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QUALIFICATION ASSESSMENT TEST PLAN FOR THE TRAC-M-SPECIFIC DATA MAP ROUTINE IN THE COUPLED TRAC-M/PARCS CODE

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I. Introduction

The Qualification Assessment Test Plan (QATP) for the TRAC-M-Specific Data Map Routine (TDMR) in the coupled TRAC-M/PARCS code is consistent with the Software Requirement Specifications (SRS) for the TDMR(1). The main function of the TDMR is mapping control and space-dependent variables between TRAC-M and the General Interface (GI)(2). In order to simplify the testing procedure and isolate errors in the thermal-hydraulics code, the GI and PARCS/PDMR will be replaced with dummy codes, which will pass the necessary data to TRAC-M. In this test plan, three input decks will be chosen which will test the functionality of the TDMR described in the SRS.

II. Test Input Decks

The input decks selected for testing the functionality of the TDMR can be separated into two distinct groups: those for testing PWR functionality and those for testing BWR functionality. The group of decks for testing PWR functionality is comprised of decks from the standard set of test problems and decks created for participation in the OECD PWR MSLB Benchmark calculation(3). The group of decks selected for testing BWR functionality is also based on a deck from the standard suite of test problems, as well as an independent deck obtained from the NRC.

II.A. PWR Functionality Test Decks

Five of the test decks are based on the Westinghouse 4-loop model (`w4loopn.inp` and `w4looprn.inp`). One (`w4loopn.inp`) is used for performing a steady-state initialization calculation, while the other (`w4looprn.inp`) is used for performing a transient calculation using the steady-state condition as restart data. Minor modifications to these decks will be made in order to test more functionality of the TDMR than would be tested with the original decks. These input decks contain other thermal-hydraulic cells which are not coupled to the neutronics calculation. The TDMR should access the correct data within these models based on the mapping information provided in the mapping table input, `MAPTAB`, which is read by the PARCS-Specific Data Map Routine (PDMR)(4). The remaining input decks for testing PWR functionality were developed for participation in the MSLB benchmark calculation. The second exercise of the benchmark is a coupled plenum-to-plenum thermal-hydraulic and neutronics model. The TRAC-M deck uses PIPE components to model the coolant flow through the core. The third exercise of the benchmark is a complete system deck coupled to a neutronics model. The TRAC-M deck represents the complete system, using a VESSEL component to model the flow through the core. The PARCS input deck representing the core was used for both the second and third exercises of the benchmark. In both cases, the TDMR should access the correct data and pass it to the General Interface. At the same time, power data being sent by the General Interface to the TDMR should be placed in the memory locations corresponding only to those components defined in the MAPTAB file.

II.B. BWR Functionality Test Decks

The TRAC-M input deck selected as a BWR test deck is a simple model of the Brown's Ferry plant and was originally developed for testing the functionality of the CHAN component. This system deck was coupled with a PARCS input deck using 1-D kinetics data from a 1-D kinetics TRAC-B input deck. The TRAC-B input deck selected for testing was also a model of the Brown's Ferry plant, although this deck is a complete 1-D kinetics TRAC-B input deck. PARCS interprets this TRAC-B input deck and stores all the relevant neutronics data, which should result in the same thermal-hydraulics and 1-D kinetics solution as the stand-alone TRAC-B results. The only possible differences between the two solutions would stem from the sophistication of the feedback model in PARCS. Furthermore, the TRAC-B input deck also demonstrates the automatic mapping capability of the coupled TRAC-M/PARCS code for TRAC-B input decks.

III. Test Plan Description

The assessment of the TDMR is separated into a Calculational Experiment and a Functional Evaluation, both of which are described below. The execution of this test plan for assessing the TDMR requires the use of a dummy General Interface and the PARCS/PDMR programs to provide the TDMR with the necessary data.

III.A. Calculational Experiment

This phase of the test plan is executed to verify the calculational accuracy of the TDMR in mapping neutronic data to TRAC-M memory locations. The first step in this procedure involves running TRAC-M in "stand-alone" mode using the models described in Section II to obtain the converged thermal-hydraulic/heat conduction solution at each time step. It should be noted that none of the input decks in either the Short or Long set of standard sample problems contain PIPE components with power deposited directly into the coolant. For this reason, this option must be added to one of the input decks in order to verify the accuracy of the TDMR. The energy deposited into each thermal-hydraulic cell will be written to a scratch file during the transient calculation. The heat generation data for each heat structure axial level will be written to a scratch file during the transient calculation.

Once the direct coolant heating and heat structure power data has been obtained from the stand-alone TRAC-M solution, TRAC-M will be run coupled to a dummy GI and PARCS/PDMR. The dummy PARCS will pass the data obtained from the stand-alone TRAC-M scratch file to the TDMR in the necessary order.

The thermal-hydraulic/heat conduction solution from the two executions will then be compared for consistency. It should be noted that due to the computational approach taken by TRAC-M to determine the volumetric heat generation rate within the fuel, the heat generated within each axial level of each average ROD/SLAB needs to be back-calculated based on the geometry of the ROD/SLAB. This calculation is needed so that the dummy GI sends the data to the TDMR in the same form the PDMR will provide. Round-off error in the calculation of the heat generated, as

well as loss of precision in writing the solution, could result in slight differences between the TRAC-M stand-alone solution and the solution produced when TRAC-M is coupled to the GI.

III.B. Functional Evaluation

The functional evaluation portion of this test plan will be executed, as outlined below, using a five step approach to exercise each of the three functional units, the error-checking procedures, and the process control of the TDMR.

III.B.1. Initilization

The first step will test the initialization, which was described in Section II.A.3 of the SRS for the TDMR, using the following steps:

a. The data structure containing PARCS control information will be received from the General Interface and processed by the TDMR.

b. The mapping of thermal-hydraulic cells and heat structures, as well as any trip controls defined in the mapping input will be decoded and processed for completeness/accuracy/existence.

c. The TRAC-M data structure will be examined to determine whether solute tracking is activated in the TRAC-M model as well as whether thermal-hydraulic cells mapped to 3-D kinetics have an initial boron concentration which is nonzero.

d. The data structure containing TRAC-M control information will be processed and sent to the General Interface.

III.B.2. TRAC-M to General Interface Mapping

The second step will test the mapping of data from the TDMR to the General Interface, which was described in Section II.A.4 of the SRS for the TDMR, using the following steps:

a. The time-dependent thermal-hydraulic control data will be sent to the General Interface.

b. A vector containing all the space-dependent TRAC-M data will be processed and sent to the General Interface.

III.B.3. General Interface to TRAC-M Mapping:

The third step will test the mapping of data from the General Interface to TRAC-M, which was described in Section II.A.5 of the SRS for the TDMR, using the following steps:

a. The time-dependent neutronic control information will be received from the General Interface.

b. A vector will be received from the General Interface containing all the permuted space-dependent neutronic data.

c. The vector will be stored in the appropriate TRAC-M memory locations.

d. The boron concentration in the system will be adjusted by the ratio determined by the PARCS critical boron concentration calculation if the current calculation is a steady-state initialization and a critical boron concentration calculation is being performed by PARCS.

III.B.4. Error Checking

The fourth step will test the error checking for each of the previous three steps, described in Section II.A.6 of the SRS for the TDMR, and also for the mapping input unit, which was outlined in Section II.F of the SRS for the PDMR:

III.B.4.a. Initialization:

1. A trip ID number is received in the initial neutronic buffer, but no trips are defined in the TRAC-M model. [Warning]

2. Trips are defined in the TRAC-M model, but the trip ID number received in the initial neutronic buffer does not exist. [Warning]

3. The trip number received in the initial neutronic buffer is outside the bounds of a trip identification number. [Warning]

4. No signal variables are defined in the TRAC-M model, but a signal variable was indicated in `MAPTAB` as being responsible for PARCS control rod positions. [Warning]

5. Signal variables are defined in the TRAC-M model, but the signal variable ID number received in the initial neutronic control buffer does not exist. [Fatal]

6. The PARCS control rod bank to be controlled by the signal variable does not match with the signal variable input. [Fatal]

7. The initial control rod insertion fraction is out of the acceptable range. [Warning]

8. A component number specified in an entry of `%TABLE1` of `MAPTAB` does not exist in the TRAC-M model. [Fatal]

9. A component specified in an entry of `%TABLE1` of `MAPTAB` is neither a PIPE/CHAN nor a VESSEL component. [Fatal]

~~10. Every cell of a PIPE/CHAN component was not specified in `%TABLE1` of `MAPTAB`. [Fatal]~~

11. A horizontal plane cell (VESSEL) specified in an entry of `%TABLE1` of `MAPTAB` does not exist in the component in the TRAC-M model. [Fatal]

12. An axial level (VESSEL) specified in an entry of `%TABLE1` of `MAPTAB` does not exist in the component in the TRAC-M model. [Fatal]

13. The option for power deposited directly into the coolant (PIPE) is not activated for a component specified in an entry of `%TABLE1` of `MAPTAB`. [Warning]

14. A cell (PIPE/CHAN) specified in an entry of `%TABLE1` of `MAPTAB` does not exist in the component in the TRAC-M model. [Fatal]

15. A component number specified in an entry of `%TABLE2` of `MAPTAB` does not exist in the TRAC-M model. [Fatal]

16. A component specified in an entry of `%TABLE2` of `MAPTAB` is neither a ROD/SLAB nor a CHAN component. [Fatal]

17. A heat structure specified in an entry of `%TABLE2` of `MAPTAB` is defined in the TRAC-M model as having no heat source. [Fatal]

18. A heat structure specified in an entry of `%TABLE2` of `MAPTAB` is defined in the TRAC-M model as having the axial fine mesh option activated. [Warning]

19. A heat structure specified in an entry of `%TABLE2` of `MAPTAB` is defined in the TRAC-M model as having only a single radial node. [Fatal]

20. The fuel surface for a heat structure specified in an entry of `%TABLE2` of `MAPTAB` was not detected. [Warning]

21. An average ROD/SLAB number specified in an entry of `%TABLE2` of `MAPTAB` does not exist in the component in the TRAC-M model. [Fatal]

22. An axial level specified in an entry of `%TABLE2` of `MAPTAB` does not exist in the component in the TRAC-M model. [Fatal]

23. Every average ROD/SLAB of a heat structure was not specified in `%TABLE2` of `MAPTAB`. [Fatal]

24. Every axial level of a heat structure in the TRAC-M model was not specified in `%TABLE2` of `MAPTAB`. [Fatal]

25. A boron criticality search is being performed by PARCS during the steady-state initialization calculation, but solute tracking has not been activated in the TRAC-M model. [Warning]

26. A boron criticality search is being performed by PARCS during the steady-state initialization, but the thermal-hydraulic cells defined in `%TABLE1` of `MAPTAB` have an initial boron concentration of `0.0000D+00`. [Warning]

III.B.4.b. Thermal-Hydraulics to Neutronics Mapping:

1. Dimension of the unpermuted vector of thermal-hydraulic data to be sent to the General Interface is inconsistent with the number of columns in the thermal-hydraulic/heat structure to neutronic permutation matrix. [Fatal]

2. Property data in the unpermuted vector are outside the bounds specified in the SDID for the TDMR. [Fatal]

III.B.4.c. Neutronics to Thermal-Hydraulic Mapping

1. Dimension of the permuted vector of neutronics data sent from the General Interface is inconsistent with the number of rows in the neutronic to thermal-hydraulic/heat structure permutation matrix. [Fatal]

2. Neutronic powers in the permuted vector are outside the bounds specified in the SDID for the TDMR. [Fatal]

Note: Testing of the PVM error checking will not be performed for this QATP.

III.B.5. Exit Handling

The fifth step will test the termination of all three processes (TRAC-M, dummy General Interface, and PARCS), described in Section II.A.7 of the SRS for the TDMR, based on the following conditions:

a. Termination based on a logical fault signal sent from either the dummy PARCS process or the dummy General Interface process.

b. Termination based on an error in either TRAC-M or the TDMR.

III.B.6. Parametrics for Testing Error Checking

Permutations of the base test case will also be performed to exercise the error checking measures of Section III.B.4, and are listed below for the three functional units. Unless otherwise noted, the permutations listed below use the Westinghouse steady-state initialization input deck, `w4loopn.inp`, as the base case.

III.B.6.a. Initialization - (See Section III.B.4.a):

Note: Items (1a) through (1d) relate to the transient heat conduction case:

1a. The number of trips defined in the TRAC-M input deck defined on card `ntrp` will be changed to `0`, and trip number 101 will be removed from the `hcond1.inp` input deck.
1b. The trip ID specified with card `%TRIP` in file `MAPTAB` will be set to `242`.
1c. No trip ID will be specified in file `MAPTAB`.
1d. The trip ID specified with card `%TRIP` in file `MAPTAB` will be set to `0`.

2a. The column specifying component number in the first row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `456`.
2b. The column specifying component number in the second row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `140`.
2c. The column specifying horizontal plane cell number in the third row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `9`.
2d. The column specifying axial level in the fourth row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `20`.

Note: Items (2e) through (2i) relate to the transient heat conduction case:

2e. The column specifying component number in the first row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `5`.
2f. The column specifying component number in the second row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `91`.
2g. The card specifying whether power is directly deposited into the coolant, `ipow`, will be changed to `0` and all power table entries will be removed from the `hcond1.inp` input deck.
2h. The column specifying cell number in the third row of the `%TABLE1` mapping information in file `MAPTAB` will be changed to `6`.
~~2i. All entries in the `%TABLE1` mapping information in file `MAPTAB` relating to cell number 2 will be changed to relate to cell number 1.~~

3a. The column specifying the component number in the first row of the `%TABLE2` mapping information in file `MAPTAB` will be changed to `548`.
3b. The column specifying the component number in the second row of the `%TABLE2` mapping information in file `MAPTAB` will be changed to `26`.

3c. The card specifying whether a heat source is present in a heat structure will be changed to `0` for heat structure component number 140 and all associated power input will be removed from the `w4loopn.inp` input deck.

3d. A trip ID number will be defined for refining the axial nodalization for heat structure `140` in the `w4loopn.inp` input deck.

3e. The card specifying the number of radial conduction nodes within a heat structure will be changed to `1` for heat structure 140 in the `w4loopn.inp` input deck, and the necessary modifications to other inputs will be made to reflect this nodalization change.

3f. The radial power distribution defined on card `rdpwr` will be changed to 8*<`1.0`> for heat structure 140 in the `w4loopn.inp` input deck.

3g. The column specifying the average ROD/SLAB number in the third row of the `%TABLE2` mapping information in file `MAPTAB` will be changed to `6`.

3h. The column specifying the axial level in the fourth row of the `%TABLE2` mapping information in file `MAPTAB` will be changed to `12`.

3i. All entries in the `%TABLE2` mapping information in file `MAPTAB` relating to the fourth average ROD of heat structure `140` will be changed to relate to the third average ROD of heat structure `140`.

3j. All entries in the `%TABLE2` mapping information in file `MAPTAB` relating to the fourth axial level of the fourth average ROD of heat structure `140` will be changed to relate to the third axial level of this average ROD.

4a. The card specifying whether solute tracking is activated in TRAC-M, `isolut`, will be changed to `0` in the `w4loopn.inp` input deck.

4b. The initial boron concentration in each cell of the VESSEL component will be changed to `0.0000D+00` in the `w4loopn.inp` input deck.

III.B.6.b. Thermal-Hydraulics to Neutronics Mapping - (See Section III.B.4.b):

1. The dimension of the unpermuted vector of thermal-hydraulic and heat structure data to be sent to the General Interface will be decreased by one.

2a. The 1st element in the unpermuted vector (moderator temperature) to be sent to the General Interface will be assigned a value of -1.0.

2b. The 1st element in the unpermuted vector (moderator temperature) to be sent to the General Interface will be assigned a value of 11000.0.

2c. The 13th element in the unpermuted vector (moderator liquid density) to be sent to the General Interface will be assigned a value of -1.0.

2d. The 13th element in the unpermuted vector (moderator liquid density) to be sent to the General Interface will be assigned a value of 6000.0.

2e. The 25th element in the unpermuted vector (moderator vapor density) to be sent to the General Interface will be assigned a value of -1.0.

2f. The 25th element in the unpermuted vector (moderator vapor density) to be sent to the General Interface will be assigned a value of 6000.0.

2g. The 37th element in the unpermuted vector (void fraction) to be sent to the General Interface will be assigned a value of -1.0.

2h. The 37th element in the unpermuted vector (void fraction) to be sent to the General Interface will be assigned a value of 2.0.

2i. The 49th element in the unpermuted vector (boron concentration) to be sent to the General Interface will be assigned a value of -1.0.

2j. The 49th element in the unpermuted vector (boron concentration) to be sent to the General Interface will be assigned a value of 1.0E+07.

2k. The 61st element in the unpermuted vector (average fuel temperature) to be sent to the General Interface will be assigned a value of -1.0.

2l. The 61st element in the unpermuted vector (average fuel temperature) to be sent to the General Interface will be assigned a value of 11000.0.

2m. The 77th element in the unpermuted vector (centerline fuel temperature) to be sent to the General Interface will be assigned a value of -1.0.

2n. The 77th element in the unpermuted vector (centerline fuel temperature) to be sent to the General Interface will be assigned a value of 11000.0.

2o. The 93rd element in the unpermuted vector (fuel surface temperature) to be sent to the General Interface will be assigned a value of -1.0.

2p. The 93rd element in the unpermuted vector (fuel surface temperature) to be sent to the General Interface will be assigned a value of 11000.0.

III.B.6.c. Neutronics to Thermal-Hydraulics Mapping - (See Section III.B.4.c):

1a. The dimension of the permuted vector of neutronic data sent from the General Interface will be decreased by one during the steady-state calculation.

1b. The dimension of the permuted vector of neutronic data sent from the General Interface will be decreased by one during the first time-dependent calculation. This test is performed because the TDMR allocates space for the permuted vector only once (at the beginning of the steady-state/transient calculation). Thus, if the dimension of the vector sent from the General Interface is different on subsequent time steps than the size of the previously allocated vector, an error should occur.

2a. The 1st element in the permuted vector (power to coolant) sent from the General Interface will be assigned a value of -1.0.

2b. The 1st element in the permuted vector (power to coolant) sent from the General Interface will be assigned a value of 1.0E+16.

2c. The 13th element in the permuted vector (power to fuel) sent from the General Interface will be assigned a value of -1.0.

2d. The 13th element in the permuted vector (power to fuel) sent from the General Interface will be assigned a value of 1.0E+16.

III.B.7. Parametrics to Test Exit Handling

The following permutations will be performed to test the exit handling procedure as mentioned in Section III.B.5:

a. Detection of faults originating in the PARCS process will be tested by assigning the first, second, and third logicals in the initial and time-dependent neutronic control buffers a value of `.TRUE.`

b. Detection of faults originating in the dummy General Interface process will be tested by assigning the fourth and fifth logicals in the time-dependent neutronic control buffers a value of `.TRUE.` Testing of the error logicals sent from the dummy General Interface will not be performed during the initialization due to the fact that the General Interface does not assign values for these error logicals prior to communicating the initial control buffers.

c. Detection of faults originating in TRAC-M will be tested by assigning the first error logical in the initial and time-dependent thermal-hydraulic control buffers a value of `.TRUE.`

IV. Test Plan Verification

The Calculational Experiment and Functional Evaluation portions of this test plan are considered successful based on the criteria described below:

IV.A. Calculational Experiment

The steady-state and transient solutions of the stand-alone TRAC-M execution will be compared to those for the coupled TRAC-M/PARCS execution. Specifically, the steady-state and time-dependent core temperature distribution will be compared for consistency. As was mentioned in Section III.A, the results from the two executions may not be exactly the same due to differences in the computational approaches taken by TRAC-M and the TDMR. However, the differences in the solutions will be minimal, if noticable.

Restart capability in the coupled TRAC-M/PARCS code will be tested by allowing a coupled calculation to run to completion. The Westinghouse decks will be used for testing the coupled code in a restart calculation scenario. A steady-state initialization calculation will be performed with the coupled code, followed by a transient calculation using the steady-state data as the initial condition (as restart data). Two different restart tests will then be performed to verify the capability of the coupled TRAC-M/PARCS code:

1. A transient calculation will be restarted from the end of the steady-state initialization calculation. This calculation should terminate normally.

2. A transient calculation will be restarted from an intermediate calculation time during the transient calculation which was run to completion. Differences in the final solution and the solution from the case above should be null.

IV.B. Functional Evaluation

This portion of the test plan will be verified using a script to compare the produced output to the expected output. The items to be verified are:

1. The unpermuted vector of thermal-hydraulic and heat structure data is correctly formed from TRAC-M data. In addition, this vector is received by the General Interface, and every element is correct compared with the data shown in Appendix B.

2. The permuted vector of neutronic data is received by the TDMR, and all elements are correct compared with the data shown in Appendix B. In addition, the data contained in this vector are correctly mapped to the appropriate memory locations in TRAC-M.

3. The initial and time-dependent control buffers sent from the dummy General Interface are the same as those received by the TDMR, and the data contained in these buffers is placed in the correct variables.

4. The initial and time-dependent control buffers processed in the TDMR are the same as those received by the dummy General Interface.

5. All parametrics produce expected results, and all error measures are properly triggered.

6. Safe termination of all processes is acheived.

V. Conclusion

The test plan for validation of functionality of the TDMR was presented. The input decks that will be used for testing were presented and described. The error checking procedures and milestones that will be used for gauging a successful implementation were also presented and discussed in depth. Finally, the parameters for verifying that the implementation meets the requirements determined in the SRS were established.

VI. References

1. R. Miller, D. Barber and T. Downar, “Software Requirements Specification for the TRAC-M-Specific Data Map Routine in the Coupled TRAC-M/PARCS Code,” Technical Report, PU/NE-98-22, Purdue University, (1998).

2. D. Barber and T. Downar, “Software Requirements Specificaiton for the General Interface in the Coupled Code,” Technical Report, PU/NE-98-8, Purdue University, (1998).

3. K. Ivanov, et al., “Pressurized Water Reactor Main Steam Line Break (MSLB) Benchmark,” Technical Report, NEA/NSC/DOC(99)8, OECD, (1999).

4. D. Barber and T. Downar, “Software Requirements Specification for the PARCS-Specific Data Map Routine in the RELAP5/PARCS Coupled Code,” Technical Report, PU/NE-98-11, Purdue University, (1998).

Appendix A: Test Input Decks

1a. Westinghouse 4-loop steady-state initialization deck (`w4loopn.inp`)
1b. Westinghouse 4-loop transient calculation deck (`w4looprn.inp`)
1c. Westinghouse 4-loop transient restart deck (`w4loopr2n.inp`)
1d. Westinghouse 4-loop steady-state initialization deck with boron (`w4loopnb.inp`)
1e. Westinghouse 4-loop transient calculation deck (`w4looprnb.inp`)

2a. Brown's Ferry TRAC-M transient deck
2b. Brown's Ferry TRAC-BF1 steady-state deck

Note: These decks are distributed with the test package instead of being listed here to reduce the length of this document substantially.

Appendix B: Control Buffers and Vector Data for Functional Evaluation

The control buffers and vector data representing the initialization and first time-dependent steps of the Westinghouse 4-loop steady-state initialization case of the functional evaluation (`w4loopn.inp`) are shown below.

PARCS Initial Control Buffers:

```
cbufn(0:0)      =   Null
lbufn(1:8)      =   [ <6>*.FALSE., .TRUE., .FALSE.]
i2bufn(0:0)     =   Null
i4bufn(1:33)    =   [ 11, 12, 16, 108, 28,
                      26001003, 26001004, 26001005,
                      26002003, 26002004, 26002005,
                      26003003, 26003004, 26003005,
                      26004003, 26004004, 26004005,
                      140001001, 140001002, 140001003, 140001004,
                      140002001, 140002002, 140002003, 140002004,
                      140003001, 140003002, 140003003, 140003004,
                      140004001, 140004002, 140004003, 140004004 ]
r4bufn(0:0)     =   Null
r8bufn(0:0)     =   Null
```

TRAC-M Initial Control Buffers:

```
cbufth(1:16)    =   [ <16>*”PIN” ]
lbufth(1:10)    =   [ <8>*.FALSE., .TRUE., .FALSE. ]
i2bufth(0:0)    =   Null
i4bufth(0:0)    =   Null
r4bufth(0:0)    =   Null
r8bufth(1:1)    =   [ 0.0 ]
```

TRAC-M Time-Dependent Control Buffers:

```
cbufth(0:0)     =   Null
lbufth(1:9)     =   [ <9>*.FALSE. ]
i2bufth(0:0)    =   Null
i4bufth(0:0)    =   Null
r4bufth(0:0)    =   Null
r8bufth(1:1)    =   [ 1.0E-14 ]
```

Thermal-Hydraulic Data:

Vector to General Interface:

```
vecth(1:108)     =   [ 562.517, 574.543, 586.156, 562.486, 574.463,
                       586.029, 562.414, 574.187, 585.290, 562.486,
                       574.463, 586.029, 747.314, 722.273, 696.887,
                       747.376, 722.412, 697.189, 747.522, 723.020,
                       698.934, 747.376, 722.442, 697.189,
                       <12>*102.070, <24>*0.0, <48>*550.000 ]
```

PARCS Time-Dependent Control Buffers:

```
cbufn(0:0)       =   Null
lbufn(1:6)       =   [ <6>*.FALSE. ]
i2bufn(0:0)      =   Null
i4bufn(1:0)      =   Null
r4bufn(0:0)      =   Null
r8bufn(0:0)      =   0.0 (indeterminate unless PARCS is performing
                          a boron criticality search)
```

Neutronic Data:

Vector From General Interface:

```
vecnp(1:28)      =   [ <12>*0.0, 8.7090E+07, 4.4976E+08,
                       2.1051E+08, 9.8120E+06, 7.6249E+07,
                       3.8654E+08, 1.7368E+08, 7.9104E+06,
                       8.7404E+07, 4.5212E+08, 2.1251E+08,
                       9.9470E+06, 1.1305E+08, 6.2526E+08,
                       3.3147E+08, 1.6685E+07 ]
```

$$\sum_{i=1}^{28} vecn(i) = 3.25\times10^{9} \text{ watts}$$