113	0.1552e+08	567.874	0.0	0.0	0.0	34
1012001	.1308e-02		34				
1011300	1						
1011301	90.0	0.0	0.0			33	

*

* Channel 102

*

1020000	inb102	pipe					
1020001		34					
1020101	0.0150		1				
1020102	0.0290		33				
1020103	0.0150		34				
1020301	0.4670		1				
1020302	0.1067		33				
1020303	0.4540		34				
1020601	90.0		34				
1020701	0.4670		1				
1020702	0.1067		33				
1020703	0.4540		34				
1020801	.60e-05	0.013083	34				
1020901	1.4	1.4	1				
1020902	0.0	0.0	4				
1020903	1.8	1.8	5				
1020904	0.0	0.0	10				
1020905	1.8	1.8	11				
1020906	0.0	0.0	15				
1020907	1.8	1.8	16				
1020908	0.0	0.0	21				
1020909	1.8	1.8	22				
1020910	0.0	0.0	26				
1020911	1.8	1.8	27				
1020912	0.0	0.0	32				
1020913	0.70	0.70	33				
1021001	0000100		34				


```

1021101 00001000      33
1021201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1021202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1021203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1021204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1021205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1021206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1021207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1021208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1021209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1021210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1021211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1021212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1021213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1021214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1021215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
1021216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
1021217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
1021218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
1021219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
1021220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
1021221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
1021222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
1021223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
1021224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
1021225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
1021226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
1021227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
1021228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
1021229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
1021230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
1021231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
1021232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1021233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1021234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1022001 .1308e-02      34
1021300 1
1021301 90.0 0.0 0.0      33

```

*

* Channel 103

*

```

1030000 inb103 pipe
1030001      34
1030101 0.0150      1
1030102 0.0290      33
1030103 0.0150      34
1030301 0.4670      1
1030302 0.1067      33
1030303 0.4540      34
1030601 90.0      34
1030701 0.4670      1
1030702 0.1067      33
1030703 0.4540      34
1030801 .60e-05 0.013083 34
1030901 1.4 1.4      1

```

```

1030902 0.0 0.0      4
1030903 1.8 1.8      5
1030904 0.0 0.0     10
1030905 1.8 1.8     11
1030906 0.0 0.0     15
1030907 1.8 1.8     16
1030908 0.0 0.0     21
1030909 1.8 1.8     22
1030910 0.0 0.0     26
1030911 1.8 1.8     27
1030912 0.0 0.0     32
1030913 0.70 0.70    33
1031001 0000100     34
1031101 00001000    33
1031201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1031202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1031203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1031204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1031205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1031206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1031207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1031208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1031209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1031210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1031211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1031212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1031213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1031214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1031215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
1031216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
1031217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
1031218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
1031219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
1031220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
1031221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
1031222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
1031223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
1031224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
1031225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
1031226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
1031227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
1031228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
1031229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
1031230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
1031231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
1031232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1031233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1031234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1032001 .1308e-02     34
1031300 1
1031301 90.0 0.0 0.0      33
*
* Channel 104
*
1040000 inb104 pipe

```



```

1041229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
1041230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
1041231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
1041232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1041233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1041234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1042001 .1308e-02 34
1041300 1
1041301 90.0 0.0 0.0 33
*
* Channel 105
*
1050000 inb105 pipe
1050001 34
1050101 0.0150 1
1050102 0.0290 33
1050103 0.0150 34
1050301 0.4670 1
1050302 0.1067 33
1050303 0.4540 34
1050601 90.0 34
1050701 0.4670 1
1050702 0.1067 33
1050703 0.4540 34
1050801 .60e-05 0.013083 34
1050901 1.4 1.4 1
1050902 0.0 0.0 4
1050903 1.8 1.8 5
1050904 0.0 0.0 10
1050905 1.8 1.8 11
1050906 0.0 0.0 15
1050907 1.8 1.8 16
1050908 0.0 0.0 21
1050909 1.8 1.8 22
1050910 0.0 0.0 26
1050911 1.8 1.8 27
1050912 0.0 0.0 32
1050913 0.70 0.70 33
1051001 0000100 34
1051101 00001000 33
1051201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1051202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1051203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1051204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1051205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1051206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1051207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1051208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1051209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1051210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1051211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1051212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1051213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1051214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1051215 113 0.1552e+08 567.874 0.0 0.0 0.0 15

```

1051216	113	0.1552e+08	567.874	0.0	0.0	0.0	16
1051217	113	0.1552e+08	567.874	0.0	0.0	0.0	17
1051218	113	0.1552e+08	567.874	0.0	0.0	0.0	18
1051219	113	0.1552e+08	567.874	0.0	0.0	0.0	19
1051220	113	0.1552e+08	567.874	0.0	0.0	0.0	20
1051221	113	0.1552e+08	567.874	0.0	0.0	0.0	21
1051222	113	0.1552e+08	567.874	0.0	0.0	0.0	22
1051223	113	0.1552e+08	567.874	0.0	0.0	0.0	23
1051224	113	0.1552e+08	567.874	0.0	0.0	0.0	24
1051225	113	0.1552e+08	567.874	0.0	0.0	0.0	25
1051226	113	0.1552e+08	567.874	0.0	0.0	0.0	26
1051227	113	0.1552e+08	567.874	0.0	0.0	0.0	27
1051228	113	0.1552e+08	567.874	0.0	0.0	0.0	28
1051229	113	0.1552e+08	567.874	0.0	0.0	0.0	29
1051230	113	0.1552e+08	567.874	0.0	0.0	0.0	30
1051231	113	0.1552e+08	567.874	0.0	0.0	0.0	31
1051232	113	0.1552e+08	567.874	0.0	0.0	0.0	32
1051233	113	0.1552e+08	567.874	0.0	0.0	0.0	33
1051234	113	0.1552e+08	567.874	0.0	0.0	0.0	34
1052001	.1308e-02		34				
1051300	1						
1051301	90.0	0.0	0.0			33	
*							
* Channel 106							
*							
1060000	inb106	pipe					
1060001		34					
1060101	0.0150		1				
1060102	0.0290		33				
1060103	0.0150		34				
1060301	0.4670		1				
1060302	0.1067		33				
1060303	0.4540		34				
1060601	90.0		34				
1060701	0.4670		1				
1060702	0.1067		33				
1060703	0.4540		34				
1060801	.60e-05	0.013083	34				
1060901	1.4	1.4	1				
1060902	0.0	0.0	4				
1060903	1.8	1.8	5				
1060904	0.0	0.0	10				
1060905	1.8	1.8	11				
1060906	0.0	0.0	15				
1060907	1.8	1.8	16				
1060908	0.0	0.0	21				
1060909	1.8	1.8	22				
1060910	0.0	0.0	26				
1060911	1.8	1.8	27				
1060912	0.0	0.0	32				
1060913	0.70	0.70	33				
1061001	0000100		34				
1061101	00001000		33				
1061201	113	0.1552e+08	567.874	0.0	0.0	0.0	1
1061202	113	0.1552e+08	567.874	0.0	0.0	0.0	2

1061203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
 1061204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
 1061205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
 1061206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
 1061207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
 1061208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
 1061209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
 1061210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
 1061211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
 1061212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
 1061213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
 1061214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
 1061215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
 1061216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
 1061217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
 1061218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
 1061219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
 1061220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
 1061221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
 1061222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
 1061223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
 1061224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
 1061225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
 1061226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
 1061227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
 1061228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
 1061229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
 1061230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
 1061231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
 1061232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
 1061233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
 1061234 113 0.1552e+08 567.874 0.0 0.0 0.0 34

1062001 .1308e-02 34
 1061300 1
 1061301 90.0 0.0 0.0 33

*
 * Channel 107
 *

1070000 inb107 pipe
 1070001 34
 1070101 0.0150 1
 1070102 0.0290 33
 1070103 0.0150 34
 1070301 0.4670 1
 1070302 0.1067 33
 1070303 0.4540 34
 1070601 90.0 34
 1070701 0.4670 1
 1070702 0.1067 33
 1070703 0.4540 34
 1070801 .60e-05 0.013083 34
 1070901 1.4 1.4 1
 1070902 0.0 0.0 4
 1070903 1.8 1.8 5
 1070904 0.0 0.0 10

```

1070905 1.8 1.8      11
1070906 0.0 0.0      15
1070907 1.8 1.8      16
1070908 0.0 0.0      21
1070909 1.8 1.8      22
1070910 0.0 0.0      26
1070911 1.8 1.8      27
1070912 0.0 0.0      32
1070913 0.70 0.70     33
1071001 0000100      34
1071101 00001000     33
1071201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1071202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1071203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1071204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1071205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1071206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1071207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1071208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1071209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1071210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1071211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1071212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1071213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1071214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1071215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
1071216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
1071217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
1071218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
1071219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
1071220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
1071221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
1071222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
1071223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
1071224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
1071225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
1071226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
1071227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
1071228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
1071229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
1071230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
1071231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
1071232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1071233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1071234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1072001 .1308e-02     34
1071300 1
1071301 90.0 0.0 0.0      33
*
* Channel 108
*
1080000 inb108 pipe
1080001      34
1080101 0.0150      1
1080102 0.0290      33

```

1080103	0.0150		34						
1080301	0.4670		1						
1080302	0.1067		33						
1080303	0.4540		34						
1080601	90.0		34						
1080701	0.4670		1						
1080702	0.1067		33						
1080703	0.4540		34						
1080801	.60e-05	0.013083	34						
1080901	1.4	1.4	1						
1080902	0.0	0.0	4						
1080903	1.8	1.8	5						
1080904	0.0	0.0	10						
1080905	1.8	1.8	11						
1080906	0.0	0.0	15						
1080907	1.8	1.8	16						
1080908	0.0	0.0	21						
1080909	1.8	1.8	22						
1080910	0.0	0.0	26						
1080911	1.8	1.8	27						
1080912	0.0	0.0	32						
1080913	0.70	0.70	33						
1081001	0000100		34						
1081101	00001000		33						
1081201	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	1	
1081202	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	2	
1081203	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	3	
1081204	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	4	
1081205	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	5	
1081206	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	6	
1081207	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	7	
1081208	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	8	
1081209	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	9	
1081210	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	10	
1081211	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	11	
1081212	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	12	
1081213	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	13	
1081214	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	14	
1081215	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	15	
1081216	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	16	
1081217	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	17	
1081218	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	18	
1081219	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	19	
1081220	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	20	
1081221	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	21	
1081222	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	22	
1081223	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	23	
1081224	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	24	
1081225	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	25	
1081226	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	26	
1081227	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	27	
1081228	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	28	
1081229	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	29	
1081230	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	30	
1081231	113	0.1552e+08	567.874	0.0	0.0	0.0	0.0	31	


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1081232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1081233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1081234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1082001 .1308e-02      34
1081300 1
1081301 90.0 0.0 0.0      33
*
* Channel 109
*
1090000 inb109 pipe
1090001      34
1090101 0.0150      1
1090102 0.0290      33
1090103 0.0150      34
1090301 0.4670      1
1090302 0.1067      33
1090303 0.4540      34
1090601 90.0      34
1090701 0.4670      1
1090702 0.1067      33
1090703 0.4540      34
1090801 .60e-05 0.013083 34
1090901 1.4 1.4      1
1090902 0.0 0.0      4
1090903 1.8 1.8      5
1090904 0.0 0.0      10
1090905 1.8 1.8      11
1090906 0.0 0.0      15
1090907 1.8 1.8      16
1090908 0.0 0.0      21
1090909 1.8 1.8      22
1090910 0.0 0.0      26
1090911 1.8 1.8      27
1090912 0.0 0.0      32
1090913 0.70 0.70      33
1091001 0000100      34
1091101 00001000      33
1091201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
1091202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
1091203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
1091204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
1091205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
1091206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
1091207 113 0.1552e+08 567.874 0.0 0.0 0.0 7
1091208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
1091209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
1091210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
1091211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
1091212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
1091213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
1091214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
1091215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
1091216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
1091217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
1091218 113 0.1552e+08 567.874 0.0 0.0 0.0 18

```

```

1091219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
1091220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
1091221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
1091222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
1091223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
1091224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
1091225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
1091226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
1091227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
1091228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
1091229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
1091230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
1091231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
1091232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
1091233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
1091234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
1092001 .1308e-02 34
1091300 1
1091301 90.0 0.0 0.0 33
*
* Bypass
*
2500000 bypa pipe
2500001 34
2500101 0.20 34
2500301 0.4670 1
2500302 0.1067 33
2500303 0.4540 34
2500601 90.0 34
2500701 0.4670 1
2500702 0.1067 33
2500703 0.4540 34
2500801 .60e-05 0.000000 34
2500901 2.8 2.8 1
2500902 0.0 0.0 4
2500903 2.8 2.8 5
2500904 0.0 0.0 10
2500905 2.8 2.8 11
2500906 0.0 0.0 15
2500907 2.8 2.8 16
2500908 0.0 0.0 21
2500909 2.8 2.8 22
2500910 0.0 0.0 26
2500911 2.8 2.8 27
2500912 0.0 0.0 32
2500913 2.8 2.8 33
2501001 0000100 34
2501101 00001000 33
2501201 113 0.1552e+08 567.874 0.0 0.0 0.0 1
2501202 113 0.1552e+08 567.874 0.0 0.0 0.0 2
2501203 113 0.1552e+08 567.874 0.0 0.0 0.0 3
2501204 113 0.1552e+08 567.874 0.0 0.0 0.0 4
2501205 113 0.1552e+08 567.874 0.0 0.0 0.0 5
2501206 113 0.1552e+08 567.874 0.0 0.0 0.0 6
2501207 113 0.1552e+08 567.874 0.0 0.0 0.0 7

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2501208 113 0.1552e+08 567.874 0.0 0.0 0.0 8
2501209 113 0.1552e+08 567.874 0.0 0.0 0.0 9
2501210 113 0.1552e+08 567.874 0.0 0.0 0.0 10
2501211 113 0.1552e+08 567.874 0.0 0.0 0.0 11
2501212 113 0.1552e+08 567.874 0.0 0.0 0.0 12
2501213 113 0.1552e+08 567.874 0.0 0.0 0.0 13
2501214 113 0.1552e+08 567.874 0.0 0.0 0.0 14
2501215 113 0.1552e+08 567.874 0.0 0.0 0.0 15
2501216 113 0.1552e+08 567.874 0.0 0.0 0.0 16
2501217 113 0.1552e+08 567.874 0.0 0.0 0.0 17
2501218 113 0.1552e+08 567.874 0.0 0.0 0.0 18
2501219 113 0.1552e+08 567.874 0.0 0.0 0.0 19
2501220 113 0.1552e+08 567.874 0.0 0.0 0.0 20
2501221 113 0.1552e+08 567.874 0.0 0.0 0.0 21
2501222 113 0.1552e+08 567.874 0.0 0.0 0.0 22
2501223 113 0.1552e+08 567.874 0.0 0.0 0.0 23
2501224 113 0.1552e+08 567.874 0.0 0.0 0.0 24
2501225 113 0.1552e+08 567.874 0.0 0.0 0.0 25
2501226 113 0.1552e+08 567.874 0.0 0.0 0.0 26
2501227 113 0.1552e+08 567.874 0.0 0.0 0.0 27
2501228 113 0.1552e+08 567.874 0.0 0.0 0.0 28
2501229 113 0.1552e+08 567.874 0.0 0.0 0.0 29
2501230 113 0.1552e+08 567.874 0.0 0.0 0.0 30
2501231 113 0.1552e+08 567.874 0.0 0.0 0.0 31
2501232 113 0.1552e+08 567.874 0.0 0.0 0.0 32
2501233 113 0.1552e+08 567.874 0.0 0.0 0.0 33
2501234 113 0.1552e+08 567.874 0.0 0.0 0.0 34
2502001 .1308e-02 34
2501300 1
2501301 415.04513 0.0 0.0 33
*
*
* upper plenum part 0
*
3000000 uppt0 branch
3000001 5 1
3000101 3.7387 0.450 0.0 0.0 90.0 0.450 0 0.013083 0000000
3000200 113 0.1552e+08 602.291 0.131e-02
3001101 300000000 301010000 0.20 0.0 0.0 0000000
3002101 300000000 302010000 2.70 0.0 0.0 0000000
3003101 300000000 303010000 0.10 0.0 0.0 0000000
3004101 300000000 304010000 0.05 0.0 0.0 0000000
3005101 300010000 400000000 0.6903 0.0 0.0 0000000
3001201 420.0 0.0 0.0
3002201 15000.0 0.0 0.0
3003201 530.0 0.0 0.0
3004201 260.0 0.0 0.0
3005201 16000.00000 0.0 0.0
*
*
*upper plenum
*
3010000 up301 branch
3010001 1 1
3010101 0.20 0.450 0.0 0.0 90.0 0.450 0 0.013083 0000000

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3010200 113 0.1552e+08 602.291 0.131e-02
3011101 301000000 250010000 0.20 0.0 0.0 0000000
3011201 420.0 0.0 0.0
*
*
*upper plenum
*
3020000 up302 branch
3020001 1 1
3020101 2.70 0.450 0.0 0.0 90.0 0.450 0 0.013083 0000000
3020200 113 0.1552e+08 602.291 0.131e-02
3021101 302000000 100010000 2.60 0.0 0.0 0000000
3021201 15000.0 0.0 0.0
*
*upper plenum
*
3030000 up303 branch
3030001 6 1
3030101 0.10 0.450 0.0 0.0 90.0 0.450 0 0.013083 0000000
3030200 113 0.1552e+08 602.291 0.131e-02
3031101 303000000 101010000 0.0150 0.0 0.0 0000000
3032101 303000000 102010000 0.0150 0.0 0.0 0000000
3033101 303000000 103010000 0.0150 0.0 0.0 0000000
3034101 303000000 104010000 0.0150 0.0 0.0 0000000
3035101 303000000 105010000 0.0150 0.0 0.0 0000000
3036101 303000000 106010000 0.0150 0.0 0.0 0000000
3031201 90.0 0.0 0.0
3032201 90.0 0.0 0.0
3033201 90.0 0.0 0.0
3034201 90.0 0.0 0.0
3035201 90.0 0.0 0.0
3036201 90.0 0.0 0.0
*
*upper plenum
*
3040000 up304 branch
3040001 3 1
3040101 0.05 0.450 0.0 0.0 90.0 0.450 0 0.013083 0000000
3040200 113 0.1552e+08 602.291 0.131e-02
3041101 304000000 107010000 0.0150 0.0 0.0 0000000
3042101 304000000 108010000 0.0150 0.0 0.0 0000000
3043101 304000000 109010000 0.0150 0.0 0.0 0000000
3041201 90.0 0.0 0.0
3042201 90.0 0.0 0.0
3043201 90.0 0.0 0.0
*
*
*-----
*Core Outlet Boundary Conditions
*-----
4000000 outle tmdpvol
4000101 100.0 .1e+9 0. 0. 0. 0. 0. 00
4000200 113
4000201 0.0 0.1552e+08 602.291 0.131e-02
4000202 .1e+07 0.1552e+08 602.291 0.131e-02

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*
*****
*
*****
*
*****Heat Structures*****
*
* Heat Structure Channel 100
*
11000000 34 6 2 1 0.0 0 34
11000100 0 1
11000101 3 .458e-02 1 .466e-02 1 .539e-02
11000201 1 3 2 4 3 5
11000301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
11000400 -1
11000401 729.222 683.440 637.627 591.844 589.627 567.874
11000402 729.222 683.440 637.627 591.844 589.627 567.874
11000403 729.222 683.440 637.627 591.844 589.627 567.874
11000404 729.222 683.440 637.627 591.844 589.627 567.874
11000405 729.222 683.440 637.627 591.844 589.627 567.874
11000406 729.222 683.440 637.627 591.844 589.627 567.874
11000407 729.222 683.440 637.627 591.844 589.627 567.874
11000408 729.222 683.440 637.627 591.844 589.627 567.874
11000409 729.222 683.440 637.627 591.844 589.627 567.874
11000410 729.222 683.440 637.627 591.844 589.627 567.874
11000411 729.222 683.440 637.627 591.844 589.627 567.874
11000412 729.222 683.440 637.627 591.844 589.627 567.874
11000413 729.222 683.440 637.627 591.844 589.627 567.874
11000414 729.222 683.440 637.627 591.844 589.627 567.874
11000415 729.222 683.440 637.627 591.844 589.627 567.874
11000416 729.222 683.440 637.627 591.844 589.627 567.874
11000417 729.222 683.440 637.627 591.844 589.627 567.874
11000418 729.222 683.440 637.627 591.844 589.627 567.874
11000419 729.222 683.440 637.627 591.844 589.627 567.874
11000420 729.222 683.440 637.627 591.844 589.627 567.874
11000421 729.222 683.440 637.627 591.844 589.627 567.874
11000422 729.222 683.440 637.627 591.844 589.627 567.874
11000423 729.222 683.440 637.627 591.844 589.627 567.874
11000424 729.222 683.440 637.627 591.844 589.627 567.874
11000425 729.222 683.440 637.627 591.844 589.627 567.874
11000426 729.222 683.440 637.627 591.844 589.627 567.874
11000427 729.222 683.440 637.627 591.844 589.627 567.874
11000428 729.222 683.440 637.627 591.844 589.627 567.874
11000429 729.222 683.440 637.627 591.844 589.627 567.874
11000430 729.222 683.440 637.627 591.844 589.627 567.874
11000431 729.222 683.440 637.627 591.844 589.627 567.874
11000432 729.222 683.440 637.627 591.844 589.627 567.874
11000433 729.222 683.440 637.627 591.844 589.627 567.874
11000434 729.222 683.440 637.627 591.844 589.627 567.874
11000501 0 0 0 1 18515.6160 1
11000502 0 0 0 1 4230.4416 33
11000503 0 0 0 1 18000.1920 34
11000601 100010000 0 1 1 18515.6160 1
11000602 100020000 10000 1 1 4230.4416 33
11000603 100340000 0 1 1 18000.1920 34

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11000701 0000 0.0 0.0 0.0 1
11000702 1000 0.031394791 0.0 0.000592853 2
11000703 1000 0.030188161 0.0 0.000570067 3
11000704 1000 0.029432508 0.0 0.000555797 4
11000705 1000 0.029017072 0.0 0.000547952 5
11000706 1000 0.028751731 0.0 0.000542942 6
11000707 1000 0.028641488 0.0 0.000540860 7
11000708 1000 0.028589559 0.0 0.000539879 8
11000709 1000 0.028598875 0.0 0.000540055 9
11000710 1000 0.028608191 0.0 0.000540231 10
11000711 1000 0.028564198 0.0 0.000539400 11
11000712 1000 0.028575757 0.0 0.000539619 12
11000713 1000 0.028584038 0.0 0.000539775 13
11000714 1000 0.028628894 0.0 0.000540622 14
11000715 1000 0.028663226 0.0 0.000541270 15
11000716 1000 0.028630619 0.0 0.000540655 16
11000717 1000 0.028650459 0.0 0.000541029 17
11000718 1000 0.028609399 0.0 0.000540254 18
11000719 1000 0.028595942 0.0 0.000540000 19
11000720 1000 0.028639763 0.0 0.000540827 20
11000721 1000 0.028610434 0.0 0.000540273 21
11000722 1000 0.028634932 0.0 0.000540736 22
11000723 1000 0.028658913 0.0 0.000541189 23
11000724 1000 0.028709808 0.0 0.000542150 24
11000725 1000 0.028770881 0.0 0.000543303 25
11000726 1000 0.028764498 0.0 0.000543183 26
11000727 1000 0.028831092 0.0 0.000544440 27
11000728 1000 0.029034088 0.0 0.000546385 28
11000729 1000 0.029118171 0.0 0.000549861 29
11000730 1000 0.029420432 0.0 0.000555569 30
11000731 1000 0.029822067 0.0 0.000563154 31
11000732 1000 0.030596179 0.0 0.000577772 32
11000733 1000 0.031653058 0.0 0.000597730 33
11000734 0000 0.0 0.0 0.0 34
11000901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

*

* Heat Structure Channel 101

*

11010000 34 6 2 1 0.0 0 34
11010100 0 1
11010101 3 .458e-02 1 .466e-02 1 .539e-02
11010201 1 3 2 4 3 5
11010301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
11010400 -1
11010401 729.222 683.440 637.627 591.844 589.627 567.874
11010402 729.222 683.440 637.627 591.844 589.627 567.874
11010403 729.222 683.440 637.627 591.844 589.627 567.874
11010404 729.222 683.440 637.627 591.844 589.627 567.874
11010405 729.222 683.440 637.627 591.844 589.627 567.874
11010406 729.222 683.440 637.627 591.844 589.627 567.874
11010407 729.222 683.440 637.627 591.844 589.627 567.874
11010408 729.222 683.440 637.627 591.844 589.627 567.874
11010409 729.222 683.440 637.627 591.844 589.627 567.874
11010410 729.222 683.440 637.627 591.844 589.627 567.874
11010411 729.222 683.440 637.627 591.844 589.627 567.874

11010412	729.222	683.440	637.627	591.844	589.627	567.874
11010413	729.222	683.440	637.627	591.844	589.627	567.874
11010414	729.222	683.440	637.627	591.844	589.627	567.874
11010415	729.222	683.440	637.627	591.844	589.627	567.874
11010416	729.222	683.440	637.627	591.844	589.627	567.874
11010417	729.222	683.440	637.627	591.844	589.627	567.874
11010418	729.222	683.440	637.627	591.844	589.627	567.874
11010419	729.222	683.440	637.627	591.844	589.627	567.874
11010420	729.222	683.440	637.627	591.844	589.627	567.874
11010421	729.222	683.440	637.627	591.844	589.627	567.874
11010422	729.222	683.440	637.627	591.844	589.627	567.874
11010423	729.222	683.440	637.627	591.844	589.627	567.874
11010424	729.222	683.440	637.627	591.844	589.627	567.874
11010425	729.222	683.440	637.627	591.844	589.627	567.874
11010426	729.222	683.440	637.627	591.844	589.627	567.874
11010427	729.222	683.440	637.627	591.844	589.627	567.874
11010428	729.222	683.440	637.627	591.844	589.627	567.874
11010429	729.222	683.440	637.627	591.844	589.627	567.874
11010430	729.222	683.440	637.627	591.844	589.627	567.874
11010431	729.222	683.440	637.627	591.844	589.627	567.874
11010432	729.222	683.440	637.627	591.844	589.627	567.874
11010433	729.222	683.440	637.627	591.844	589.627	567.874
11010434	729.222	683.440	637.627	591.844	589.627	567.874
11010501	0	0	0	1	110.2120	1
11010502	0	0	0	1	25.1812	33
11010503	0	0	0	1	107.1440	34
11010601	101010000	0	1	1	110.2120	1
11010602	101020000	10000	1	1	25.1812	33
11010603	101340000	0	1	1	107.1440	34
11010701	0000	0.0	0.0	0.0	1	
11010702	1000	0.000192536	0.0	0.000003636	2	
11010703	1000	0.000186153	0.0	0.000003515	3	
11010704	1000	0.000182012	0.0	0.000003437	4	
11010705	1000	0.000179597	0.0	0.000003391	5	
11010706	1000	0.000177872	0.0	0.000003359	6	
11010707	1000	0.000177182	0.0	0.000003346	7	
11010708	1000	0.000176664	0.0	0.000003336	8	
11010709	1000	0.000176837	0.0	0.000003339	9	
11010710	1000	0.000176837	0.0	0.000003339	10	
11010711	1000	0.000176492	0.0	0.000003333	11	
11010712	1000	0.000176492	0.0	0.000003333	12	
11010713	1000	0.000176664	0.0	0.000003336	13	
11010714	1000	0.000177009	0.0	0.000003343	14	
11010715	1000	0.000177182	0.0	0.000003346	15	
11010716	1000	0.000177009	0.0	0.000003343	16	
11010717	1000	0.000177182	0.0	0.000003346	17	
11010718	1000	0.000156479	0.0	0.000002955	18	
11010719	1000	0.000136984	0.0	0.000002587	19	
11010720	1000	0.000137156	0.0	0.000002590	20	
11010721	1000	0.000136984	0.0	0.000002587	21	
11010722	1000	0.000137156	0.0	0.000002590	22	
11010723	1000	0.000137156	0.0	0.000002590	23	
11010724	1000	0.000137501	0.0	0.000002597	24	
11010725	1000	0.000137674	0.0	0.000002600	25	
11010726	1000	0.000137674	0.0	0.000002600	26	

11010727 1000 0.000138019 0.0 0.000002606 27
 11010728 1000 0.000138364 0.0 0.000002613 28
 11010729 1000 0.000139226 0.0 0.000002629 29
 11010730 1000 0.000140607 0.0 0.000002655 30
 11010731 1000 0.000142159 0.0 0.000002685 31
 11010732 1000 0.000145092 0.0 0.000002740 32
 11010733 1000 0.000148888 0.0 0.000002812 33
 11010734 0000 0.0 0.0 0.0 34
 11010901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 1.0 34

*
* Heat Structure Channel 102
*

11020000 34 6 2 1 0.0 0 34
 11020100 0 1
 11020101 3 .458e-02 1 .466e-02 1 .539e-02
 11020201 1 3 2 4 3 5
 11020301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 11020400 -1
 11020401 729.222 683.440 637.627 591.844 589.627 567.874
 11020402 729.222 683.440 637.627 591.844 589.627 567.874
 11020403 729.222 683.440 637.627 591.844 589.627 567.874
 11020404 729.222 683.440 637.627 591.844 589.627 567.874
 11020405 729.222 683.440 637.627 591.844 589.627 567.874
 11020406 729.222 683.440 637.627 591.844 589.627 567.874
 11020407 729.222 683.440 637.627 591.844 589.627 567.874
 11020408 729.222 683.440 637.627 591.844 589.627 567.874
 11020409 729.222 683.440 637.627 591.844 589.627 567.874
 11020410 729.222 683.440 637.627 591.844 589.627 567.874
 11020411 729.222 683.440 637.627 591.844 589.627 567.874
 11020412 729.222 683.440 637.627 591.844 589.627 567.874
 11020413 729.222 683.440 637.627 591.844 589.627 567.874
 11020414 729.222 683.440 637.627 591.844 589.627 567.874
 11020415 729.222 683.440 637.627 591.844 589.627 567.874
 11020416 729.222 683.440 637.627 591.844 589.627 567.874
 11020417 729.222 683.440 637.627 591.844 589.627 567.874
 11020418 729.222 683.440 637.627 591.844 589.627 567.874
 11020419 729.222 683.440 637.627 591.844 589.627 567.874
 11020420 729.222 683.440 637.627 591.844 589.627 567.874
 11020421 729.222 683.440 637.627 591.844 589.627 567.874
 11020422 729.222 683.440 637.627 591.844 589.627 567.874
 11020423 729.222 683.440 637.627 591.844 589.627 567.874
 11020424 729.222 683.440 637.627 591.844 589.627 567.874
 11020425 729.222 683.440 637.627 591.844 589.627 567.874
 11020426 729.222 683.440 637.627 591.844 589.627 567.874
 11020427 729.222 683.440 637.627 591.844 589.627 567.874
 11020428 729.222 683.440 637.627 591.844 589.627 567.874
 11020429 729.222 683.440 637.627 591.844 589.627 567.874
 11020430 729.222 683.440 637.627 591.844 589.627 567.874
 11020431 729.222 683.440 637.627 591.844 589.627 567.874
 11020432 729.222 683.440 637.627 591.844 589.627 567.874
 11020433 729.222 683.440 637.627 591.844 589.627 567.874
 11020434 729.222 683.440 637.627 591.844 589.627 567.874
 11020501 0 0 0 1 110.2120 1
 11020502 0 0 0 1 25.1812 33
 11020503 0 0 0 1 107.1440 34

11020601 102010000 0 1 1 110.2120 1
11020602 102020000 10000 1 1 25.1812 33
11020603 102340000 0 1 1 107.1440 34
11020701 0000 0.0 0.0 0.0 1
11020702 1000 0.000192364 0.0 0.000003633 2
11020703 1000 0.000185980 0.0 0.000003512 3
11020704 1000 0.000181840 0.0 0.000003434 4
11020705 1000 0.000179424 0.0 0.000003388 5
11020706 1000 0.000177699 0.0 0.000003356 6
11020707 1000 0.000177009 0.0 0.000003343 7
11020708 1000 0.000176664 0.0 0.000003336 8
11020709 1000 0.000176664 0.0 0.000003336 9
11020710 1000 0.000176664 0.0 0.000003336 10
11020711 1000 0.000176492 0.0 0.000003333 11
11020712 1000 0.000176492 0.0 0.000003333 12
11020713 1000 0.000176492 0.0 0.000003333 13
11020714 1000 0.000176837 0.0 0.000003339 14
11020715 1000 0.000177009 0.0 0.000003343 15
11020716 1000 0.000176837 0.0 0.000003339 16
11020717 1000 0.000177009 0.0 0.000003343 17
11020718 1000 0.000177182 0.0 0.000003346 18
11020719 1000 0.000177354 0.0 0.000003349 19
11020720 1000 0.000177699 0.0 0.000003356 20
11020721 1000 0.000177527 0.0 0.000003352 21
11020722 1000 0.000177699 0.0 0.000003356 22
11020723 1000 0.000177872 0.0 0.000003359 23
11020724 1000 0.000178044 0.0 0.000003362 24
11020725 1000 0.000178562 0.0 0.000003372 25
11020726 1000 0.000178389 0.0 0.000003369 26
11020727 1000 0.000178907 0.0 0.000003378 27
11020728 1000 0.000179424 0.0 0.000003388 28
11020729 1000 0.000180632 0.0 0.000003411 29
11020730 1000 0.000182357 0.0 0.000003444 30
11020731 1000 0.000184600 0.0 0.000003486 31
11020732 1000 0.000188741 0.0 0.000003564 32
11020733 1000 0.000194261 0.0 0.000003668 33
11020734 0000 0.0 0.0 0.0 34
11020901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

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* Heat Structure Channel 103

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11030000 34 6 2 1 0.0 0 34
11030100 0 1
11030101 3 .458e-02 1 .466e-02 1 .539e-02
11030201 1 3 2 4 3 5
11030301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
11030400 -1
11030401 729.222 683.440 637.627 591.844 589.627 567.874
11030402 729.222 683.440 637.627 591.844 589.627 567.874
11030403 729.222 683.440 637.627 591.844 589.627 567.874
11030404 729.222 683.440 637.627 591.844 589.627 567.874
11030405 729.222 683.440 637.627 591.844 589.627 567.874
11030406 729.222 683.440 637.627 591.844 589.627 567.874
11030407 729.222 683.440 637.627 591.844 589.627 567.874
11030408 729.222 683.440 637.627 591.844 589.627 567.874

11030409	729.222	683.440	637.627	591.844	589.627	567.874
11030410	729.222	683.440	637.627	591.844	589.627	567.874
11030411	729.222	683.440	637.627	591.844	589.627	567.874
11030412	729.222	683.440	637.627	591.844	589.627	567.874
11030413	729.222	683.440	637.627	591.844	589.627	567.874
11030414	729.222	683.440	637.627	591.844	589.627	567.874
11030415	729.222	683.440	637.627	591.844	589.627	567.874
11030416	729.222	683.440	637.627	591.844	589.627	567.874
11030417	729.222	683.440	637.627	591.844	589.627	567.874
11030418	729.222	683.440	637.627	591.844	589.627	567.874
11030419	729.222	683.440	637.627	591.844	589.627	567.874
11030420	729.222	683.440	637.627	591.844	589.627	567.874
11030421	729.222	683.440	637.627	591.844	589.627	567.874
11030422	729.222	683.440	637.627	591.844	589.627	567.874
11030423	729.222	683.440	637.627	591.844	589.627	567.874
11030424	729.222	683.440	637.627	591.844	589.627	567.874
11030425	729.222	683.440	637.627	591.844	589.627	567.874
11030426	729.222	683.440	637.627	591.844	589.627	567.874
11030427	729.222	683.440	637.627	591.844	589.627	567.874
11030428	729.222	683.440	637.627	591.844	589.627	567.874
11030429	729.222	683.440	637.627	591.844	589.627	567.874
11030430	729.222	683.440	637.627	591.844	589.627	567.874
11030431	729.222	683.440	637.627	591.844	589.627	567.874
11030432	729.222	683.440	637.627	591.844	589.627	567.874
11030433	729.222	683.440	637.627	591.844	589.627	567.874
11030434	729.222	683.440	637.627	591.844	589.627	567.874
11030501	0	0	0	1	110.2120	1
11030502	0	0	0	1	25.1812	33
11030503	0	0	0	1	107.1440	34
11030601	103010000	0	1	1	110.2120	1
11030602	103020000	10000	1	1	25.1812	33
11030603	103340000	0	1	1	107.1440	34
11030701	0000	0.0	0.0	0.0	1	
11030702	1000	0.000194089	0.0	0.000003665	2	
11030703	1000	0.000188223	0.0	0.000003554	3	
11030704	1000	0.000184255	0.0	0.000003479	4	
11030705	1000	0.000181840	0.0	0.000003434	5	
11030706	1000	0.000180287	0.0	0.000003405	6	
11030707	1000	0.000179597	0.0	0.000003391	7	
11030708	1000	0.000179252	0.0	0.000003385	8	
11030709	1000	0.000179252	0.0	0.000003385	9	
11030710	1000	0.000179252	0.0	0.000003385	10	
11030711	1000	0.000178907	0.0	0.000003378	11	
11030712	1000	0.000178907	0.0	0.000003378	12	
11030713	1000	0.000179079	0.0	0.000003382	13	
11030714	1000	0.000179252	0.0	0.000003385	14	
11030715	1000	0.000179424	0.0	0.000003388	15	
11030716	1000	0.000179252	0.0	0.000003385	16	
11030717	1000	0.000179424	0.0	0.000003388	17	
11030718	1000	0.000179597	0.0	0.000003391	18	
11030719	1000	0.000179942	0.0	0.000003398	19	
11030720	1000	0.000180287	0.0	0.000003405	20	
11030721	1000	0.000180115	0.0	0.000003401	21	
11030722	1000	0.000180115	0.0	0.000003401	22	
11030723	1000	0.000180287	0.0	0.000003405	23	

11030724 1000 0.000180632 0.0 0.000003411 24
 11030725 1000 0.000180977 0.0 0.000003418 25
 11030726 1000 0.000180977 0.0 0.000003418 26
 11030727 1000 0.000181322 0.0 0.000003424 27
 11030728 1000 0.000181840 0.0 0.000003434 28
 11030729 1000 0.000183047 0.0 0.000003457 29
 11030730 1000 0.000184600 0.0 0.000003486 30
 11030731 1000 0.000186843 0.0 0.000003528 31
 11030732 1000 0.000190811 0.0 0.000003603 32
 11030733 1000 0.000195987 0.0 0.000003701 33
 11030734 0000 0.0 0.0 0.0 34
 11030901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

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* Heat Structure Channel 104

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11040000 34 6 2 1 0.0 0 34
 11040100 0 1
 11040101 3 .458e-02 1 .466e-02 1 .539e-02
 11040201 1 3 2 4 3 5
 11040301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 11040400 -1
 11040401 729.222 683.440 637.627 591.844 589.627 567.874
 11040402 729.222 683.440 637.627 591.844 589.627 567.874
 11040403 729.222 683.440 637.627 591.844 589.627 567.874
 11040404 729.222 683.440 637.627 591.844 589.627 567.874
 11040405 729.222 683.440 637.627 591.844 589.627 567.874
 11040406 729.222 683.440 637.627 591.844 589.627 567.874
 11040407 729.222 683.440 637.627 591.844 589.627 567.874
 11040408 729.222 683.440 637.627 591.844 589.627 567.874
 11040409 729.222 683.440 637.627 591.844 589.627 567.874
 11040410 729.222 683.440 637.627 591.844 589.627 567.874
 11040411 729.222 683.440 637.627 591.844 589.627 567.874
 11040412 729.222 683.440 637.627 591.844 589.627 567.874
 11040413 729.222 683.440 637.627 591.844 589.627 567.874
 11040414 729.222 683.440 637.627 591.844 589.627 567.874
 11040415 729.222 683.440 637.627 591.844 589.627 567.874
 11040416 729.222 683.440 637.627 591.844 589.627 567.874
 11040417 729.222 683.440 637.627 591.844 589.627 567.874
 11040418 729.222 683.440 637.627 591.844 589.627 567.874
 11040419 729.222 683.440 637.627 591.844 589.627 567.874
 11040420 729.222 683.440 637.627 591.844 589.627 567.874
 11040421 729.222 683.440 637.627 591.844 589.627 567.874
 11040422 729.222 683.440 637.627 591.844 589.627 567.874
 11040423 729.222 683.440 637.627 591.844 589.627 567.874
 11040424 729.222 683.440 637.627 591.844 589.627 567.874
 11040425 729.222 683.440 637.627 591.844 589.627 567.874
 11040426 729.222 683.440 637.627 591.844 589.627 567.874
 11040427 729.222 683.440 637.627 591.844 589.627 567.874
 11040428 729.222 683.440 637.627 591.844 589.627 567.874
 11040429 729.222 683.440 637.627 591.844 589.627 567.874
 11040430 729.222 683.440 637.627 591.844 589.627 567.874
 11040431 729.222 683.440 637.627 591.844 589.627 567.874
 11040432 729.222 683.440 637.627 591.844 589.627 567.874
 11040433 729.222 683.440 637.627 591.844 589.627 567.874
 11040434 729.222 683.440 637.627 591.844 589.627 567.874

11040501 0 0 0 1 110.2120 1
 11040502 0 0 0 1 25.1812 33
 11040503 0 0 0 1 107.1440 34
 11040601 104010000 0 1 1 110.2120 1
 11040602 104020000 10000 1 1 25.1812 33
 11040603 104340000 0 1 1 107.1440 34
 11040701 0000 0.0 0.0 0.0 1
 11040702 1000 0.000178044 0.0 0.000003362 2
 11040703 1000 0.000168555 0.0 0.000003183 3
 11040704 1000 0.000162690 0.0 0.000003072 4
 11040705 1000 0.000159412 0.0 0.000003010 5
 11040706 1000 0.000157341 0.0 0.000002971 6
 11040707 1000 0.000156651 0.0 0.000002958 7
 11040708 1000 0.000156306 0.0 0.000002952 8
 11040709 1000 0.000156479 0.0 0.000002955 9
 11040710 1000 0.000156651 0.0 0.000002958 10
 11040711 1000 0.000156306 0.0 0.000002952 11
 11040712 1000 0.000156479 0.0 0.000002955 12
 11040713 1000 0.000156479 0.0 0.000002955 13
 11040714 1000 0.000156996 0.0 0.000002965 14
 11040715 1000 0.000157341 0.0 0.000002971 15
 11040716 1000 0.000156996 0.0 0.000002965 16
 11040717 1000 0.000157169 0.0 0.000002968 17
 11040718 1000 0.000157341 0.0 0.000002971 18
 11040719 1000 0.000157859 0.0 0.000002981 19
 11040720 1000 0.000158204 0.0 0.000002987 20
 11040721 1000 0.000158032 0.0 0.000002984 21
 11040722 1000 0.000158204 0.0 0.000002987 22
 11040723 1000 0.000158377 0.0 0.000002991 23
 11040724 1000 0.000158894 0.0 0.000003001 24
 11040725 1000 0.000159239 0.0 0.000003007 25
 11040726 1000 0.000159239 0.0 0.000003007 26
 11040727 1000 0.000159757 0.0 0.000003017 27
 11040728 1000 0.000160447 0.0 0.000003030 28
 11040729 1000 0.000162000 0.0 0.000003059 29
 11040730 1000 0.000164242 0.0 0.000003102 30
 11040731 1000 0.000167348 0.0 0.000003160 31
 11040732 1000 0.000173386 0.0 0.000003274 32
 11040733 1000 0.000181495 0.0 0.000003427 33
 11040734 0000 0.0 0.0 0.0 34
 11040901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

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* Heat Structure Channel 105

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11050000 34 6 2 1 0.0 0 34
 11050100 0 1
 11050101 3 .458e-02 1 .466e-02 1 .539e-02
 11050201 1 3 2 4 3 5
 11050301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 11050400 -1
 11050401 729.222 683.440 637.627 591.844 589.627 567.874
 11050402 729.222 683.440 637.627 591.844 589.627 567.874
 11050403 729.222 683.440 637.627 591.844 589.627 567.874
 11050404 729.222 683.440 637.627 591.844 589.627 567.874
 11050405 729.222 683.440 637.627 591.844 589.627 567.874

11050406	729.222	683.440	637.627	591.844	589.627	567.874
11050407	729.222	683.440	637.627	591.844	589.627	567.874
11050408	729.222	683.440	637.627	591.844	589.627	567.874
11050409	729.222	683.440	637.627	591.844	589.627	567.874
11050410	729.222	683.440	637.627	591.844	589.627	567.874
11050411	729.222	683.440	637.627	591.844	589.627	567.874
11050412	729.222	683.440	637.627	591.844	589.627	567.874
11050413	729.222	683.440	637.627	591.844	589.627	567.874
11050414	729.222	683.440	637.627	591.844	589.627	567.874
11050415	729.222	683.440	637.627	591.844	589.627	567.874
11050416	729.222	683.440	637.627	591.844	589.627	567.874
11050417	729.222	683.440	637.627	591.844	589.627	567.874
11050418	729.222	683.440	637.627	591.844	589.627	567.874
11050419	729.222	683.440	637.627	591.844	589.627	567.874
11050420	729.222	683.440	637.627	591.844	589.627	567.874
11050421	729.222	683.440	637.627	591.844	589.627	567.874
11050422	729.222	683.440	637.627	591.844	589.627	567.874
11050423	729.222	683.440	637.627	591.844	589.627	567.874
11050424	729.222	683.440	637.627	591.844	589.627	567.874
11050425	729.222	683.440	637.627	591.844	589.627	567.874
11050426	729.222	683.440	637.627	591.844	589.627	567.874
11050427	729.222	683.440	637.627	591.844	589.627	567.874
11050428	729.222	683.440	637.627	591.844	589.627	567.874
11050429	729.222	683.440	637.627	591.844	589.627	567.874
11050430	729.222	683.440	637.627	591.844	589.627	567.874
11050431	729.222	683.440	637.627	591.844	589.627	567.874
11050432	729.222	683.440	637.627	591.844	589.627	567.874
11050433	729.222	683.440	637.627	591.844	589.627	567.874
11050434	729.222	683.440	637.627	591.844	589.627	567.874
11050501	0	0	0	1	110.2120	1
11050502	0	0	0	1	25.1812	33
11050503	0	0	0	1	107.1440	34
11050601	105010000	0	1	1	110.2120	1
11050602	105020000	10000	1	1	25.1812	33
11050603	105340000	0	1	1	107.1440	34
11050701	0000	0.0	0.0	0.0	1	
11050702	1000	0.000179424	0.0	0.000003388	2	
11050703	1000	0.000170453	0.0	0.000003219	3	
11050704	1000	0.000164760	0.0	0.000003111	4	
11050705	1000	0.000161655	0.0	0.000003053	5	
11050706	1000	0.000159757	0.0	0.000003017	6	
11050707	1000	0.000158894	0.0	0.000003001	7	
11050708	1000	0.000158549	0.0	0.000002994	8	
11050709	1000	0.000158722	0.0	0.000002997	9	
11050710	1000	0.000158722	0.0	0.000002997	10	
11050711	1000	0.000158377	0.0	0.000002991	11	
11050712	1000	0.000158549	0.0	0.000002994	12	
11050713	1000	0.000158549	0.0	0.000002994	13	
11050714	1000	0.000158894	0.0	0.000003001	14	
11050715	1000	0.000159239	0.0	0.000003007	15	
11050716	1000	0.000158894	0.0	0.000003001	16	
11050717	1000	0.000159239	0.0	0.000003007	17	
11050718	1000	0.000159412	0.0	0.000003010	18	
11050719	1000	0.000159757	0.0	0.000003017	19	
11050720	1000	0.000160102	0.0	0.000003023	20	

11050721 1000 0.000159757 0.0 0.000003017 21
 11050722 1000 0.000159929 0.0 0.000003020 22
 11050723 1000 0.000160102 0.0 0.000003023 23
 11050724 1000 0.000160447 0.0 0.000003030 24
 11050725 1000 0.000160964 0.0 0.000003040 25
 11050726 1000 0.000160792 0.0 0.000003036 26
 11050727 1000 0.000161309 0.0 0.000003046 27
 11050728 1000 0.000162000 0.0 0.000003059 28
 11050729 1000 0.000163380 0.0 0.000003085 29
 11050730 1000 0.000165623 0.0 0.000003128 30
 11050731 1000 0.000168555 0.0 0.000003183 31
 11050732 1000 0.000174249 0.0 0.000003290 32
 11050733 1000 0.000182185 0.0 0.000003440 33
 11050734 0000 0.0 0.0 0.0 34
 11050901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

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* Heat Structure Channel 106

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11060000 34 6 2 1 0.0 0 34
 11060100 0 1
 11060101 3 .458e-02 1 .466e-02 1 .539e-02
 11060201 1 3 2 4 3 5
 11060301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 11060400 -1
 11060401 729.222 683.440 637.627 591.844 589.627 567.874
 11060402 729.222 683.440 637.627 591.844 589.627 567.874
 11060403 729.222 683.440 637.627 591.844 589.627 567.874
 11060404 729.222 683.440 637.627 591.844 589.627 567.874
 11060405 729.222 683.440 637.627 591.844 589.627 567.874
 11060406 729.222 683.440 637.627 591.844 589.627 567.874
 11060407 729.222 683.440 637.627 591.844 589.627 567.874
 11060408 729.222 683.440 637.627 591.844 589.627 567.874
 11060409 729.222 683.440 637.627 591.844 589.627 567.874
 11060410 729.222 683.440 637.627 591.844 589.627 567.874
 11060411 729.222 683.440 637.627 591.844 589.627 567.874
 11060412 729.222 683.440 637.627 591.844 589.627 567.874
 11060413 729.222 683.440 637.627 591.844 589.627 567.874
 11060414 729.222 683.440 637.627 591.844 589.627 567.874
 11060415 729.222 683.440 637.627 591.844 589.627 567.874
 11060416 729.222 683.440 637.627 591.844 589.627 567.874
 11060417 729.222 683.440 637.627 591.844 589.627 567.874
 11060418 729.222 683.440 637.627 591.844 589.627 567.874
 11060419 729.222 683.440 637.627 591.844 589.627 567.874
 11060420 729.222 683.440 637.627 591.844 589.627 567.874
 11060421 729.222 683.440 637.627 591.844 589.627 567.874
 11060422 729.222 683.440 637.627 591.844 589.627 567.874
 11060423 729.222 683.440 637.627 591.844 589.627 567.874
 11060424 729.222 683.440 637.627 591.844 589.627 567.874
 11060425 729.222 683.440 637.627 591.844 589.627 567.874
 11060426 729.222 683.440 637.627 591.844 589.627 567.874
 11060427 729.222 683.440 637.627 591.844 589.627 567.874
 11060428 729.222 683.440 637.627 591.844 589.627 567.874
 11060429 729.222 683.440 637.627 591.844 589.627 567.874
 11060430 729.222 683.440 637.627 591.844 589.627 567.874
 11060431 729.222 683.440 637.627 591.844 589.627 567.874

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11060432 729.222 683.440 637.627 591.844 589.627 567.874
11060433 729.222 683.440 637.627 591.844 589.627 567.874
11060434 729.222 683.440 637.627 591.844 589.627 567.874
11060501 0 0 0 1 110.2120 1
11060502 0 0 0 1 25.1812 33
11060503 0 0 0 1 107.1440 34
11060601 106010000 0 1 1 110.2120 1
11060602 106020000 10000 1 1 25.1812 33
11060603 106340000 0 1 1 107.1440 34
11060701 0000 0.0 0.0 0.0 1
11060702 1000 0.000208581 0.0 0.000003939 2
11060703 1000 0.000206856 0.0 0.000003906 3
11060704 1000 0.000205993 0.0 0.000003890 4
11060705 1000 0.000205303 0.0 0.000003877 5
11060706 1000 0.000204785 0.0 0.000003867 6
11060707 1000 0.000204613 0.0 0.000003864 7
11060708 1000 0.000204440 0.0 0.000003861 8
11060709 1000 0.000204268 0.0 0.000003857 9
11060710 1000 0.000204095 0.0 0.000003854 10
11060711 1000 0.000204095 0.0 0.000003854 11
11060712 1000 0.000203923 0.0 0.000003851 12
11060713 1000 0.000203923 0.0 0.000003851 13
11060714 1000 0.000203923 0.0 0.000003851 14
11060715 1000 0.000203923 0.0 0.000003851 15
11060716 1000 0.000204095 0.0 0.000003854 16
11060717 1000 0.000204095 0.0 0.000003854 17
11060718 1000 0.000204268 0.0 0.000003857 18
11060719 1000 0.000204440 0.0 0.000003861 19
11060720 1000 0.000204613 0.0 0.000003864 20
11060721 1000 0.000204613 0.0 0.000003864 21
11060722 1000 0.000204785 0.0 0.000003867 22
11060723 1000 0.000204785 0.0 0.000003867 23
11060724 1000 0.000204958 0.0 0.000003870 24
11060725 1000 0.000204958 0.0 0.000003870 25
11060726 1000 0.000205130 0.0 0.000003874 26
11060727 1000 0.000205303 0.0 0.000003877 27
11060728 1000 0.000205475 0.0 0.000003880 28
11060729 1000 0.000205648 0.0 0.000003883 29
11060730 1000 0.000205993 0.0 0.000003890 30
11060731 1000 0.000206683 0.0 0.000003903 31
11060732 1000 0.000207546 0.0 0.000003919 32
11060733 1000 0.000208753 0.0 0.000003942 33
11060734 0000 0.0 0.0 0.0 34
11060901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34
*
* Heat Structure Channel 107
*
11070000 34 6 2 1 0.0 0 34
11070100 0 1
11070101 3 .458e-02 1 .466e-02 1 .539e-02
11070201 1 3 2 4 3 5
11070301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
11070400 -1
11070401 729.222 683.440 637.627 591.844 589.627 567.874
11070402 729.222 683.440 637.627 591.844 589.627 567.874

```

11070403	729.222	683.440	637.627	591.844	589.627	567.874
11070404	729.222	683.440	637.627	591.844	589.627	567.874
11070405	729.222	683.440	637.627	591.844	589.627	567.874
11070406	729.222	683.440	637.627	591.844	589.627	567.874
11070407	729.222	683.440	637.627	591.844	589.627	567.874
11070408	729.222	683.440	637.627	591.844	589.627	567.874
11070409	729.222	683.440	637.627	591.844	589.627	567.874
11070410	729.222	683.440	637.627	591.844	589.627	567.874
11070411	729.222	683.440	637.627	591.844	589.627	567.874
11070412	729.222	683.440	637.627	591.844	589.627	567.874
11070413	729.222	683.440	637.627	591.844	589.627	567.874
11070414	729.222	683.440	637.627	591.844	589.627	567.874
11070415	729.222	683.440	637.627	591.844	589.627	567.874
11070416	729.222	683.440	637.627	591.844	589.627	567.874
11070417	729.222	683.440	637.627	591.844	589.627	567.874
11070418	729.222	683.440	637.627	591.844	589.627	567.874
11070419	729.222	683.440	637.627	591.844	589.627	567.874
11070420	729.222	683.440	637.627	591.844	589.627	567.874
11070421	729.222	683.440	637.627	591.844	589.627	567.874
11070422	729.222	683.440	637.627	591.844	589.627	567.874
11070423	729.222	683.440	637.627	591.844	589.627	567.874
11070424	729.222	683.440	637.627	591.844	589.627	567.874
11070425	729.222	683.440	637.627	591.844	589.627	567.874
11070426	729.222	683.440	637.627	591.844	589.627	567.874
11070427	729.222	683.440	637.627	591.844	589.627	567.874
11070428	729.222	683.440	637.627	591.844	589.627	567.874
11070429	729.222	683.440	637.627	591.844	589.627	567.874
11070430	729.222	683.440	637.627	591.844	589.627	567.874
11070431	729.222	683.440	637.627	591.844	589.627	567.874
11070432	729.222	683.440	637.627	591.844	589.627	567.874
11070433	729.222	683.440	637.627	591.844	589.627	567.874
11070434	729.222	683.440	637.627	591.844	589.627	567.874
11070501	0	0	0	1	110.2120	1
11070502	0	0	0	1	25.1812	33
11070503	0	0	0	1	107.1440	34
11070601	107010000	0	1	1	110.2120	1
11070602	107020000	10000	1	1	25.1812	33
11070603	107340000	0	1	1	107.1440	34
11070701	0000	0.0	0.0	0.0	0.0	1
11070702	1000	0.000179424	0.0	0.000003388	2	
11070703	1000	0.000170453	0.0	0.000003219	3	
11070704	1000	0.000164760	0.0	0.000003111	4	
11070705	1000	0.000161655	0.0	0.000003053	5	
11070706	1000	0.000159757	0.0	0.000003017	6	
11070707	1000	0.000158894	0.0	0.000003001	7	
11070708	1000	0.000158549	0.0	0.000002994	8	
11070709	1000	0.000158722	0.0	0.000002997	9	
11070710	1000	0.000158722	0.0	0.000002997	10	
11070711	1000	0.000158377	0.0	0.000002991	11	
11070712	1000	0.000158549	0.0	0.000002994	12	
11070713	1000	0.000158722	0.0	0.000002997	13	
11070714	1000	0.000159067	0.0	0.000003004	14	
11070715	1000	0.000159239	0.0	0.000003007	15	
11070716	1000	0.000159067	0.0	0.000003004	16	
11070717	1000	0.000159239	0.0	0.000003007	17	

11070718 1000 0.000159412 0.0 0.000003010 18
 11070719 1000 0.000159757 0.0 0.000003017 19
 11070720 1000 0.000160102 0.0 0.000003023 20
 11070721 1000 0.000159757 0.0 0.000003017 21
 11070722 1000 0.000159929 0.0 0.000003020 22
 11070723 1000 0.000160102 0.0 0.000003023 23
 11070724 1000 0.000160619 0.0 0.000003033 24
 11070725 1000 0.000160964 0.0 0.000003040 25
 11070726 1000 0.000160792 0.0 0.000003036 26
 11070727 1000 0.000161309 0.0 0.000003046 27
 11070728 1000 0.000162000 0.0 0.000003059 28
 11070729 1000 0.000163380 0.0 0.000003085 29
 11070730 1000 0.000165623 0.0 0.000003128 30
 11070731 1000 0.000168728 0.0 0.000003186 31
 11070732 1000 0.000174421 0.0 0.000003294 32
 11070733 1000 0.000182357 0.0 0.000003444 33
 11070734 0000 0.0 0.0 0.0 34
 11070901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 1.0 34

*

* Heat Structure Channel 108

*

11080000 34 6 2 1 0.0 0 34
 11080100 0 1
 11080101 3 .458e-02 1 .466e-02 1 .539e-02
 11080201 1 3 2 4 3 5
 11080301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 11080400 -1
 11080401 729.222 683.440 637.627 591.844 589.627 567.874
 11080402 729.222 683.440 637.627 591.844 589.627 567.874
 11080403 729.222 683.440 637.627 591.844 589.627 567.874
 11080404 729.222 683.440 637.627 591.844 589.627 567.874
 11080405 729.222 683.440 637.627 591.844 589.627 567.874
 11080406 729.222 683.440 637.627 591.844 589.627 567.874
 11080407 729.222 683.440 637.627 591.844 589.627 567.874
 11080408 729.222 683.440 637.627 591.844 589.627 567.874
 11080409 729.222 683.440 637.627 591.844 589.627 567.874
 11080410 729.222 683.440 637.627 591.844 589.627 567.874
 11080411 729.222 683.440 637.627 591.844 589.627 567.874
 11080412 729.222 683.440 637.627 591.844 589.627 567.874
 11080413 729.222 683.440 637.627 591.844 589.627 567.874
 11080414 729.222 683.440 637.627 591.844 589.627 567.874
 11080415 729.222 683.440 637.627 591.844 589.627 567.874
 11080416 729.222 683.440 637.627 591.844 589.627 567.874
 11080417 729.222 683.440 637.627 591.844 589.627 567.874
 11080418 729.222 683.440 637.627 591.844 589.627 567.874
 11080419 729.222 683.440 637.627 591.844 589.627 567.874
 11080420 729.222 683.440 637.627 591.844 589.627 567.874
 11080421 729.222 683.440 637.627 591.844 589.627 567.874
 11080422 729.222 683.440 637.627 591.844 589.627 567.874
 11080423 729.222 683.440 637.627 591.844 589.627 567.874
 11080424 729.222 683.440 637.627 591.844 589.627 567.874
 11080425 729.222 683.440 637.627 591.844 589.627 567.874
 11080426 729.222 683.440 637.627 591.844 589.627 567.874
 11080427 729.222 683.440 637.627 591.844 589.627 567.874
 11080428 729.222 683.440 637.627 591.844 589.627 567.874

11080429 729.222 683.440 637.627 591.844 589.627 567.874
11080430 729.222 683.440 637.627 591.844 589.627 567.874
11080431 729.222 683.440 637.627 591.844 589.627 567.874
11080432 729.222 683.440 637.627 591.844 589.627 567.874
11080433 729.222 683.440 637.627 591.844 589.627 567.874
11080434 729.222 683.440 637.627 591.844 589.627 567.874
11080501 0 0 0 1 110.2120 1
11080502 0 0 0 1 25.1812 33
11080503 0 0 0 1 107.1440 34
11080601 108010000 0 1 1 110.2120 1
11080602 108020000 10000 1 1 25.1812 33
11080603 108340000 0 1 1 107.1440 34
11080701 0000 0.0 0.0 0.0 1
11080702 1000 0.000191846 0.0 0.000003623 2
11080703 1000 0.000185290 0.0 0.000003499 3
11080704 1000 0.000181150 0.0 0.000003421 4
11080705 1000 0.000178734 0.0 0.000003375 5
11080706 1000 0.000177009 0.0 0.000003343 6
11080707 1000 0.000176319 0.0 0.000003330 7
11080708 1000 0.000175974 0.0 0.000003323 8
11080709 1000 0.000175974 0.0 0.000003323 9
11080710 1000 0.000175974 0.0 0.000003323 10
11080711 1000 0.000175629 0.0 0.000003317 11
11080712 1000 0.000175801 0.0 0.000003320 12
11080713 1000 0.000175801 0.0 0.000003320 13
11080714 1000 0.000176146 0.0 0.000003326 14
11080715 1000 0.000176319 0.0 0.000003330 15
11080716 1000 0.000176146 0.0 0.000003326 16
11080717 1000 0.000176319 0.0 0.000003330 17
11080718 1000 0.000176664 0.0 0.000003336 18
11080719 1000 0.000177009 0.0 0.000003343 19
11080720 1000 0.000177354 0.0 0.000003349 20
11080721 1000 0.000177182 0.0 0.000003346 21
11080722 1000 0.000177354 0.0 0.000003349 22
11080723 1000 0.000177527 0.0 0.000003352 23
11080724 1000 0.000177872 0.0 0.000003359 24
11080725 1000 0.000178217 0.0 0.000003365 25
11080726 1000 0.000178217 0.0 0.000003365 26
11080727 1000 0.000178562 0.0 0.000003372 27
11080728 1000 0.000179252 0.0 0.000003385 28
11080729 1000 0.000180287 0.0 0.000003405 29
11080730 1000 0.000182185 0.0 0.000003440 30
11080731 1000 0.000184428 0.0 0.000003483 31
11080732 1000 0.000189086 0.0 0.000003571 32
11080733 1000 0.000194952 0.0 0.000003681 33
11080734 0000 0.0 0.0 0.0 34
11080901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 1.0 34
*

* Heat Structure Channel 109

*
11090000 34 6 2 1 0.0 0 34
11090100 0 1
11090101 3 .458e-02 1 .466e-02 1 .539e-02
11090201 1 3 2 4 3 5
11090301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5

11090400 -1
11090401 729.222 683.440 637.627 591.844 589.627 567.874
11090402 729.222 683.440 637.627 591.844 589.627 567.874
11090403 729.222 683.440 637.627 591.844 589.627 567.874
11090404 729.222 683.440 637.627 591.844 589.627 567.874
11090405 729.222 683.440 637.627 591.844 589.627 567.874
11090406 729.222 683.440 637.627 591.844 589.627 567.874
11090407 729.222 683.440 637.627 591.844 589.627 567.874
11090408 729.222 683.440 637.627 591.844 589.627 567.874
11090409 729.222 683.440 637.627 591.844 589.627 567.874
11090410 729.222 683.440 637.627 591.844 589.627 567.874
11090411 729.222 683.440 637.627 591.844 589.627 567.874
11090412 729.222 683.440 637.627 591.844 589.627 567.874
11090413 729.222 683.440 637.627 591.844 589.627 567.874
11090414 729.222 683.440 637.627 591.844 589.627 567.874
11090415 729.222 683.440 637.627 591.844 589.627 567.874
11090416 729.222 683.440 637.627 591.844 589.627 567.874
11090417 729.222 683.440 637.627 591.844 589.627 567.874
11090418 729.222 683.440 637.627 591.844 589.627 567.874
11090419 729.222 683.440 637.627 591.844 589.627 567.874
11090420 729.222 683.440 637.627 591.844 589.627 567.874
11090421 729.222 683.440 637.627 591.844 589.627 567.874
11090422 729.222 683.440 637.627 591.844 589.627 567.874
11090423 729.222 683.440 637.627 591.844 589.627 567.874
11090424 729.222 683.440 637.627 591.844 589.627 567.874
11090425 729.222 683.440 637.627 591.844 589.627 567.874
11090426 729.222 683.440 637.627 591.844 589.627 567.874
11090427 729.222 683.440 637.627 591.844 589.627 567.874
11090428 729.222 683.440 637.627 591.844 589.627 567.874
11090429 729.222 683.440 637.627 591.844 589.627 567.874
11090430 729.222 683.440 637.627 591.844 589.627 567.874
11090431 729.222 683.440 637.627 591.844 589.627 567.874
11090432 729.222 683.440 637.627 591.844 589.627 567.874
11090433 729.222 683.440 637.627 591.844 589.627 567.874
11090434 729.222 683.440 637.627 591.844 589.627 567.874
11090501 0 0 0 1 110.2120 1
11090502 0 0 0 1 25.1812 33
11090503 0 0 0 1 107.1440 34
11090601 109010000 0 1 1 110.2120 1
11090602 109020000 10000 1 1 25.1812 33
11090603 109340000 0 1 1 107.1440 34
11090701 0000 0.0 0.0 0.0 1
11090702 1000 0.000208753 0.0 0.000003942 2
11090703 1000 0.000207201 0.0 0.000003913 3
11090704 1000 0.000206166 0.0 0.000003893 4
11090705 1000 0.000205648 0.0 0.000003883 5
11090706 1000 0.000205130 0.0 0.000003874 6
11090707 1000 0.000204958 0.0 0.000003870 7
11090708 1000 0.000204613 0.0 0.000003864 8
11090709 1000 0.000204440 0.0 0.000003861 9
11090710 1000 0.000204440 0.0 0.000003861 10
11090711 1000 0.000204268 0.0 0.000003857 11
11090712 1000 0.000204268 0.0 0.000003857 12
11090713 1000 0.000204268 0.0 0.000003857 13
11090714 1000 0.000204268 0.0 0.000003857 14

11090715 1000 0.000204268 0.0 0.000003857 15
 11090716 1000 0.000204268 0.0 0.000003857 16
 11090717 1000 0.000204440 0.0 0.000003861 17
 11090718 1000 0.000204440 0.0 0.000003861 18
 11090719 1000 0.000204613 0.0 0.000003864 19
 11090720 1000 0.000204785 0.0 0.000003867 20
 11090721 1000 0.000204785 0.0 0.000003867 21
 11090722 1000 0.000204958 0.0 0.000003870 22
 11090723 1000 0.000204958 0.0 0.000003870 23
 11090724 1000 0.000205130 0.0 0.000003874 24
 11090725 1000 0.000205130 0.0 0.000003874 25
 11090726 1000 0.000205303 0.0 0.000003877 26
 11090727 1000 0.000205475 0.0 0.000003880 27
 11090728 1000 0.000205648 0.0 0.000003883 28
 11090729 1000 0.000205821 0.0 0.000003887 29
 11090730 1000 0.000206338 0.0 0.000003896 30
 11090731 1000 0.000206856 0.0 0.000003906 31
 11090732 1000 0.000207718 0.0 0.000003923 32
 11090733 1000 0.000209098 0.0 0.000003949 33
 11090734 0000 0.0 0.0 0.0 34
 11090901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

*

* Heat Structure Bypass

*

12500000 34 6 2 1 0.0 0 34
 12500100 0 1
 12500101 3 .458e-02 1 .466e-02 1 .539e-02
 12500201 1 3 2 4 3 5
 12500301 0.3131 1 0.3207 2 0.3592 3 0.0000 4 0.0070 5
 12500400 -1
 12500401 567.874 567.874 567.874 567.874 567.874 567.874
 12500402 567.874 567.874 567.874 567.874 567.874 567.874
 12500403 567.874 567.874 567.874 567.874 567.874 567.874
 12500404 567.874 567.874 567.874 567.874 567.874 567.874
 12500405 567.874 567.874 567.874 567.874 567.874 567.874
 12500406 567.874 567.874 567.874 567.874 567.874 567.874
 12500407 567.874 567.874 567.874 567.874 567.874 567.874
 12500408 567.874 567.874 567.874 567.874 567.874 567.874
 12500409 567.874 567.874 567.874 567.874 567.874 567.874
 12500410 567.874 567.874 567.874 567.874 567.874 567.874
 12500411 567.874 567.874 567.874 567.874 567.874 567.874
 12500412 567.874 567.874 567.874 567.874 567.874 567.874
 12500413 567.874 567.874 567.874 567.874 567.874 567.874
 12500414 567.874 567.874 567.874 567.874 567.874 567.874
 12500415 567.874 567.874 567.874 567.874 567.874 567.874
 12500416 567.874 567.874 567.874 567.874 567.874 567.874
 12500417 567.874 567.874 567.874 567.874 567.874 567.874
 12500418 567.874 567.874 567.874 567.874 567.874 567.874
 12500419 567.874 567.874 567.874 567.874 567.874 567.874
 12500420 567.874 567.874 567.874 567.874 567.874 567.874
 12500421 567.874 567.874 567.874 567.874 567.874 567.874
 12500422 567.874 567.874 567.874 567.874 567.874 567.874
 12500423 567.874 567.874 567.874 567.874 567.874 567.874
 12500424 567.874 567.874 567.874 567.874 567.874 567.874
 12500425 567.874 567.874 567.874 567.874 567.874 567.874

12500426 567.874 567.874 567.874 567.874 567.874 567.874
12500427 567.874 567.874 567.874 567.874 567.874 567.874
12500428 567.874 567.874 567.874 567.874 567.874 567.874
12500429 567.874 567.874 567.874 567.874 567.874 567.874
12500430 567.874 567.874 567.874 567.874 567.874 567.874
12500431 567.874 567.874 567.874 567.874 567.874 567.874
12500432 567.874 567.874 567.874 567.874 567.874 567.874
12500433 567.874 567.874 567.874 567.874 567.874 567.874
12500434 567.874 567.874 567.874 567.874 567.874 567.874
12500501 0 0 0 1 19507.5240 1
12500502 0 0 0 1 4457.0724 33
12500503 0 0 0 1 18964.4880 34
12500601 250010000 10000 1 1 19507.5240 1
12500602 250020000 10000 1 1 4457.0724 33
12500603 250340000 10000 1 1 18964.4880 34
12500701 1000 0.0 0.0 0.0 1
12500702 1000 0.0 0.0 0.000016037 2
12500703 1000 0.0 0.0 0.000015425 3
12500704 1000 0.0 0.0 0.000015042 4
12500705 1000 0.0 0.0 0.000014831 5
12500706 1000 0.0 0.0 0.000014696 6
12500707 1000 0.0 0.0 0.000014640 7
12500708 1000 0.0 0.0 0.000014613 8
12500709 1000 0.0 0.0 0.000014618 9
12500710 1000 0.0 0.0 0.000014623 10
12500711 1000 0.0 0.0 0.000014600 11
12500712 1000 0.0 0.0 0.000014606 12
12500713 1000 0.0 0.0 0.000014610 13
12500714 1000 0.0 0.0 0.000014633 14
12500715 1000 0.0 0.0 0.000014651 15
12500716 1000 0.0 0.0 0.000014634 16
12500717 1000 0.0 0.0 0.000014644 17
12500718 1000 0.0 0.0 0.000014615 18
12500719 1000 0.0 0.0 0.000014600 19
12500720 1000 0.0 0.0 0.000014623 20
12500721 1000 0.0 0.0 0.000014608 21
12500722 1000 0.0 0.0 0.000014620 22
12500723 1000 0.0 0.0 0.000014633 23
12500724 1000 0.0 0.0 0.000014659 24
12500725 1000 0.0 0.0 0.000014689 25
12500726 1000 0.0 0.0 0.000014686 26
12500727 1000 0.0 0.0 0.000014720 27
12500728 1000 0.0 0.0 0.000014772 28
12500729 1000 0.0 0.0 0.000014866 29
12500730 1000 0.0 0.0 0.000015019 30
12500731 1000 0.0 0.0 0.000015222 31
12500732 1000 0.0 0.0 0.000015614 32
12500733 1000 0.0 0.0 0.000016149 33
12500734 1000 0.0 0.0 0.0 34
12500901 0.13083e-01 10.0 10.0 0.0 0.0 0.0 0.0 1.0 34

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* *modelo de cinetica*

* *tipo cin realim*

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30000000 point separabl
* pr.fis potencia reac n.ret cte cte
30000001 gamma-ac .101000000e+01 0. .2467e+03 1. 1.
* dec prod fis (ans73,ans79-1,ans79-3
30000002 ans79-3 200. 0.531 0.078 0.391
30000101 0.030221 0.012800
30000102 0.205212 0.031500
30000103 0.184944 0.124700
30000104 0.389432 0.328200
30000105 0.151466 1.405200
30000106 0.038726 3.844700

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* heat structures properties *

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20100100 tbl/fctn 1 1 * uo-2
20100200 tbl/fctn 1 1 * gap-normalstab
20100300 tbl/fctn 1 1 * zircaloy
20100400 tbl/fctn 1 1 * s-steel extrapolado
20100500 tbl/fctn 1 1 * inconel
20100600 tbl/fctn 1 1 * ferrit
20100700 tbl/fctn 1 1 * austenit aprox. 7800 kg/m3
20100800 tbl/fctn 1 1 * spalt heisstab
20100900 tbl/fctn 1 1 * aislante r213/e41/81, re-l 2668 ea
20101000 tbl/fctn 1 1 * aire
20101100 tbl/fctn 1 1 * cobre

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* thermal conductivity

*

* fuel uo-2 (wie bethy eingabe)

*

* temp(k) lambda(w/m-k) temp(k) lambda(w/m-k)

*

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20100101 273.15 7.8736 373.15 7.874
20100102 473.15 6.675 573.15 5.733
20100103 673.14 5.107 773.15 4.599
20100104 873.15 4.178 973.15 3.833
20100105 1073.15 3.53 1173.15 3.282
20100106 1273.15 3.066 1373.15 2.872
20100107 1473.15 2.731 1573.15 2.613
20100108 1673.15 2.516 1773.15 2.462
20100109 1873.15 2.418 1973.15 2.429
20100110 2073.15 2.429 2173.15 2.429
20100111 2273.15 2.451 2373.15 2.505
20100112 2473.15 2.591 2573.15 2.688
20100113 2673.15 2.807 2773.15 2.969
20100114 2873.15 3.142 2973.15 3.336
20100115 3073.15 3.561 3173.15 3.828
20100116 3573.15 5.224 4873.15 14.959

```

*

*-----

* gap gas normalstab

```

*
20100201 273.15 0.366725381 3000.00 0.366725381
*
*-----
*   cladding  zircaloy
*   temp(k) lamda(w/m-k) temp(k) lamda(w/m-k)
*
20100301 273.15 13.6 373.15 14.1
20100302 473.15 14.8 573.15 15.8
20100303 673.15 16.9 773.15 18.1
20100304 873.15 19.5 973.15 21.1
20100305 1073.15 22.8 1173.15 24.6
20100306 1273.15 26.8 1373.15 29.2
20100307 1473.15 31.7 1573.15 34.4
20100308 1673.15 37.3 1773.15 40.4
*
*-----
*   s-steel
*   internally stored thermal property, s-steel
*   temperature thermal conduct. temperature thermal conduct.
*   (k) (watt/m-k) (k) (watt/m-k)
*
20100401 2.731500e+02 1.298051e+01 1.199817e+03 2.510604e+01
*
*-----
*** inconel ***
20100501 293.0 17.612
20100502 533.0 21.777
20100503 833.0 27.132
*
*-----
*   ferrit
*
*   temp(k) lambda(w/m-k) temp(k) lambda(w/m-k)
*
* se extrapola a 273.15 para locas
20100601 273.15 44. 373.15 44.
20100602 473.15 43. 573.15 42.
20100603 673.15 40. 773.15 39.
20100604 873.15 39. 973.15 39.
20100605 1073.15 39. 1173.15 39.
*
*
*-----
*   austenit
*
*   temp(k) lamda(w/m-k) temp(k) lamda(w/m-k)
*
* se extrapola a 273.15 para locas
20100701 273.15 13.83 413.15 16.7
20100702 523.15 18.6 683.15 18.6
20100703 773.15 20.9 873.15 20.9
20100704 973.15 20.9 2000. 20.9
*
*-----

```

```

*      gap      gas heisstab
*
20100801 273.15  0.731969044 3000.00  0.731969044
*-----
*      aislante
*      temp(k) lamda(w/m-k) temp(k) lamda(w/m-k)
20100901 273.15  0.1      3000.00  0.1 * dato r213 /e41/81
*
*-----
*      aire
*      temp(k) lamda(w/m-k) temp(k) lamda(w/m-k)
20101001 277.75  0.0247  361.15  0.027
20101002 555.54  0.045   833.15  0.064
20101003 1333.15 0.09
*
*-----
*      cobre
*      temp(k) lamda(w/m-k) temp(k) lamda(w/m-k)
20101101 250.    406.    300.    401.
20101102 350.    396.    400.    393.
20101103 500.    386.    600.    379.
20101104 800.    366.    1000.   352.
20101105 1200.   339.
*
*****
*
*      volumetric heat capacity
*
*****
*
*      fuel uo-2
*
*      temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
20100151 273.150  2.427e6  400.    2.754e6
20100152 500.    2.927e6  600.    3.043e6
20100153 700.    3.139e6  800.    3.178e6
20100154 900.    3.236e6  1000.   3.274e6
20100155 1100.   3.313e6  1200.   3.351e6
20100156 1300.   3.378e6  1400.   3.428e6
20100157 1500.   3.459e6  1600.   3.502e6
20100158 1700.   3.582e6  1800.   3.660e6
20100159 1900.   3.775e6  2000.   3.992e6
20100160 2100.   4.169e6  2200.   4.366e6
20100161 2300.   4.622e6  2400.   4.897e6
20100162 2500.   5.212e6  2600.   5.585e6
20100163 3000.   7.395e6
*
*-----
*      gap      gas normalstab
*      temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
20100251 273.15  5.4      3273.15  5.4
*
*-----

```



```

* cladding zircaloy
* temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
20100351 273.15 1.881e6 573.15 2.079e6
20100352 773.15 2.211e6 903.15 2.290e6
20100353 923.15 2.376e6 1083.15 2.376e6
20100354 1103.15 3.630e6 1123.15 4.455e6
20100355 1143.15 4.950e6 1163.15 5.115e6
20100356 1183.15 4.950e6 1203.15 4.455e6
20100357 1213.15 3.360e6 1243.15 2.376e6
20100358 2073.15 2.376e6
*
*-----
* s-steel (extrapolado a 273c)
* internally stored thermal property, s-steel
* temperature heat capacity temperature heat capacity
* (k) (j/m3-k) (k) (j/m3-k)
20100451 2.7315e+2 3.604613e+06
20100452 3.664833e+02 3.830413e+06 4.220389e+02 3.964814e+06
20100453 4.775944e+02 4.099214e+06 5.331500e+02 4.233615e+06
20100454 5.887056e+02 4.334415e+06 6.442611e+02 4.435081e+06
20100455 6.998167e+02 4.502416e+06 8.109278e+02 4.636816e+06
20100456 1.366483e+03 5.376019e+06
*
*-----
* inconel
*
* temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
20100551 273. 3.988e6 293.0 3.916e6
20100552 373. 4.169e6 473.0 4.418e6
20100553 573. 4.703e6 673.0 5.095e6
20100554 773. 5.593e6 873.0 6.307e6
20100555 973. 7.482e6 1000.0 7.482e6
*
*-----
* ferrit
*
* temp(k) cp(j/m3-k) temp(k) cp(j/mf-k)
*
* se extrapola a 273.15 para locas
*20100651 293.15 3.611e6 373.15 3.847e6
20100651 273.15 3.552e6 373.15 3.847e6
20100652 473.15 4.082e6 573.15 4.396e6
20100653 673.15 4.788e6 773.15 5.338e6
20100654 2000. 5.338e6
*
*-----
* austenit
*
* temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
* se extrapola a 273.15 para locas
20100751 273.15 3.5012e6 368. 3.837e6
20100752 478.15 4.102e6 588.15 4.333e6

```

```

20100753 698.15 4.465e6 813.15 4.597e6
20100754 873.15 4.465e6 2000. 4.465e6
*
*-----
*   gap   gas heisstab
*   temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
*
20100851 200. 5.4 3273.15 5.4
*
*-----
*   aislante
*   temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
20100951 200. 130.e3 1200. 130.e3 *
*
*-----
*   aire
*   temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
20101051 200. 400. 1200. 478.
*
*-----
*   cobre (8960 kg/m3) (25C)
*   temp(k) cp(j/m3-k) temp(k) cp(j/m3-k)
20101151 200. 3.5e6 1200. 3.5e6
*
*****
. * end

```

INPUT DECK FOR RELAP5 COUPLED STEADY-STATE SIMULATION:

=PWR R5M3.3 beta (INPUT FOR STEADY-STATE FROM RESTART)

* PWR REACTOR RELAP5 INPUT FILE0

*****restart file input*****

*

1 88

*

* Problem Options

*

100 restart stdy-st *1

101 run

102 si si

103 -1

* remaining cpu time

105 5. 6.

*

*

			Min	mj	re			
201	600.0	0.00002	0.05	07003	1	1	5000	
202	500.0	0.00002	0.05	07003	1	1	5000	

*

.

INPUT DECK FOR PARCS V2.7 COUPLED STEADY-STATE SIMULATION:

```

/*****
CASEID PARCS_CSS          GENERAL DATA FOR A PWR
/*****
CNTL !table 5
  core_type PWR
  core_power 0.1 !
  ppm      0.0
!
!!! Control Rod Banks position in steps withdrawn: (14 cont. rod banks)
!!!   Totally withdrawn= 340.0
!!!   Totally inserted= 15.0 (corresponds to the minimum insertion length)
!
!          bk1 bk2 bk3 bk4 bk5 bk6 bk7 bk8 bk9 bk10 bk11 bk12 bk13 bk14
bank_pos 15.0 340. 340. 340. 15.0 15.0 340. 340. 340. 340. 340. 340. 340. 15.0
th_fdbk  F T
xe_sm    3 0
!
!      0 : no xe, 1 : eq. xe  2 : tr. xe  3 : given xe
decay_heat F
rot_adf    T
! for LPRM
DETECTOR F 5848.
pin_power F
ext_th    T  MAPTAB_RP      RELAP 1 1
transient F
restart   F  PARCS_SS.rst 1
!
!      input iteration  planar          adj
!      edit   table   power      pin    reac
print_opt  T    F    T    F    T
!
!      fdbk  flux  planar
!      rho  precurs  flux      Xe      T/H
print_opt  T    F    F    F    F
!
!
!      oneD  PKRE  Radial  Radial  assy
!      const Data  Shape  Shape  const
print_opt  F    F    F    F    F
oned_kin  F SA1D
!
!
!      END OF CONTROL CARD
!
/*****
PARAM !table 6
  n_iters 5 500
  conv_ss 1.0e-6 1.e-5 1.e-5 0.001 !keff,globfs,locfs,tempf
  wielandt 0.04 0.1 1.0
  nodal_kern HYBRID
  nlupd_ss 2 3 1
  eps_anm 0.005
  eps_erb 0.005
  decusp 0
  init_guess 0
/*****
XSEC !tabl 7

```

```

func_type 13
dnp_ngrp 6
kin_comp 1 1 -867
! PWR specs
dnp_beta 0.000158 0.001100 0.000977 0.002046 0.000789 0.000195
dnp_lambda 0.012812 0.031456 0.124555 0.328429 1.410936 3.818017
!*****
GEOM !table 8
file GEOM_LWR
!*****
TH !table 9
UNIF_TH 0.2 1200.00 650.0
!*****
PFF !table 10, power form function
npin_side 16
pff_comp 1 1 -867
pff_unrodd 1 !group 1 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_unrodd 2 !group 2 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_rodde 1 !group 1 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_rodde 2 !group 2 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
!*****
TRAN !table 11
time_step 1000. 1.e-4 200. 1.

```

```
! time_step 600.0 0.05 !TIME STEP N.B.  
expo_opt F F  
Scram F 1000.0 0.0 1048.  
!  
!!! move_bank provides the control rod bank movement.  
!!! The first parameter is the number of the control rod bank  
!!! The following parameters are: time and position (for each step)  
!  
! move_bank 14 0.0 15.0 2.0 15.0 2.1 340.0  
!  
! The above values need checking  
theta 0.5 0.5 0.5  
conv_tr 0.001  
nlupd_tr 5 1 5 10  
eps_xsec 0.01  
.
```

GEOM_LWR FILE TAIL FOR PARCS V2.7 SIMULATION:

```
.  
. .  
. .  
PR_Assign 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26  
27 28 29 30 31 32 33 34  
!  
!  
!fix: assume 340 steps: 1  
CR_axinfo 14.0 1. !fully withdrawn position and step size  
!  
!!! Control rod banks radial configuration  
!!! (14 control rod banks defined)  
!!! (0 means no bank defined)  
!  
bank_conf  
0 0 0 0 0 0 0  
0 0 0 0 0 0 0 0 0 0  
0 0 0 0 3 0 9 0 11 0 0 0 0  
0 0 0 0 1 0 7 0 6 0 2 0 0 0 0  
0 0 0 8 0 0 0 10 0 0 0 8 0 0 0  
0 0 0 2 0 12 0 5 0 4 0 12 0 1 0 0 0  
0 0 11 0 0 0 0 0 0 0 0 0 0 3 0 0  
0 0 0 6 0 4 0 13 0 13 0 5 0 7 0 0 0  
0 0 9 0 10 0 0 0 0 0 0 10 0 9 0 0  
0 0 0 7 0 5 0 13 0 13 0 4 0 14 0 0 0  
0 0 3 0 0 0 0 0 0 0 0 0 0 11 0 0  
0 0 0 1 0 12 0 4 0 5 0 12 0 2 0 0 0  
0 0 0 8 0 0 0 10 0 0 0 8 0 0 0  
0 0 0 0 2 0 6 0 7 0 1 0 0 0 0  
0 0 0 0 11 0 9 0 3 0 0 0 0  
0 0 0 0 0 0 0 0 0 0 0  
0 0 0 0 0 0 0
```

MAPTAB_RP FILE HEAD FOR COUPLED STEADY-STATE AND TRANSIENT SIMULATION:

```
*
* MAPTAB FILE FOR LWR - RELAP/PARCS COUPLING
*
%DOPL
*
LINC 0.70
*
***
*** %CRSIG - Control variables identification for
*** Control Rod Banks movement
*** - Control variables have to be introduced by order
*** (1 for each control rod bank).
*** - 0 means that the control rod bank is not moved.
*** - If %CRSIG is enabled, control rod bank movement is
*** driven by RELAP input, no matter what PARCS input says.
***
*
%CRSIG
0 0 0 0 0 0 0 0 0 0 0 0 0 0 521
*
*
%REFLPROP
*
569.55 569.55 724.00 0.0 0.0
* coolrefl(K) tfuelrefl(K) rhomixrefl alparefl ppmrefl
*
*
* VOLUME TO NODE TABLE
*
%TABLE1
250010000 1 1.00000
250010000 2 1.00000
.
.
.
```


INPUT DECK FOR RELAP5 COUPLED TRANSIENT SIMULATION:

```
=PWR R5M3.3 beta (INPUT FOR TRANSIENT FROM RESTART)
* PWR REACTOR RELAP5 INPUT FILE0
*****restart file input*****
*
1 88
*
*-----
* Problem Options
*-----
*
100 restart transnt *1
101 run
102 si si
103 -1
* remaining cpu time
105 5. 6.
*
      Min   mj   re
201  2.0  0.00002  0.1  07003  10  10  5000
202  4.0  0.00002  0.001 07003  10  10  5000
203 15.0  0.00002  1.000 07003  10  10  5000
204 500.0 0.00002  1.0  07003  10  10  5000
*
* control expandido 205cccc0 (0001 < cccc < 9999)
20500000 9999
*
* trips expandidos 206cccc0 (0001 < cccc < 0999)
* trips logicos 206cccc0 (1000 < cccc < 2000)
20600000 expanded
*
*****
*Variables de control
*
*** Control variable for Control Rod Bank movement
*** - Initial position of the CRB is indicated
*** - Movement table is identified
*
* name/type/scaling factor/initial value/initial flag/limiter control/minimum/maximum
20505210 bar_pos function 1. 15.0 0 3 0. 340.
*** name of variable on 'function'/integer name of variable/table number
20505211 time 0 521
*
*** Control Rod Bank movement table
*** - 202TTT00 where TTT is the table number
*** - react-t for reactivity versus time quantities; 0 means no trip used
*** - linear interpolation is used between argument values:
*** time position (in notches)
2052100 reac-t 0
2052101 0.0 15.0
2052102 2.0 15.0
2052103 2.1 340.0
*
.
```

INPUT DECK FOR PARCS V2.7 COUPLED TRANSIENT SIMULATION:

```

/*****
CASEID PARCS_TR          GENERAL DATA FOR A PWR
/*****
CNTL !table 5
  core_type PWR
  core_power 0.1 !
  ppm      0.0
!
!!! Control Rod Banks position in steps withdrawn: (14 cont. rod banks)
!!! Totally withdrawn= 340.0
!!! Totally inserted= 15.0 (corresponds to the minimum insertion lenght)
!
!          bk1 bk2 bk3 bk4 bk5 bk6 bk7 bk8 bk9 bk10 bk11 bk12 bk13 bk14
bank_pos 15.0 340. 340. 340. 15.0 15.0 340. 340. 340. 340. 340. 340. 340. 15.0
th_fdbk  F T
xe_sm    3 0
!
!      0 : no xe, 1 : eq. xe  2 : tr. xe  3 : given xe
decay_heat F
rot_adf    T
! for LPRM
DETECTOR F 5848.
pin_power F
ext_th    T  MAPTAB_RP      RELAP  1  1
transient T
restart   T  PARCS_CSS.rst 1
!
!      input iteration  planar          adj
!      edit   table   power      pin   reac
print_opt  T    F    T    F    T
!
!      fdbk  flux  planar
!      rho  precurs  flux      Xe      T/H
print_opt  T    F    F    F    F
!
!
!      oneD  PKRE  Radial  Radial  assy
!      const Data  Shape  Shape  const
print_opt  F    F    F    F    F
oned_kin  F SA1D
!
!
!      END OF CONTROL CARD
!
/*****
PARAM !table 6
  n_iters 5 500
  conv_ss 1.0e-6 1.e-5 1.e-5 0.001 !keff,globfs,locfs,tempf
  wielandt 0.04 0.1 1.0
  nodal_kern HYBRID
  nlupd_ss 2 3 1
  eps_anm 0.005
  eps_erb 0.005
  decusp 0
  init_guess 0
/*****
XSEC !tabl 7

```

```

func_type 13
dnp_ngrp 6
kin_comp 1 1 -867
! PWR specs
dnp_beta 0.000158 0.001100 0.000977 0.002046 0.000789 0.000195
dnp_lambda 0.012812 0.031456 0.124555 0.328429 1.410936 3.818017
!*****
GEOM !table 8
file GEOM_LWR
!*****
TH !table 9
!fix assume all assemblies are 16x16 with 20 guide/instrumentation tubes
! N_PINGT 236 20 !npin,ngt(n guide tubes)
!fix by ldj: 3010/177=17.005
! FA_POWERPIT 17. 10.625 !assembly power(Mw) and pitch(cm)
!
! gamma_frac 0. !direct heating fraction
! Dm_u Tf_u Tm_u
UNIF_TH 0.2 1200.00 650.0
!*****
PFF !table 10, power form function
npin_side 16
pff_comp 1 1 -867
pff_unrodd 1 !group 1 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_unrodd 2 !group 2 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_rodde 1 !group 1 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
pff_rodde 2 !group 2 of set 1
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
1. 1. 0. 1. 1. 0. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.

```

```

1. 1. 1. 1. 1. 1. 0. 1.
1. 1. 0. 1. 1. 1. 1. 1.
1. 1. 1. 1. 0. 1. 1. 1.
1. 1. 1. 1. 1. 1. 1. 1.
!!*****
TRAN !table 11
  time_step 1000. 1.e-4 200. 1.
! time_step 600.0 0.05 !TIME STEP N.B.
  expo_opt F F
  Scram F 1000.0 0.0 1048.
!
!!! move_bank provides the control rod bank movement.
!!! The first parameter is the number of the control rod bank
!!! The following parameters are: time and position (for each step)
!
! move_bank 14 0.0 15.0 2.0 15.0 2.1 340.0
!
! The above values need checking
theta 0.5 0.5 0.5
conv_tr 0.001
nlupd_tr 5 1 5 10
eps_xsec 0.01
.

```

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

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10. SUPPLEMENTARY NOTES

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11. ABSTRACT (200 words or less)

The objective of this work is to introduce an improvement in best estimate coupled neutronic-thermohydraulic 3D codes simulations, by adding a model for the control rod movement in the coupled code RELAP5/PARCS v2.7, by means of control variables, with the aim of being able to dynamically analyze asymmetric transient accidents, as the reactivity insertion accidents (RIA) in a nuclear reactor, reproducing all the reactors control systems.

The modification developed in this work permits the automatic movement of the control rods, activated by the RELAP5 code control system, and also they can depend on signals related to the reactor reactivity, like pressure, fuel temperature or moderator temperature, etc., improving the realism of the calculation and increasing the simulation capabilities.

This report was prepared by the Nuclear Engineering Group belonging to the Institute for Industrial, Radiophysical and Environmental Safety (ISIRYM) at the Universitat Politècnica de València (UPV), which collaborates in the simulation area with the Spanish company Centrales Nucleares Almaraz-Trillo (CNAT). The Asociación Española de la Industria Eléctrica (UNESA, Electric Industry Association of Spain), equivalent to the American EPRI sponsored this work.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

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Thermal-hydraulic

CAMP-Spain program

TRAC/RELAP Advanced Computational Engine (TRACE) code

RELAP5/PARCS v2.7

UNESA, Electric Industry Association of Spain

TRACE

SNAP

3D best estimate system codes

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Variables in RELAP5/PARCS v2.7 Coupled Code**

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