APPENDIX I

DEFINING INPUT DATA FOR THE REACTIVITY-FEEDBACK MODEL

I.1. Introduction

Powered HTSTR component ROD 900 is coupled to the reactor-core region coolant of VESSEL component 1 in the three-loop Westinghouse PWR-plant model discussed in Appendix E. Its neutronic power is evaluated by a point-reactor kinetics model based on a programmed-reactivity table that is input. Reactivity feedback effects resulting from reactor-core region changes in fuel and coolant temperature (T_f and T_c), coolant gas volume fraction (α), and coolant control-absorber (boron) solute concentration (B) are not being modeled. This thermal-hydraulic feedback effect on neutronic reactivity, r, can be modeled in TRAC–M because r (the driving function for the point-reactor kinetics solution) is the sum of programmed reactivity, r_{prog} (defined by the power/reactivity component-action table) and feedback reactivity, r_{fdbk} (defined by the optional reactivity-feedback model).

The reactivity-feedback model in TRAC–M is based on defining the change in r_{fdbk} to be a function of the change in the above four parameters that it is assumed to be a function of. Thus,

$$r_{fdbk} = fcn(T_f, T_c, \alpha, B) \qquad \text{(I-1)}$$

allows one to approximate the change in r_{fdbk} by a first-order Taylor series expansion of r_{fdbk} in terms of its independent variables; i.e.,

$$\Delta r_{fdbk} = \partial r_{fdbk}/\partial T_f * \Delta T_f + \partial r_{fdbk}/\partial T_c * \Delta T_c + \partial r_{fdbk}/\partial \alpha * \Delta \alpha + \partial r_{fdbk}/\partial B * \Delta B. \qquad \text{(I-2)}$$

The partial derivatives are the reactivity-feedback coefficients of each of the independent-variable, reactivity-feedback parameters. These coefficients will need to be user specified through input. Each Δ factor is the reactor-core region volume-averaged change in a reactivity-feedback parameter. The Δ factors are averaged over the rector-core region because they are to be applied in a core-average (point) reactor kinetics model. Based on an approximation of perturbation theory, the Δ factors are weighted by the product of the fuel or coolant mass (for ΔT_f or ΔT_c only) and the spatial power distribution raised to the user-defined POWEXP power when averaging them over the reactor-core region.

When the point-reactor kinetics model is applied, the user should model reactivity-feedback effects. By not modeling reactivity feedback, the user is assuming that its effect on the neutronic power is negligible during the transient of interest. This is not the case for the steam-generator single-tube rupture transient of the three-loop Westinghouse PWR-plant model example. During this slow transient, the reactivity-feedback parameters in the reactor-core region do change by a significant amount before the

reactor-core neutronic power is scrammed by safety control-rod insertion. Before the power scram, r_{prog} is zero and r_{fdbk} needs to be evaluated to represent the reactivity effect caused by changes in the reactivity-feedback parameters. After the power scram, however, r_{prog} gets large and quickly dominates so that modeling feedback reactivity becomes much less important for the highly subcritical shutdown state of the reactor core.

The most common reason why a TRAC–M user decides not to model reactivity-feedback effects in the point-reactor kinetics solution is that the reactivity-feedback coefficients required for TRAC–M input are unknown and not conveniently available. To evaluate them requires few- or multigroup neutronic cross-section generating programs and a multidimensional neutron-diffusion and/or neutron-transport solution computer program to evaluate the neutron multiplication constant K_{eff} and the neutronic reactivity $r = (K_{eff}-1)/K_{eff}$. This in itself is a complex calculative procedure. Generally, the most convenient source for reactivity-feedback coefficients is the preliminary or final safety-analysis report (PSAR or FSAR) for the specific reactor of interest. In these reports, such calculations have already been done and reactivity-coefficient values usually are given for all four reactivity-feedback parameters averaged over the core-region. Each reactivity coefficient may be defined by a constant value (usually the case for $\partial r/\partial \alpha$ or $\partial K_{eff}/\partial \alpha$) or by values dependent upon one or more of the reactivity-feedback parameters. Because they generally were evaluated for the beginning-of-cycle (and sometimes end-of-cycle) burnup state of the reactor core, applying them to a different reactor-core burnup state for the transient of interest is an approximation the user often needs to make. Using approximate values that represent some measure of the reactivity-feedback effect is much better than neglecting the effect of reactivity feedback altogether as in the three-loop Westinghouse PWR-plant model example.

The remainder of Appendix I will discuss how one would modify the HTSTR-component ROD 900 input data in Appendix E to apply the reactivity-feedback model to the HTSTR's point-reactor kinetics solution. Reactivity-coefficient plots of $\partial r/\partial T_f$ as a function of T_f in Fig. I-1, $\partial r/\partial T_c$ as a function of T_c, α, and B_r in Fig. I-2, and $\partial K_{eff}/\partial B_r$ as a function of T_c and B_r in Fig. I-3 and a single constant value of $\partial K_{eff}/\partial \alpha = -0.12345$ are representative of the reactivity coefficients defined in a PSAR or FSAR. B_r is the ratio of boron mass to liquid mass in parts per million (ppm). In this example, we assume the availability of these data. These are representative but not specific values for a Westinghouse PWR. TRAC-M users should not assume these data values are appropriate for their plant model. Section I.2. describes the nature of the reactivity-feedback model in more detail and then adds this reactivity-feedback coefficient data to the input-data of ROD 900 shown in Section I.3. with annotation. The different number of reactivity-feedback parameter dependencies that these reactivity-feedback coefficient data have should provide a sufficient number of examples on how to input-specify their tabular data.

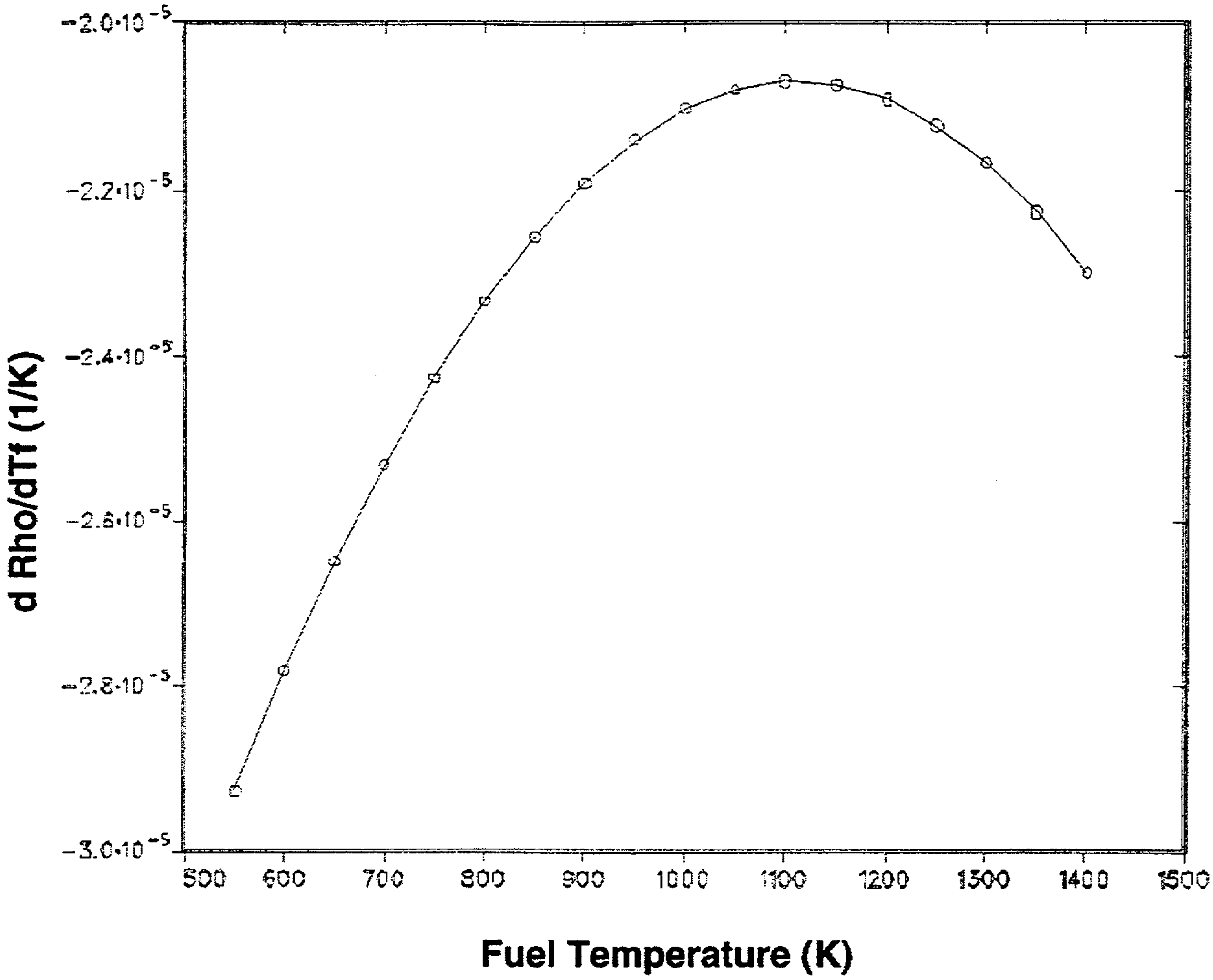

Fig. I-1 Fuel-temperature reactivity coefficient as a function of fuel temperature.

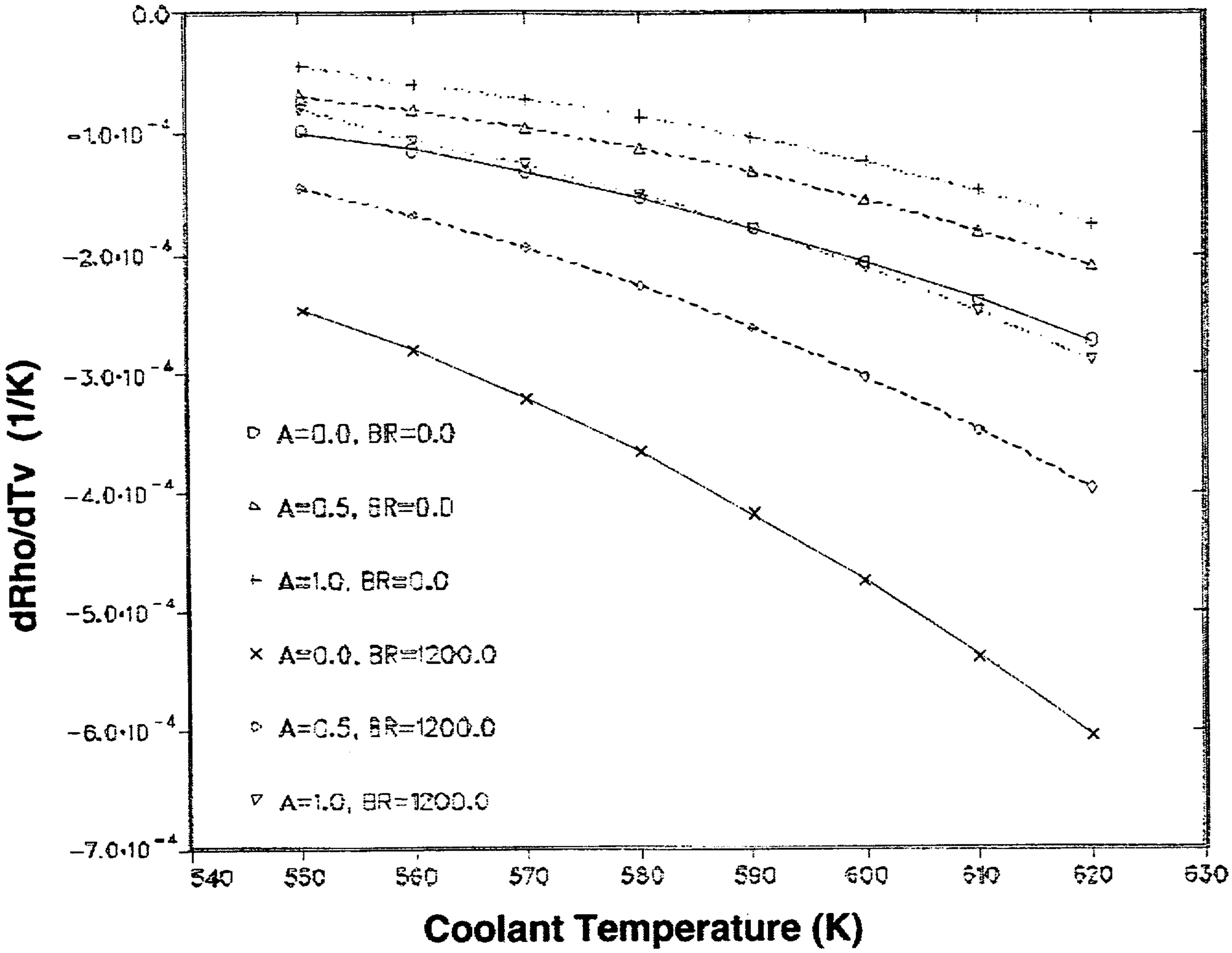

Fig. I-2 Coolant-temperature reactivity coefficient as a function of the coolant temperature, coolant gas volume fraction, and boron ppm ratio.

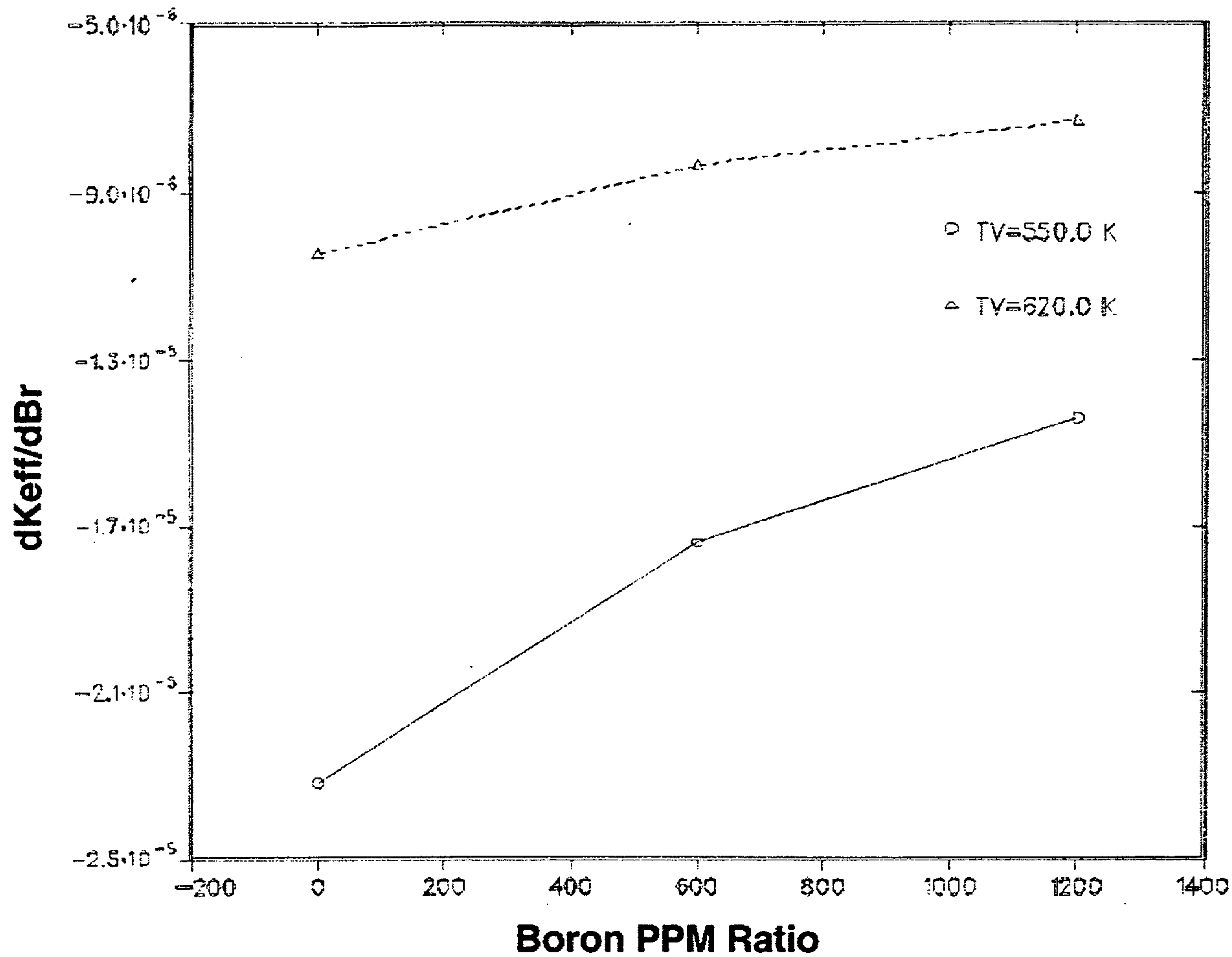

Fig. I-3 Boron ppm ratio reactivity coefficient as a function of the coolant temperature and boron ppm ratio.

I.2. Input Specifying the Reactivity-Feedback Model

While the first difficulty the TRAC-M user generally encounters is finding (or evaluating) reactivity-feedback coefficient data, the second difficulty usually is inputting these data in the general four-dimensional tabular form that TRAC-M requires. Each reactivity-feedback coefficient is assumed to have a possible functional dependence on all four reactivity-feedback parameters; i.e.,

$$\partial r/\partial T_f = fcn_{J=1}(T_f, T_c, \alpha, B), \qquad \partial r/\partial T_c = fcn_{J=2}(T_f, T_c, \alpha, B),$$
$$\partial r/\partial \alpha = fcn_{J=3}(T_f, T_c, \alpha, B), \text{ and } \partial r/\partial B = fcn_{J=4}(T_f, T_c, \alpha, B). \qquad \text{(I-3)}$$

The functional dependence of available reactivity-feedback coefficient data generally is less than all four parameters. This is the case for the data of this example: $\partial r/\partial T_c$ is a function of T_c, α, and B_r; $\partial K_{eff}/\partial B_r$ is a function of T_c and B_r; $\partial r/\partial T_f$ is a function of T_f; and

$\partial K_{eff}/\partial\alpha$ is independent of all four reactivity-feedback parameters (a constant value). TRAC-M provides the user with full flexibility of input form by allowing dependence on all four parameters or any combination of them. TRAC-M also allows the user four different forms for defining neutronic reactivity in the reactivity coefficients as shown in Table I-1 where $x = T_f, T_c, \alpha$, or B. Reactivity coefficients $\partial K_{eff}/\partial\alpha$ and $\partial K_{eff}/\partial B$ have form 0, and $\partial r/\partial T_f$ and $\partial r/\partial T_c$ have form 1. There also are two defining forms for the control-absorber solute concentration B of boron (or equivalent boron based on absorption of neutrons): B_m, the boron mass per unit volume of liquid coolant; and B_r, the ratio of boron mass to liquid-coolant mass in units of parts per million (ppm). Four different forms of boron (or equivalent boron) in the reactor core are included in the evaluation of B_m or B_r: dissolved boric acid in the liquid coolant defined by the solute CONC array, boric acid plated on the reactor-core structure defined by the SN array, borosilicate glass in the burnable-poison pins defined by BPP = BPP0 + BPP1 * T_c where BPP0 and BPP1 are user-defined input parameters, and boron oxide in the control-rod-cluster pins defined by BCR = BCR0 + BCR1 * r_{prog} where BCR0 and BCR1 are user-defined input parameters. Input-data parameter IBU_J defines the form of B from among the four possible combinations that B can have in the $\partial r/\partial x = fcn_{J=j}(T_f, T_c, \alpha, B)$ defining form of the reactivity-feedback coefficient:

TABLE I-1
REACTIVITY-COEFFICIENT FORMS

Form Number	Reactivity-Coefficient Form
0	$\partial K_{eff}/\partial x$
1	$1/K_{eff}\ \partial K_{eff}/\partial x = \partial r/\partial x$
2	$x\ \partial K_{eff}/\partial x$
3	$x/K_{eff}\ \partial K_{eff}/\partial x = x\ \partial r/\partial x$

$$\begin{aligned} IBU_J &= -2 \text{ when } x = B_r \text{ and } B = B_r, \\ IBU_J &= -1 \text{ when } x = B_r \text{ and } B = B_m, \\ IBU_J &= \ \ 0 \text{ when } x = B_m \text{ and } B = B_r, \text{ and} \\ IBU_J &= \ \ 1 \text{ when } x = B_m \text{ and } B = B_m. \end{aligned} \qquad \text{(I-4)}$$

When $x = T_f$, T_c, or α, $IBU_J = -2$ or 0 defines $B = B_r$ and $IBU_J = -1$ or 1 defines $B = B_m$. For the data of this example,

$IBU_4 = -2$ for $\partial K_{eff}/\partial B_r = fcn_{J=4}(T_c, B_r)$,
$IBU_2 = -2$ or 0 (0 will be input) for $\partial r/\partial Tc = fcn_{J=2}(T_c, \alpha, B_r)$, and
IBU_1 and IBU_3 can have any of the four values (0 will be input)
since $\partial r/\partial Tf = fcn_{J=1}(T_f)$ and $\partial K_{eff}/\partial\alpha = fcn_{J=3}(-)$
are not dependent on the boron concentration. (I-5)

Based on the above information, we can define the reactivity-feedback model data for powered HTSTR component ROD 900. Notes in this section are referenced by callouts that are marked on the ROD 900 input-data listing shown in Section I.3. For example, [1] is note 1.

1. Add 10 to the power-type option parameter IRPWTY to evaluate the reactivity-feedback model. IRPWTY = 4 evaluates the point-reactor kinetics equations with programmed reactivity defined by the trip IRPWTR = 10 controlled component-action table RPWTB. We add 10 to the value 4 so that IRPWTY = 14 evaluates reactivity-feedback effects as well. Adding 10 to IRPWTY = 1 through 4 evaluates the point-reactor kinetics equations with reactivity feedback; adding 10 to IRPWTY = 5 through 7 evaluates reactivity feedback (and prints its results), but doesn't apply it to determining the power because the power is defined directly by the power component action.

2. The IRCJTB(I,J) array defines the number of values of each reactivity-feedback parameter I, where I = 1 for T_f, I = 2 for T_c, I = 3 for α, and I = 4 for B_r (if IBU_J = -2 or 0) or B_m (if IBU_J = -1 or 1) corresponding to reactivity-feedback coefficient J tabular data. The values of IRCJTB(I,J) are defined on a different record (card) for each reactivity-feedback coefficient J, where J = 1, 2, 3, and 4 is the derivative of reactivity with respect to T_f, T_c, α, and B_r (if IBU_J = -2 or -1) or B_m (if IBU_J = 0 or 1), respectively. For the tabular data of each reactivity coefficient J, the number of different T_f values defines IRCJTB(1,J), the number of different T_c values defines IRCJTB(2,J), the number of different coolant void fraction a values defines IRCJTB(3,J), and the number of different B_r (if IBU_J = -2 or 0) or B_m (if IBU_J = -1 or 1) values defines IRCJTB(4,J). Each reactivity-feedback parameter has one or more values corresponding to its reactivity-feedback coefficient data. A reactivity-feedback coefficient that is not dependent on a reactivity-feedback parameter has 1 value that is constant (not 0 values) for that parameter. Later in notes 5 through 8 when defining the reactivity-feedback coefficient data, the reactivity-feedback parameter single value will be defined arbitrarily to be 0.0. The last value on each record (card) is the appropriate value of IBU(J) that defines the boron-concentration form number. The following is a summary of what the data on each of the four records (cards) represent.

   J = 1 record: The fuel-temperature reactivity-feedback coefficient $\partial r/\partial T_f$ has 18 different values of fuel temperature T_f and 1 value for each of the other 3 reactivity-feedback parameters for which there is no dependency (see Fig. I-1). This corresponds to $18 * 1 * 1 * 1 = 18$ reactivity-feedback coefficient values. Because there is no boron-concentration dependence, a IBU(1) = 0 boron-concentration form number is input but not used.

J = 2 record: The coolant-temperature reactivity-feedback coefficient $\partial r/\partial T_c$ has 1 value of the fuel temperature T_f for which there is no dependency (see Fig. I-2), 8 different values of the coolant temperature T_c, 3 different values of the coolant gas volume fraction α, and 2 different values of the boron mass ratio B_r. This corresponds to 1 * 8 * 3 * 2 = 48 reactivity-feedback coefficient values. IBU(2) = 0 defines the boron-concentration form for B as being B_r

J = 3 record: The coolant gas volume-fraction reactivity-feedback coefficient $\partial K_{eff}/\partial\alpha$ has 1 value for each of the 4 reactivity-feedback parameters for which there is no dependency and 1 * 1 * 1 * 1 = 1 value of $\partial K_{eff}/\partial\alpha$ because it is defined as a constant value. IBU(3) = 0 is input but not used because there is no boron-concentration dependence.

J = 4 record: The boron mass to liquid-coolant mass ratio reactivity-feedback coefficient $\partial K_{eff}/B_r$ has 1 value for the fuel temperature T_f (for which there is no dependency), 2 different values for the coolant temperature T_c, 1 value for the coolant gas volume fraction (for which there is no dependency), and 3 different values for the boron mass to liquid-coolant mass ratio B_r (see Fig. I-3). This corresponds to 1 * 2 * 1 * 3 = 6 reactivity-feedback coefficient values. Because there is boron-concentration dependence in both the derivative and functional form, IBU(4) = –2 defines the form of B in $\partial K_{eff}/B_r$ as well as $fcn_{J=4}(T_c, B_r)$.

3. The IRCJFM(J) array defines the form of the reactivity-feedback parameter (see Table I-1), which is IRCJFM(1) = 1 for $\partial r/\partial T_f$, IRCJFM(2) = 1 for $\partial r/\partial T_c$, IRCJFM(3) = 0 for $\partial K_{eff}/\partial\alpha$, and IRCJFM(4) = 0 for $\partial K_{eff}/\partial B_r$. Input variable ISNOTB = 0 indicates that the dissolved solute defined by the CONC array (where all its input-specified values are 0.0) and defined by the SN array (having plated out from the CONC array) is considered to be boron and included in defining x and B in the reactivity-feedback coefficient general form $\partial r/\partial x = fcn_{J=j}(T_f, T_c, \alpha, B)$.

4. The POWEXP = 2.0 input parameter is the exponential power that the power-distribution weighting factor is raised to when averaging the reactivity-feedback parameters over the reactor-core region. When the fuel enrichment and fission cross section is uniform throughout the reactor core, POWEXP = 2.0 corresponds to the weighting factor being the product of the neutron flux and adjoint flux from perturbation theory with the adjoint flux approximated by the neutron flux (the Galerkin approximation). The input parameters BPP0 = 2.6000E-01 kg m^{-3} (1.6231E-02 lb_m ft^{-3}), BPP1 = –2.0000E-01 kg m^{-3} K^{-1} (-6.9364E-05 lb_m ft^{-3} $°F^{-1}$), BCR0 =

1.0000E-01 kg m^{-3} (6.2428E-03 lb_m ft^{-3}), and BCR1 = –3.0000E+01 kg m^{-3} (-1.8728E+00 lb_m ft^{-3}) define the burnable-poison pin equivalent boron concentration as a linear function of T_c and the control-rod-cluster pins equivalent boron concentration as a linear function of rprog. Their boron concentrations are included in the B but not the x definitions of boron concentration in the reactivity-feedback coefficient general form $r/\partial x = fcn_{J=j}(T_f, T_c, \alpha, B)$.

5. The fuel-temperature reactivity-feedback coefficient shown in Fig. I-1 has its tabular values input to array RCTF. Rather than inputting data pairs (x,y) (such as that done for the 1D component-action tables) or data pairs [x,y(z)] (such as for the 2D axial-power shape and QPPP component-action tables), the four-dimensional reactivity-feedback table is input in a condensed form with its values in the following order: all the different values of T_f in ascending order, all the different values of T_c in ascending order, all the different values of the coolant gas volume fraction α in ascending order, all the different values of B_r or B_m in ascending order, and finally all the reactivity-feedback coefficient values. The order of the reactivity-feedback coefficient values is as follows: first input the values of $fcn_{J=j}(T_{f1},T_{c1},\alpha_1,B_{r1})$, $fcn_{J=j}(T_{f2},T_{c1},\alpha_1,B_{r1})$, ... , $fcn_{J=j}(T_{fL},T_{c1},\alpha_1,B_{r1})$ where L=IRCJTB(1,j) changing only the corresponding value of T_f; then do the same but for T_{c2} rather than T_{c1}; continue doing the same for ascending values of T_c until $T_{c\,IRCJTB(2,j)}$. Then this entire process is done for ascending values of the coolant gas volume fraction α, and finally the process is then done for ascending values of B_r. This condensed form requires fewer values to be input than inputting each tabular reactivity-feedback coefficient with a single record (card) defining each (T_f, T_c, α,B_r, $\partial r/\partial x$) data pair. For example, in the case where all IRCJTB(I,j), I = 1,4 having the value 5, the condensed form requires inputting 5 + 5 + 5 + 5 + (5 ∗ 5 ∗ 5 ∗ 5) = 645 values while the data-pair form would require 5 ∗ (5 ∗ 5 ∗ 5 ∗ 5) = 3125 values. For the fuel-temperature reactivity-feedback coefficient, which has only fuel-temperature dependence, there are 18 + 1 + 1 + 1 + (18 ∗ 1 ∗ 1 ∗ 1) = 39 values input compared with 5 ∗ (18 ∗ 1 ∗ 1 ∗ 1) = 90 values otherwise. The RCTF array is input using the LOAD format. Using skip (s) identifiers for records (cards) with less than five value, we have segregated the condensed-form input data so that values for each of the reactivity-feedback parameters and the fuel-temperature reactivity-feedback coefficients are on their own records (cards). This is done in the input listing of Section I.3. with an added comment (following a star) giving the total number of such values and the parameters they represent.

6. The coolant-temperature reactivity-feedback coefficient shown in Fig. I-2 has its tabular values input to array RCTC. Refer to note 5 for a description of the order that its data are specified. With dependence on T_c, α, and B_r, its condensed form that is input has 1 + 8 + 3 + 2 + (1 ∗ 8 ∗ 3 ∗ 2) = 62 values.

7. The coolant gas volume-fraction reactivity-feedback coefficient has its tabular values input to array RCAL. Refer to note 5 for a description of the order that its data are specified. Because $\partial K_{eff}/\partial\alpha$ is not dependent on any of the reactivity-feedback parameters and has a constant value, its input consists of five values: a 0.0 value for each of the reactivity-feedback parameters and a constant reactivity-feedback coefficient value of –1.2345e–01. While these data could be input on a single record (card), we have chosen to input each value on its own card with a comment defining its parameter that is consistent with the way the other reactivity-feedback coefficients are being input.

8. The boron mass to liquid-coolant mass ratio reactivity-feedback coefficient shown in Fig. I-3 has its tabular values input to array RCBM. Refer to note 5 for a description of the order that its data are specified. With dependence on T_c and B_r, its condensed form that is input has $1 + 2 + 1 + 3 + (1 * 2 * 1 * 3) = 13$ values.

I.3. Printout of the Input Data for HTSTR Component ROD 900 With Reactivity Feedback Modeled

```
**********************************************************************
*******    type            num             id        ctitle
rod                        900            900 $900$ reactor-core fuel rods
*              ncrx           ncrz           ittc           iext            m1d
                  6              4              0              0              0
*            nopowr          nridr          modez         liqlev         iaxcnd
                  0              0              0              1              1
*             idbci          idbco           hdri           hdro
                  0              2     0.0000e+00     0.0000e+00
*             nrods          nodes          irftr          nzmax         irftr2
                 12              8           9997            200           9998
*          dtxht(1)       dtxht(2)         dznht          hgapo          shelv
         3.0000e+00     1.0000e+01     5.0000e-03     1.7000e+04     0.0000e+00
*            irpwty           ndgx           ndhx           nrts          nhist
                 14 <-- [1]      6             11             10              0
*            irpwtr         irpwsv         nrpwtb         nrpwsv         nrpwrf
                 10              1             -4              0              0
*            izpwtr         izpwsv         nzpwtb         nzpwsv         nzpwrf
                  0              1              1              0              0
*             nmwrx           nfci          nfcil         ipwrad         ipwdep
                  1              1              1              0              0
*             nzpwz          nzpwi         nfbpwt          nrpwr          nrpwi
                  0              0              0              0              0
*             react          tneut         rpwoff         rrpwmx         rpwscl
         0.0000e+00     1.6250e-05    -1.0000e+20     1.0000e+20     1.0000e+00
*            rpowri          zpwin         zpwoff         rzpwmx
         2.3000e+09     1.0000e+00    -1.0000e+20     1.0000e+20
*            extsou           pldr          pdrat         fucrac
         0.0000e+00     0.0000e+00     1.3280e+00     5.0000e-01
*
*       ircjtb(1,j)    ircjtb(2,j)    ircjtb(3,j)    ircjtb(4,j)         ibu(j)  --+
* j=1 *          18              1              1              1              0    |
* j=2 *           1              8              3              2              0    |-- [2]
* j=3 *           1              1              1              1              0    |
* j=4 *           1              2              1              3             -2  --+
*         ircjfm(1)      ircjfm(2)      ircjfm(3)      ircjfm(4)         isnotb
                  1              1              0              0              0 <-- [3]
*            powexp           bpp0           bpp1           bcr0           bcr1
         2.0000e+00     2.6000e-01    -2.0000e-03     1.0000e-01    -3.0000e+01 <-- [4]
*
* nhcomo* f              1e
* nhcelo*               -3              3              4              5              6
* nhcelo*                7e
* z     *        3.0004e+00     3.9148e+00     4.8292e+00     5.7436e+00     6.6580e+00
* z     * e
* grav  * f      1.0000e+00e
* idrod *                 1              2              3              4              5
* idrod *                6e
* rdx   * f      5.3380e+03e
* radrd *        0.0000e+00     1.1319e-03     2.2638e-03     3.3957e-03     4.5275e-03
* radrd *        4.6228e-03     5.0038e-03     5.3848e-03e
* matrd * r04             1           3r02              2e
* nfax  * f              5e
* rftn  * f      5.5910e+02e
* rftn  * f      5.5910e+02e
```

```
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rftn   * f    5.5910e+02e
* rdpwr  * r05 1.0000e+00r03 0.0000e+00e
* cpowr  * f    1.0000e+00e
* rpkf   * f    1.6780e+00e
* zpwtb  *      0.0000e+00     9.0000e-01     1.5460e+00     1.6570e+00     1.5220e+00
* zpwtb  *      9.2600e-01e
* rpwtb  *      1.0000e+00     0.0000e+00     1.6000e+00    -8.4000e-03     2.0000e+00
* rpwtb  *     -3.2500e-02     2.2000e+00    -3.5000e-02e
*
* rctf   *      5.5000e+02     6.0000e+02     6.5000e+02     7.0000e+02     7.5000e+02
* rctf   *      8.0000e+02     8.5000e+02     9.0000e+02     9.5000e+02     1.0000e+03
* rctf   *      1.0500e+03     1.1000e+03     1.1500e+03     1.2000e+03     1.2500e+03
* rctf   *      1.3000e+03     1.3500e+03     1.4000e+03s    * 18 fuel temperatures
* rctf   *      0.0000e+00s                                 * 1 coolant temperature
* rctf   *      0.0000e+00s                                 * 1 gas volume fraction      5
* rctf   *      0.0000e+00s                                 * 1 boron ppm ratio
* rctf   *     -2.9280e-05    -2.7818e-05    -2.6492e-05    -2.5303e-05    -2.4250e-05
* rctf   *     -2.3334e-05    -2.2554e-05    -2.1911e-05    -2.1404e-05    -2.1034e-05
* rctf   *     -2.0800e-05    -2.0703e-05    -2.0742e-05    -2.0918e-05    -2.1230e-05
* rctf   *     -2.1679e-05    -2.2264e-05    -2.2986e-05e   * 18 drho/dtf=fcn(tf)
*
* rctc   *      0.0000e+00s                                 * 1 fuel temperature
* rctc   *      5.5000e+02     5.6000e+02     5.7000e+02     5.8000e+02     5.9000e+02
* rctc   *      6.0000e+02     6.1000e+02     6.2000e+02s    * 8 coolant temperatures
* rctc   *      0.0000e+00     5.0000e-01     1.0000e+00s    * 3 gas volume fractions
* rctc   *      0.0000e+00     1.2000e+03s                  * 2 boron ppm ratios
* rctc   *     -9.8500e-05    -1.1372e-04    -1.3214e-04    -1.5376e-04    -1.7858e-04
* rctc   *     -2.0660e-04    -2.3782e-04    -2.7224e-04s   * 8 drho/dtv=fcn(tv,a1,br1)
* rctc   *     -6.8950e-05    -8.0740e-05    -9.5140e-05    -1.1220e-04    -1.3210e-04
* rctc   *     -1.5500e-04    -1.8070e-04    -2.0960e-04s   * 8 drho/dtv=fcn(tv,a2,br1)   6
* rctc   *     -4.4250e-05    -5.9130e-05    -7.1360e-05    -8.6110e-05    -1.0360e-04
* rctc   *     -1.2400e-04    -1.4740e-04    -1.7420e-04s   * 8 drho/dtv=fcn(tv,a3,br1)
* rctc   *     -2.4620e-04    -2.7980e-04    -3.1980e-04    -3.6600e-04    -4.1790e-04
* rctc   *     -4.7520e-04    -5.3750e-04    -6.0440e-04s   * 8 drho/dtv=fcn(tv,a1,br2)
* rctc   *     -1.4480e-04    -1.6710e-04    -1.9410e-04    -2.2550e-04    -2.6160e-04
* rctc   *     -3.0230e-04    -3.4690e-04    -3.9610e-04s   * 8 drho/dtv=fcn(tv,a2,br2)
* rctc   *     -7.9650e-05    -1.0530e-04    -1.2560e-04    -1.4980e-04    -1.7820e-04
* rctc   *     -2.1080e-04    -2.4760e-04    -2.8920e-04e   * 8 drho/dtv=fcn(tv,a3,br2)
*
* rcal   *      0.0000e+00s                                 * 1 fuel temperature
* rcal   *      0.0000e+00s                                 * 1 coolant temperature
* rcal   *      0.0000e+00s                                 * 1 gas volume fraction      7
* rcal   *      0.0000e+00s                                 * 1 boron ppm ratio
* rcal   *     -1.2345e-01e                                 * 1 dkeff/da=constant
*
```

```
* rcbm   *     0.0000e+00s                                          * 1 fuel temperature
* rcbm   *     5.5000e+02   6.2000e+02s                             * 2 coolant temperatures
* rcbm   *     0.0000e+00s                                          * 1 gas volume fraction
* rcbm   *     0.0000e+00   6.0000e+02   1.2000e+03s                * 3 boron ppm ratios
* rcbm   *    -2.3210e-05  -1.0440e-05s                             * 2 dkeff/dbr=fcn(tv,br1)
* rcbm   *    -1.7410e-05  -8.3520e-06s                             * 2 dkeff/dbr=fcn(tv,br2)
*        *    -1.4390e-05  -7.3080e-06e                             * 2 dkeff/dbr=fcn(tv,br3)
*
* beta   *     1.6900e-04   8.3200e-04   2.6400e-03   1.2200e-03   1.3800e-03
* beta   *     2.4700e-04e
* lamda  *     3.8700e+00   1.4000e+00   3.1100e-01   1.1500e-01   3.1700e-02
* lamda  *     1.2700e-02e
* cdgn   *     6.1809e+09   8.4114e+10   1.2015e+12   1.5015e+12   6.1616e+12
* cdgn   *     2.7528e+12e
* lamdh  *     1.7720e+00   5.7740e-01   6.7430e-02   6.2140e-03   4.7390e-04
* lamdh  *     4.8100e-05   5.3440e-06   5.7260e-07   1.0360e-07   2.9590e-08
* lamdh  *     7.5850e-10e
* edh    *     2.9900e-03   8.2500e-03   1.5500e-02   1.9350e-02   1.1650e-02
* edh    *     6.4500e-03   2.3100e-03   1.6400e-03   8.5000e-04   4.3000e-04
* edh    *     5.7000e-04e
* cdhn   *     3.8809e+06   3.2863e+07   5.2870e+08   7.1621e+09   5.6541e+10
* cdhn   *     3.0842e+11   9.9420e+11   6.5875e+12   1.8871e+13   3.3423e+13
* cdhn   *     1.7284e+15e
*
* fpuo2  * f   0.0000e+00e
* ftd    * f   9.4000e-01e
* gmix   *     1.0000e+00r06 0.0000e+00  1.0000e+00r06 0.0000e+00  1.0000e+00
* gmix   * r06 0.0000e+00  1.0000e+00r06 0.0000e+00  1.0000e+00r06 0.0000e+00
* gmix   *     1.0000e+00r06 0.0000e+00e
* gmles  * f   0.0000e+00e
* pgapt  * f   1.0000e+07e
* plvol  * f   0.0000e+00e
* pslen  * f   0.0000e+00e
* clenn  * f   0.0000e+00e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
* burn   * f   1.0127e+04e
```

[8]

APPENDIX J

CONVERTING ACCUM AND STGEN COMPONENTS

The ACCUM and STGEN 1D hydraulic components were eliminated from TRAC-P by update PRGAST in Version 5.4.17 (i.e., before the base version of TRAC-M, 5.4.25, was created). This was done because an ACCUM component can be modeled by a PIPE component with the IACC option ON and modeled with more features. The STGEN-component coding was difficult to maintain and its heat-transfer calculation can be modeled by HTSTR components with more features and flexibility. Now the steam-generator primary-coolant side can be modeled with multiple PIPE and TEE components. Eliminating these two components purged 24 component-specific subroutines and reduced the TRAC-P Cray source-file size by 5.1% from 1.69 Mwords to 1.60 Mwords and Cray executable-file size by 3.0 % from 1.29 Mwords to 1.25 Mwords.

The detrimental effects from eliminating the ACCUM and STGEN components are:

1. an existing ACCUM component needs to be remodeled by a FILL and PIPE component with the FILL component defining the accumulator's PIPE-component no-flow, top-end boundary condition,

2. noncondensable gas that is only present in the accumulator and modeled as nitrogen and only evaluated in the ACCUM component now needs to be modeled and evaluated in all hydraulic components of the system model,

3. an existing STGEN component needs to be remodeled by three or more HTSTR, PIPE, and TEE components, and

4. the more implicit coupling of STGEN heat transfer and hydraulic flow (evaluated in the outer stage of the timestep calculation) now is explicitly coupled (with hydraulic flow evaluated in the outer stage and heat transfer evaluated in the post stage) [a procedure was programmed in TRAC-P Version 5.4.09 to control the timestep size so that the energy-exchange error between the heat-structure and hydraulic components is constrained below a user-defined POWERC level (Word 5 on Timestep Data Card 1)].

This appendix provides user guidance in dealing with items 1 and 3. While an automated procedure could have been programmed to convert ACCUM- and STGEN-component input data, it is better for the user to do it by hand with the following guidance. A model upgrade is possible then, which generally should be done. Only the user (not the computer) should make that decision.

J.1. Converting the ACCUM Component

The Westinghouse three-loop plant model's input-data TRACIN file in Appendix E has each loop's accumulator, originally modeled by an ACCUM component, now modeled by a FILL component and a PIPE component. We will use the conversion of this ACCUM

component to a FILL component and a PIPE component as an example. How such a conversion is done is easiest to understand when based on an example. Familiarity with the input data of each component is assumed. Only the conversion items that are not a direct equivalent or are of special significance will be discussed.

Consider ACCUM component 50 modeling the accumulator in loop 1 with the following 23 lines of component data.

```
**********************************************************************
*******    type             num             id        ctitle
accum                        50             50 $50$ accumulator 1
*         ncells           jun2        iconc
               5             52             1
*
* dx      *     1.48907e+0r02 1.4478e+00r02 7.44535e-1e
* vol     *     6.90931e00r02 1.00808e10    4.79015e00    2.15916e00e
* fa      *     5.0870e-02r03 6.96594e00    5.22446e00    5.0870e-02e
* kfac    * f   0.0000e+00e
* rkfac   * f   0.0000e+00e
* grav    * f  -1.0000e+00e
* hd      *     2.5451e-01r03 2.97814e00    2.57947e00    2.5451e-01e
* icflg   * f              0e
* nff     * f             -1e
* alp     *     1.0000e+00    5.0843e-01r03 0.0000e+00e
* vl      * f   0.0000e+00e
* vv      * f   0.0000e+00e
* tl      * f   3.2200e+02e
* tv      * f   3.2200e+02e
* p       * f   4.4471e+06e
* pa      * f   0.0000e+00e
* conc    * f   0.0000e+00e
```

ACCUM component 50 was converted to PIPE component 50 and a no-flow FILL component 49 boundary condition at the PIPE component's JUN1 = 49 junction with the following 48 lines of component data.

```
**********************************************************************
*******    type            num           id       ctitle
fill                        49           49 $49$ acc-1 bc
*           jun1          ifty         ioff
              49             2            0
*         twtold          rfmx       concin          felv
      0.0000e+00    1.0000e+20   0.0000e+00    0.0000e+00
*           dxin         volin        alpin          vlin          tlin
      1.0000e+00    5.0870e-02   0.0000e+00    0.0000e+00    5.4800e+02
*            pin          pain       flowin          vvin          tvin
      5.0000e+06    0.0000e+00   0.0000e+00    0.0000e+00    5.4800e+02
*
**********************************************************************
*******    type            num           id       ctitle
pipe                        50           50 $50$ accumulator 1
*         ncells         nodes         jun1          jun2          epsw
               5             1           49            52    1.0000e-04
*           ichf         iconc         iacc          ipow
               0             1            1             0
*         iqp3tr        iqp3sv       nqp3tb        nqp3sv        nqp3rf
               0             0            0             0             0
*          radin            th        houtl         houtv         toutl
      1.4890e+00    3.4900e-02   0.0000e+00    5.0000e+00    3.0000e+02
*          toutv         powin       powoff        rpowmx        powscl
      3.2200e+02    0.0000e+00   0.0000e+00    1.0000e+20    1.0000e+00
```

```
*          qp3in         qp3off          rqp3mx          qp3scl
     0.0000e+00    0.0000e+00     1.0000e+20     1.0000e+00
*
* dx      *      1.48907e+0r02 1.4478e+00r02 7.44535e-1e
* vol     *      6.90931e00r02 1.00808e10     4.79015e00     2.15916e00e
* fa      *      5.0870e-02r03 6.96594e00     5.22446e00     5.0870e-02e
* kfac    * f    0.0000e+00e
* rkfac   * f    0.0000e+00e
* grav    * f   -1.0000e+00e
* hd      *      2.5451e-01r03 2.97814e00     2.57947e00     2.5451e-01e
* icflg   * f             0e
* nff     * f            -1e
* alp     *      1.0000e+00    5.0843e-01r03 0.0000e+00e
* vl      * f    0.0000e+00e
* vv      * f    0.0000e+00e
* tl      * f    3.2200e+02e
* tv      * f    3.2200e+02e
* p       * f    4.4471e+06e
* pa      * r02 4.43542e06r03 0.0000e+00e
* qppp    * f    0.0000e+00e
* matid   * f             7e
* tw      * f    3.2200e+02e
* conc    * f    0.0000e+00e
```

ACCUM components 50, 60, and 70 from the three loops are defined identically and have only a JUN2 junction. This results in a no-flow condition on the other side of cell 1 from cell 2 because cell 1 has no JUN1 junction. The conversion of each ACCUM component has added a new component and a new junction to the system model. For the three ACCUM components, that means that both NCOMP and NJUN (Words 3 and 4 on Main-Data Card 4) need to be increased by 3, and the IORDER array needs FILL component numbers 49, 59, and 69 added to it.

FILL component 49 is a simple IFTY = 2 option constant mass flow FLOWIN = 0.0 kg s^{-1} no-flow boundary condition. Normally,

1. it's RFMX = 10^{20} kg s^{-2} maximum rate of mass-flow change should be 0.0 kg s^{-2} to be consistent with the IFTY = 2 constant mass flow option,

2. its fluid should be the same as (or similar to) cell 1 of PIPE component 50 [ALPIN = 0.0 ≠ ALP(1) = 1.0, TLIN = TVIN = 548.0 K (526.73°F) ≠ TL(1) = TV(1) = 322.0 K (119.93°F), PIN = 5.0 MPa (725.2 psia) ≠ P(1) = 4.4471 MPa (645.0 psia), PAIN = 0.0 MPa (0.0 psia) ≠ PA(1) = 4.43542 MPa (643.3 psia)], and

3. its cell size should be the same as cell 1 of PIPE component 50 (DXIN = 1.0 m (3.28 ft) ≠ DX(1) = 1.48907 m (4.8854 ft), VOLIN = 0.05087 m^3 (1.7965 ft^3) ≠ VOL(1) = 6.90931 m^3 (244.0 ft^3),

but none of these inappropriate input-data values have any effect because the mass-flow (velocity) boundary condition is zero. The appropriateness of items 2 and 3 is customary but not necessary.

The PIPE-component 50 array data are the same as the ACCUM-component 50 array data except for the noncondensable-gas partial pressure PA(1&2) = 4.43542 MPa (643.3

psia) not being 0.0 MPa (0.0 psia) and the wall heat-transfer input-data arrays QPPP, MATID and TW being defined. The gas phase in cells 1 and 2 of the PIPE is air (NAMELIST variable IGAS = 1, default) with water vapor at 100% humidity (where P(1&2) – PA(1&2) = 4.4471 MPa – 4.43542 MPa = 0.01168 MPa (1.694 psia) = $P_{SAT}(T_{SAT}$ = 322.0 K = 119.93°F). Cell 3 also has gas in the fraction 1.0–ALP(3) = 0.49157 of its volume, but it is 100% water vapor because PA(3) = 0.0 MPa. PA(3) should have been defined as 4.43542 MPa. The noncondensable-gas partial-pressure of air is evaluated because NAMELIST variable NOAIR = 0 is input specified. For the ACCUM component, however, the gas phase in cells 1, 2, and 3 is 100% nitrogen by definition and the noncondensable-gas partial-pressure of nitrogen (being the total pressure) is not evaluated because NOAIR = 1 by default. The user who converted the ACCUM component to a PIPE component chose to model water vapor at 100% humidity in the noncondensable gas and chose to model the noncondensable gas as air rather than nitrogen, but made an error in defining

```
            * pa      * r02 4.43542e06r03 0.0000e+00e
rather than * pa      * r03 4.43542e06r02 0.0000e+00e.
```

The gas phase in all three cells of the PIPE should be the same.

The PIPE-component 50 scalar data defines NODES = 1 for a one-node lumped-parameter heat-transfer calculation in the accumulator wall with convection heat transfer on the inner surface of the wall to the accumulator fluid. That is why wall heat-transfer calculation arrays QPPP, MATID and TW needed to be input for the PIPE. QPPP = 0.0 models no energy generation in the wall, MATID = 7 models the wall material as stainless steel type 316, and TW = 322.0 K (119.93°F) models the initial wall temperature to be the same as the accumulator fluid temperature. HOUTL = 0.0 W m^{-2} K^{-1} and HOUTV = 5.0 W m^{-2} K^{-1} (0.880551 Btu h^{-1} ft^{-2} $°F^{-1}$) model convection heat transfer to room air at a temperature of TOUTV = 322.0 K (119.93°F) on the outer surface of the accumulator wall. For the ACCUM component, however, an adiabatic (no heat transfer) boundary condition by definition is applied at the inner surface of its wall. The user who converted the ACCUM component to a PIPE component chose additionally to model convection and conduction heat transfer between the accumulator fluid and the room air and defined the air outside the accumulator to be unusually hot for room air.

In the same way that RFMX = 10^{20} kg s^{-2} was input for FILL component 49, RPOWMX = 10^{20} W s^{-1} for the maximum rate that no power is deposited in the liquid by the IPOW = 0 option and RQP3MX = 10^{20} W s^{-1} for the maximum rate that no energy is generated in the wall by QPPP = 0.0 are input for PIPE component 50. These maximum rates should be input as zero, to be consistent with their component actions being constant, rather than being input as the nonconstraining generic value of 10^{20}. Doing so, however, has no effect on the calculative results.

Wall drag on accumulator fluid flow is modeled by PIPE-component 50 with a wall-surface roughness of EPSW = 0.0001 m (0.000328 ft) effect on the NFF = –1 evaluated homogeneous-flow friction factor. NFF being negative valued results in TRAC-P internally evaluating cell-to-cell abrupt flow-area change irreversible form-loss K factors

for all interfaces of the PIPE. Wall drag and abrupt flow-area change form loss are not modeled by the ACCUM component.

The IACC = 1 option is defined in PIPE component 50 to apply the ACCUM interface-sharpener model and output the ACCUM-calculated water level, volumetric flow, and liquid-volume discharge parameters. Had the IACC = 2 option been selected, PIPE component 50 also would have modeled the ACCUM-component defined feature of not allowing gas-phase outflow at JUN2. After PIPE component 50 empties of liquid, the air/water-vapor gas phase will flow across the JUN2 interface, while ACCUM component 50 prevents such outflow of its nitrogen gas phase.

Converting ACCUM component 50 to FILL component 49 and PIPE component 50 has involved a number of remodeling decisions. Had a computer program performed the conversion, no such modeling changes would have been made. To the ACCUM-component model has been added 100%-humidity water vapor in the noncondensable gas, the evaluation of heat-transfer from the accumulator fluid to the room air, fluid-wall drag on its inner surface, and abrupt flow-area change form losses. Its noncondensable gas has been changed from nitrogen to air and the liquid-separator constraint preventing gas-phase outflow at JUN2 has been removed.

J.2. Converting the STGEN Component

The Westinghouse three-loop plant model's input-data TRACIN file in Appendix E has each loop's steam generator, originally modeled by a STGEN component, now modeled by 9 HTSTR, 2 PIPE, and 2 TEE components. The loop-2 steam generator is an exception where the single tube rupture requires modeling the 2 PIPEs by 2 TEEs and 2 no-flow FILLs for the steady-state calculation or by 2 TEEs and a connecting PIPE for the transient calculation. The 8 HTSTR components, through multiple hydraulic-component coupling, model 8 different heat-transfer paths in all 3 steam generators. That results in the 3 STGEN components being converted to 2 FILL, 11 HTSTR, 4 PIPE, and 8 TEE components in the steady-state calculation input-data TRACIN file of Appendix E. The 2 FILL components are replaced by 1 PIPE component to model the single tube-rupture flow path in the transient calculation.

The 3 HTSTR components that model primary- to secondary-coolant heat transfer through the steam-generator tube wall in the 3 steam generators also could have been modeled by a single HTSTR component. These HTSTR components model the tubes of separate steam generators in case, at some future time, a CSS type 5 controller is applied individually to each of the HTSTR components 910, 920, and 930 to provide separate control. In the Appendix E input-data model, CSS type 5 controllers were not applied during the steady-state calculation.

As was done for the ACCUM component in the previous section, we will use the conversion of the loop 1 STGEN component to 9 HTSTR, 2 PIPE, and 2 TEE components as an example. How such a conversion is done is easiest to understand when based on an example. Familiarity with the input data of each component is assumed. Only the conversion items that are not a direct equivalent or are of special significance will be

discussed. Remodeling decisions by the user have been kept to a minimum because of the complexity of doing an equivalent conversion.

Consider STGEN component 12 modeling the steam generator in loop 1 with the following 221 lines of component data.

```
***********************************************************************
*******    type              num              id        ctitle
stgen                         12              12 $12$ steam generator 1
*        ncell1            ntube           nodes         nscmp            epsw
             18               14               3             3     0.0000e+00
*         iconc            ichf1           jun11         jun12
              1                1              12            14
*         icnc2            ichf2
              1                1
*          junp             jclp            nclp          cosp
              0                0               0    0.0000e+00
*         nsjun
              5
*          nght             ndht
             28                3
*         qp3in
     0.0000e+00
*
*    secondary-component description
*         stype             ncls            nclt
pipe                           7               0
*
*         stype             ncls            nclt
tee                            6               4
*
*         stype             ncls            nclt
tee                           10               1
*
*    primary-side cell arrays
* dx     *      1.0668e+00    1.2192e+00r14 1.3320e+00    1.2192e+00    1.0668e+00
* dx     * e
* vol    *      1.4640e+00    2.8320e+00r14 1.2573e+00    2.8320e+00    1.4640e+00
* vol    * e
* fa     *      4.8695e-01    2.3226e+00r15 9.7818e-01    2.3226e+00    4.8695e-01
* fa     * e
* fric   *      5.0000e-01    0.0000e+00    3.0000e-01r13 1.3530e-02    1.0000e+00
* fric   *      0.0000e+00    2.0000e-01e
* rv fri*       2.0000e-01    0.0000e+00    3.0000e-01r13 1.3530e-02    1.0000e+00
* rv fri*       0.0000e+00    5.0000e-01e
* grav   *      7.6600e-01r08 1.0000e+00    0.0000e+00r08-1.0000e+00   -7.6600e-01
* grav   * e
* hd     *      7.8740e-01    1.4844e+00r15 1.9685e-02    1.4844e+00    7.8740e-01
* hd     * e
* icflg  * f             0e
* nff    * f             1e
* alp    * f    0.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     * f    5.9110e+02e
* tv     * f    5.9110e+02e
* p      * f    1.5500e+07e
* pa     * f    0.0000e+00e
* conc   * f    0.0000e+00e
*
*    internal pipe component 100, boiler region
*     jsint(1)      jsint(2)      jsint(3)          nums
          100           105             0            100
*
* dx     * f    1.3320e+00e
* vol    * r06 5.8490e+00     6.7440e+00e
```

```
* fa     *      2.8456e+00r06 4.4073e+00    4.2500e+00e
* fric   *      1.0000e+01r07 0.0000e+00e
* rv fri*       1.0000e+03r07 0.0000e+00e
* grav   *      0.0000e+00r07 1.0000e+00e
* hd     * r07 9.1200e-03    3.2410e+00e
* icflg * f             0e
* nff    * f             1e
* alp    * r05 0.0000e+00    7.5000e-01    1.0000e+00e
* vl     * f   0.0000e+00e
* vv     * f   0.0000e+00e
* tl     * f   5.4330e+02e
* tv     * f   5.4330e+02e
* p      * f   5.5158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
*    internal tee component 105, separator and steam dome
*     jsint(1)      jsint(2)      jsint(3)          nums
          105           190           110           105
*
*    main-cell arrays (separator region)
* dx     *      1.2440e+00    1.1670e+00    1.0910e+00r03 1.0000e+00e
* vol    *      7.6460e+00r02 4.5570e+00    5.6630e+00    7.3060e+00    8.9610e+00
* vol    * e
* fa     *      4.2500e+00r03 4.0320e+00    5.5740e+00    6.9880e+00    8.5590e+00
* fa     * e
* fric   * f   0.0000e+00e
* rv fri* f    0.0000e+00e
* grav   * r04 1.0000e+00r02 0.0000e+00   -1.0000e+00e
* hd     *      3.2410e+00r03 1.3080e+00    2.6640e+00    2.9780e+00    1.2070e+00
* hd     * e
* icflg * f             0e
* nff    * f             1e
* alp    * f   1.0000e+00e
* vl     * f   0.0000e+00e
* vv     * f   0.0000e+00e
* tl     * f   5.4330e+02e
* tv     * f   5.4330e+02e
* p      * f   5.5158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
*    side-cell arrays (steam dome)
*          coss          jclt
    0.0000e+00              5
*
* dx     *      1.0150e+00    9.3900e-01    7.0000e-01    2.3900e-01e
* vol    * r02 5.1080e+00    7.0000e+00    1.6220e+00e
* fa     * r02 5.0325e+00    6.0000e+00    6.7866e+00    1.2897e-01e
* fric   * f   0.0000e+00e
* rv fri* f    0.0000e+00e
* grav   * f   1.0000e+00e
* hd     *      4.3220e+00    3.4380e+00    2.0480e+00    1.0000e+00    6.0985e-01
* hd     * e
* icflg * r04          0             1e
* nff    * r04          1            -1e
* alp    * f   1.0000e+00e
* vl     * f   0.0000e+00e
* vv     * f   0.0000e+00e
* tl     * f   5.4330e+02e
* tv     * f   5.4330e+02e
* p      * f   5.5158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
*    internal tee component 190, downcomer
*     jsint(1)      jsint(2)      jsint(3)          nums
          190           100           185           190
```

```
*
*    main-cell arrays (downcomer annulus)
*
* dx     *      1.0910e+00    1.1670e+00    1.2440e+00r07 1.3320e+00e
* vol    * r02 9.7890e+00    7.5320e+00    2.7290e+00    8.0750e-01r05 7.0000e-01
* vol    * e
* fa     *      8.5590e+00r02 8.6600e+00    3.3610e+00    1.2350e+00r05 5.2120e-01
* fa     *      2.8456e+00e
* fric   * r02 0.0000e+00    1.0000e-01r02 3.0000e-01r05 0.0000e+00    1.0000e+01
* fric   * e
* rv fri* r02 0.0000e+00    2.0000e-01r02 6.0000e-01r05 0.0000e+00    1.0000e+03
* rv fri* e
* grav   * r10-1.0000e+00    0.0000e+00e
* hd     *      1.2070e+00r02 1.3750e+00    6.0000e-01    2.5280e-01r05 1.0912e-01
* hd     *      9.1200e-03e
* icflg  * f             0e
* nff    * f             1e
* alp    *      1.0000e+00    5.0000e-01r08 0.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     * f    4.9330e+02e
* tv     * f    4.9330e+02e
* p      * f    5.5158e+06e
* pa     * f    0.0000e+00e
* conc   * f    0.0000e+00e
*
*    side-cell arrays (feedwater inlet)
*           coss            jclt
    0.0000e+00              2
*
* dx     *      1.4570e+00e
* vol    *      1.4340e-01e
* fa     * f    9.8440e-02e
* fric   *      5.0000e-01    3.0000e-01e
* rv fri*       1.0000e+00    3.0000e-01e
* grav   *      0.0000e+00   -1.0000e+00e
* hd     * f    3.5400e-01e
* icflg  * f             0e
* nff    * f             1e
* alp    *      0.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     *      4.9330e+02e
* tv     *      4.9330e+02e
* p      *      5.5158e+06e
* pa     *      0.0000e+00e
* conc   *      0.0000e+00e
*
*    heat-conduction paths
*      9/18/83--includes wrapper and outer shell
*    10/29/83--includes tubesheet, lower plenum, and secondary dryer
* icmp   * r14          0r07          100r03         105r10         190r02          105
* icmp   * r04          0r02          105e
* icell  *                 3             4              5              6              7
* icell  *                 8             9             10             11             12
* icell  *                13            14             15             16              1
* icell  *                 2             3              4              5              6
* icell  *                 7             1              2              3             10
* icell  *                 9             8              7              6              5
* icell  *                 4             3              2              1              6
* icell  *                 9             3             17              1             18
* icell  *                 7             8e
* ocmp   * r14        100r10        190r16            0r02         105e
* ocell  *                 1             2              3              4              5
* ocell  *               6r02            7              6              5              4
* ocell  *                 3             2              1             10              9
* ocell  *                 8             7              6              5              4
* ocell  *                 3             2              1r12           0              2
```

```
* ocell *            16r02          0r02           5e
* matg  * r28        12r56          9e
* radig * r14 9.8400e-03r06 1.4821e+00    1.5513e+00    1.0668e+00r02 .5380e-01
* radig * r06 1.5462e+00    1.7742e+00    1.9749e+00r04 2.0193e+00r02 1.9680e-02
* radig * r02 1.5045e+00r02 3.0480e+00e
* thg   * r14 1.2700e-03r10 9.5250e-03r06 6.6550e-02r02 9.1950e-02r04 8.8900e-02
* thg   * r02 6.6800e-03r02 2.3165e-01r02 6.3500e-03e
* qppg  * r99 0.0000e+00r27 0.0000e+00e
* twgn  * r99 5.4330e+02r27 5.4330e+02e
* hilg  * f   0.0000e+00e
* hivg  * f   0.0000e+00e
* tilg  * f   5.9110e+02e
* tivg  * f   5.9110e+02e
* waig  * r14 2.5548e+02    9.5653e+00r05 1.2404e+01    1.2983e+01    1.3646e+01
* waig  *     1.4386e+01    1.3448e+01r06 1.2940e+01    1.4848e+01    1.5431e+01
* waig  *     1.4812e+01    1.3844e+01    1.5771e+01    2.0000e+01r02 1.1100e+02
* waig  * r02 7.1070e+00r02 1.1020e+02e
* holg  * f   0.0000e+00e
* hovg  * f   0.0000e+00e
* tolg  * f   3.0000e+02e
* tovg  * f   3.0000e+02e
* waog  * r14 2.8845e+02    9.6266e+00r05 1.2483e+01    1.3063e+01    1.3889e+01
* waog  *     1.4596e+01    1.3644e+01r06 1.3497e+01    1.5618e+01    1.6149e+01
* waog  *     1.5464e+01    1.4454e+01    1.6466e+01    2.0880e+01r02 1.4870e+02
* waog  * r02 8.2010e+00r02 1.1040e+02e
```

STGEN component 12 was converted to PIPE components 12 and 100, TEE components 105 and 190, and HTSTR components 910 and 931 to 938 with the following 517 lines of component data.

```
***********************************************************************
*******     type            num             id        ctitle
pipe                         12             12 $12$ steam-gen primary 1
*          ncells         nodes           jun1          jun2          epsw
               18             0             12            14    0.0000e+00
*            ichf         iconc           iacc          ipow
                1             1              0             0
*           radin            th          houtl         houtv         toutl
       9.8400e-03    1.2700e-03     0.0000e+00    0.0000e+00    3.0000e+02
*           toutv         powin         powoff        rpowmx        powscl
       3.0000e+02    0.0000e+00     0.0000e+00    0.0000e+00    0.0000e+00
*
* dx    *     1.0668e+00    1.2192e+00r14 1.3320e+00    1.2192e+00    1.0668e+00
* dx    * e
* vol   *     1.4640e+00    2.8320e+00r14 1.2573e+00    2.8320e+00    1.4640e+00
* vol   * e
* fa    *     4.8695e-01    2.3226e+00r15 9.4392e-01    2.3226e+00    4.8695e-01
* fa    * e
* kfac  *     5.0000e-01    0.0000e+00    3.0000e-01r13 1.3530e-02    0.5000e+00
* kfac  *     0.0000e+00    2.0000e-01e
* rkfac *     2.0000e-01    0.0000e+00    3.0000e-01r13 1.3530e-02    0.5000e+00
* rkfac *     0.0000e+00    5.0000e-01e
* grav  *     7.6600e-01r08 1.0000e+00    0.0000e+00r08-1.0000e+00   -7.6600e-01
* grav  * e
* hd    *     7.8740e-01    1.4844e+00r15 1.9685e-02    1.4844e+00    7.8740e-01
* hd    * e
* icflg * f            0e
* nff   * f            1e
* alp   * f   0.0000e+00e
* vl    * f   0.0000e+00e
* vv    * f   0.0000e+00e
* tl    * r09 5.9110e+02r09 5.5910e+02e
* tv    * r09 5.9110e+02r09 5.5910e+02e
* p     * f   1.5500e+07e
* pa    * f   0.0000e+00e
* conc  * f   0.0000e+00e
```

```
*
************************************************************************
*******    type               num              id        ctitle
pipe                          100             100 $100$ steam-gen boiler 1
*       ncells             nodes            jun1          jun2          epsw
                 7             0             100           105    0.0000e+00
*         ichf             iconc            iacc          ipow
                 1             1               0             0
*        radin                th           houtl         houtv         toutl
    1.4821e+00    9.5250e-03      0.0000e+00    0.0000e+00    3.0000e+02
*        toutv             powin          powoff        rpowmx        powscl
    3.0000e+02    0.0000e+00      0.0000e+00    0.0000e+00    0.0000e+00
*
* dx     * f    1.3320e+00e
* vol    * r06 5.8490e+00     6.7440e+00e
* fa     *      2.8456e+00r06 4.3911e+00     4.2500e+00e
* kfac   *      2.1500e+02r07 0.0000e+00e
* rkfac  *      1.0000e+03r07 0.0000e+00e
* grav   *      0.0000e+00r07 1.0000e+00e
* hd     * r07 9.1200e-03     3.2410e+00e
* icflg  * f             0e
* nff    * f             1e
* alp    * r05 0.0000e+00     5.0000e-01     1.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     * f    5.4211e+02e
* tv     * f    5.4212e+02e
* p      * f    5.4158e+06e
* pa     * f    0.0000e+00e
* conc   * f    0.0000e+00e
*
************************************************************************
*******    type               num              id        ctitle
tee                           105             105 $105$ separator & dome 1
*        jcell             nodes            ichf          cost          epsw
                 6             0               1    0.0000e+00    0.0000e+00
*       iconc1            ncell1            jun1          jun2         ipow1
                 1             8             105           190             0
*       radin1               th1          houtl1        houtv1        toutl1
    6.5380e-01    9.5250e-03      0.0000e+00    0.0000e+00    3.0000e+02
*       toutv1             pwin1          pwoff1        rpwmx1        pwscl1
    3.0000e+02    0.0000e+00      0.0000e+00    0.0000e+00    0.0000e+00
*       iconc2            ncell2            jun3         ipow2
                 1             4             110             0
*       radin2               th2          houtl2        houtv2        toutl2
    2.0193e+00    8.8900e-02      0.0000e+00    0.0000e+00    3.0000e+02
*       toutv2             pwin2          pwoff2        rpwmx2        pwscl2
    3.0000e+02    0.0000e+00      0.0000e+00    0.0000e+00    0.0000e+00
*
* main-cell arrays (separator region)
* dx     *      1.2440e+00    1.1670e+00     1.0910e+00    1.0000e+00r03 3.3333e-01
* dx     *      1.0000e+00e
* vol    *      7.6460e+00r02 4.5570e+00     5.6630e+00r03 2.4353e+00     8.9610e+00
* vol    * e
* fa     *      4.2500e+00r03 4.0320e+00     5.5740e+00r02 7.3060e+00     6.9880e+00
* fa     *      8.5590e+00e
* kfac   * f    0.0000e+00e
* rkfac  * f    0.0000e+00e
* grav   * r04 1.0000e+00r04 0.0000e+00    -1.0000e+00e
* hd     *      3.2410e+00r03 1.3080e+00     2.6640e+00r02 2.8210e+00     2.9780e+00
* hd     *      1.2070e+00e
* icflg  * f             0e
* nff    * f             1e
* alp    * f    1.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     * f    5.4211e+02e
* tv     * f    5.4212e+02e
```

```
* p      * f   5.4158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
* side-cell arrays (steam dome)
* dx     *     1.0150e+00    9.3900e-01    7.0000e-01    2.3900e-01e
* vol    * r02 5.1080e+00    7.0000e+00    1.6220e+00e
* fa     * r02 5.0325e+00    6.0000e+00    6.7866e+00    1.2897e-01e
* kfac   * r02 1.0000e-10r03 0.0000e+00e
* rkfac  * r02 1.0000e-10r03 0.0000e+00e
* grav   * f   1.0000e+00e
* hd     *     4.3220e+00    3.4380e+00    2.0480e+00    1.0000e+00    6.0985e-01
* hd     * e
* icflg  * r04          0             1e
* nff    * r04          1            -1e
* alp    * f   1.0000e+00e
* vl     * f   0.0000e+00e
* vv     * f   0.0000e+00e
* tl     * f   5.4211e+02e
* tv     * f   5.4212e+02e
* p      * f   5.4158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
*************************************************************************
*******    type          num            id       ctitle
tee                      190           190 $190$ steam-gen downcomer 1
*         jcell        nodes          ichf          cost          epsw
              3            0             1    0.0000e+00    0.0000e+00
*        iconc1       ncell1          jun1          jun2         ipow1
              1           12           190           100             0
*        radin1          th1        houtl1        houtv1        toutl1
     1.0920e-01   3.8040e-02    0.0000e+00    0.0000e+00    3.0000e+02
*        toutv1        pwin1        pwoff1        rpwmx1        pwscl1
     3.0000e+02   0.0000e+00    0.0000e+00    0.0000e+00    0.0000e+00
*        iconc2       ncell2          jun3         ipow2
              1            1           185             0
*        radin2          th2        houtl2        houtv2        toutl2
     1.7700e-01   2.6200e-02    0.0000e+00    0.0000e+00    3.0000e+02
*        toutv2        pwin2        pwoff2        rpwmx2        pwscl2
     3.0000e+02   0.0000e+00    0.0000e+00    0.0000e+00    0.0000e+00
*
* main-cell arrays (downcomer annulus)
* dx     *     1.0910e+00r03 3.8900e-01    1.2440e+00r07 1.3320e+00e
* vol    *     9.7890e+00r03 3.2630e+00    7.5320e+00    2.7290e+00    8.0750e-01
* vol    * r05 7.0000e-01e
* fa     *     8.5590e+00    8.6600e+00r02 8.3882e+00    8.6600e+00    3.3610e+00
* fa     *     1.2350e+00r05 5.2120e-01    2.8456e+00e
* kfac   * r04 0.0000e+00    1.0000e-01r02 3.0000e-01r05 0.0000e+00    2.1500e+02
* kfac   * e
* rkfac  * r04 0.0000e+00    2.0000e-01r02 6.0000e-01r05 0.0000e+00    1.0000e+03
* rkfac  * e
* grav   * r12-1.0000e+00    0.0000e+00e
* hd     *     1.2070e+00r04 1.3750e+00    6.0000e-01    2.5280e-01r05 1.0912e-01
* hd     *     9.1200e-03e
* icflg  * f            0e
* nff    * f            1e
* alp    * r04 1.0000e+00    7.2195e-01r07 0.0000e+00e
* vl     * f   0.0000e+00e
* vv     * f   0.0000e+00e
* tl     * f   4.9330e+02e
* tv     * f   4.9330e+02e
* p      * f   5.4158e+06e
* pa     * f   0.0000e+00e
* conc   * f   0.0000e+00e
*
* side-cell arrays (feedwater inlet)
* dx     *     1.4569e+00e
```

```
* vol    *      1.4340e-01e
* fa     * f    9.8430e-02e
* kfac   *      5.0000e-01    3.0000e-01e
* rkfac  *      1.0000e+00    3.0000e-01e
* grav   *      0.0000e+00   -1.0000e+00e
* hd     * f    3.5400e-01e
* icflg  * f            0e
* nff    * f            1e
* alp    *      0.0000e+00e
* vl     * f    0.0000e+00e
* vv     * f    0.0000e+00e
* tl     *      4.8870e+02e
* tv     *      4.8870e+02e
* p      *      5.4158e+06e
* pa     *      0.0000e+00e
* conc   *      0.0000e+00e
*
**********************************************************************
*******    type              num            id       ctitle
rod                          910           910 $910$ st-gen-1 tube bundle
*              ncrx          ncrz          ittc          iext          m1d
                  1            14             0             0            0
*            nopowr         nridr         modez        liqlev       iaxcnd
                  1             0             1             0            1
*             idbci         idbco          hdri          hdro
                  2             2    1.9680e-02    2.2220e-02
*             nrods         nodes         irftr         nzmax       irftr2
                  1             3             0            15            0
*         dtxht(1)      dtxht(2)         dznht         hgapo        shelv
         3.0000e+00    1.0000e+01    5.0000e-03    0.0000e+00   0.0000e+00
*
* nhcomi* f            12e
* nhceli*              -3             3             4             5             6
* nhceli*               7             8             9            10            11
* nhceli*              12            13            14            15            16
* nhceli*             17e
* nhcomo* f          100e
* nhcelo*              -1             1             2             3             4
* nhcelo*               5             6             7            -7            -6
* nhcelo*              -5            -4            -3            -2            -1
* nhcelo*             -1e
* dz     * f    1.3320e+00e
* grav   * r07 1.0000e+00r07-1.0000e+00e
* rdx    *      3.1022e+03e
* radrd  *      9.8400e-03    1.0475e-02    1.1110e-02e
* matrd  * f            12e
* nfax   * f            0e
* rftn   * f    5.4211e+02e
*
**********************************************************************
*******    type              num            id       ctitle
slab                         931           931 $931$ st-gen-1,2,3 wrapper
*              ncrx          ncrz          ittc          iext          m1d
                  3            12             0             0            1
*            nopowr         nridr         modez        liqlev       iaxcnd
                  1             0             1             0            1
*             idbci         idbco          hdri          hdro
                  2             2    2.9642e+00    2.9832e+00
*             width        ipatch
         9.34215e00             0
*             nrods         nodes         irftr         nzmax       irftr2
                  3             3             0            25            0
*         dtxht(1)      dtxht(2)         dznht         hgapo        shelv
         3.0000e+00    1.0000e+01    5.0000e-03    0.0000e+00   0.0000e+00
*
* nhcomi* r08         100r06         105e
* nhceli*              -1             1             2             3             4
* nhceli*               5             6             7             1             2
```

```
* nhceli*            2           2           3            4e
* nhcomo* f        190e
* nhcelo*           12         -12         -11          -10          -9
* nhcelo*           -8          -7          -6           -5          -4
* nhcelo*           -3          -2          -1           -1e
* nhcomi* r08      200r06      205e
* nhceli*           -1           1           2            3           4
* nhceli*            5           6           7            1           2
* nhceli*            2           2           3            4e
* nhcomo* f        290e
* nhcelo*           12         -12         -11          -10          -9
* nhcelo*           -8          -7          -6           -5          -4
* nhcelo*           -3          -2          -1           -1e
* nhcomi* r08      300r06      305e
* nhceli*           -1           1           2            3           4
* nhceli*            5           6           7            1           2
* nhceli*            2           2           3            4e
* nhcomo* f        390e
* nhcelo*           12         -12         -11          -10          -9
* nhcelo*           -8          -7          -6           -5          -4
* nhcelo*           -3          -2          -1           -1e
* dz    *      1.0272e+00r05 1.3320e+00   1.39399e00   1.46717e00r03 5.1689e-01
* dz    *      1.44969e00e
* grav  * f    1.0000e+00e
* rdx   * f    1.0000e+00e
* radrd *      0.0000e+00   4.7625e-03   9.5250e-03e
* matrd * f             9e
* nfax  * f             0e
* rftn  * f    5.4211e+02e
* rftn  * f    5.4211e+02e
* rftn  * f    5.4211e+02e
*
**********************************************************************
*******   type            num           id        ctitle
rod                       932          932 $932$ st-gen-1,2,3 l.o.shell
*           ncrx         ncrz         ittc          iext          m1d
               3            6            0             0            2
*         nopowr        nridr        modez        liqlev       iaxcnd
               1            0            1             0            1
*          idbci        idbco         hdri          hdro
               2            1   3.0924e+00    0.0000e+00
*            tlo          tvo          hlo           hvo
      3.0000e+02   3.0000e+02   0.0000e+00    0.0000e+00
*          nrods        nodes        irftr         nzmax       irftr2
               3            3            0             8            0
*      dtxht(1)     dtxht(2)        dznht         hgapo        shelv
      3.0000e+00   1.0000e+01   5.0000e-03    0.0000e+00    0.0000e+00
*
* nhcomi* f        190e
* nhceli*           12         -12         -11          -10          -9
* nhceli*           -8          -7          -7e
* nhcomi* f        290e
* nhceli*           12         -12         -11          -10          -9
* nhceli*           -8          -7          -7e
* nhcomi* f        390e
* nhceli*           12         -12         -11          -10          -9
* nhceli*           -8          -7          -7e
* dz    * f    1.3320e+00e
* grav  * f    1.0000e+00e
* rdx   * f    1.0000e+00e
* radrd *      1.5462e+00   1.5795e+00   1.6127e+00e
* matrd * f             9e
* nfax  * f             0e
* rftn  * f    5.4211e+02e
* rftn  * f    5.4211e+02e
* rftn  * f    5.4211e+02e
*
**********************************************************************
```

```
*******    type              num              id         ctitle
rod                           933             933 $933$ st-gen-1,2,3 u.o.shell
*          ncrx             ncrz            ittc           iext          m1d
              3                8               0              0            3
*        nopowr            nridr           modez         liqlev       iaxcnd
              1                0               1              0            1
*         idbci            idbco            hdri           hdro
              2                1      4.0386e+00     0.0000e+00
*           tlo              tvo             hlo            hvo
     3.0000e+02       3.0000e+02      0.0000e+00     0.0000e+00
*         nrods            nodes           irftr          nzmax       irftr2
              3                3               0             17            0
*     dtxht(1)         dtxht(2)           dznht          hgapo        shelv
     3.0000e+00       1.0000e+01      5.0000e-03     0.0000e+00   0.0000e+00
*
* nhcomi* r07         190r03         105e
* nhceli*                 6            -6              -5             -4            -3
* nhceli*                -2            -1               8             12            12
* nhceli* e
* nhcomi* r07         290r03         205e
* nhceli*                 6            -6              -5             -4            -3
* nhceli*                -2            -1               8             12            12
* nhceli* e
* nhcomi* r07         390r03         305e
* nhceli*                 6            -6              -5             -4            -3
* nhceli*                -2            -1               8             12            12
* nhceli* e
* dz      *     1.17032e00     1.21665e00r03 3.8900e-01     1.0910e+00     1.2430e+00
* dz      *     1.5763e+00e
* grav    * f   1.0000e+00e
* rdx     * f   1.0000e+00e
* radrd   *     2.0193e+00     2.0637e+00     2.1082e+00e
* matrd   * f           9e
* nfax    * f           0e
* rftn    * f   5.4211e+02e
* rftn    * f   5.4211e+02e
* rftn    * f   5.4211e+02e
*
**********************************************************************
*******    type              num              id         ctitle
rod                           934             934 $934$ st-gen-1,2,3 i.t.sheet
*          ncrx             ncrz            ittc           iext          m1d
              3                1               0              0            4
*        nopowr            nridr           modez         liqlev       iaxcnd
              1                0               1              0            0
*         idbci            idbco            hdri           hdro
              2                2      3.9360e-02     5.2720e-02
*         nrods            nodes           irftr          nzmax       irftr2
              3                3               0              8            0
*     dtxht(1)         dtxht(2)           dznht          hgapo        shelv
     3.0000e+00       1.0000e+01      5.0000e-03     0.0000e+00   0.0000e+00
*
* nhcomi* f            12e
* nhceli*              -3             3              3e
* nhcomo* f            12e
* nhcelo*              -2             2              2e
* nhcomi* f            22e
* nhceli*              -3             3              3e
* nhcomo* f            22e
* nhcelo*              -2             2              2e
* nhcomi* f            32e
* nhceli*              -3             3              3e
* nhcomo* f            32e
* nhcelo*              -2             2              2e
* dz      * f   1.0000e+00e
* grav    * f   0.0000e+00e
* rdx     * f   8.9767e+02e
* radrd   *     1.9680e-02     2.3020e-02     2.6360e-02e
* matrd   * f           9e
```

```
* nfax   * f          0e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
*
*************************************************************************
******* type              num              id        ctitle
rod                        935             935 $935$ st-gen-1,2,3 o.t.sheet
*          ncrx           ncrz            ittc            iext           m1d
              3              1               0               0             5
*        nopowr          nridr           modez          liqlev        iaxcnd
              1              0               1               0             0
*         idbci          idbco            hdri            hdro
              2              2      3.9360e-02      5.2720e-02
*         nrods          nodes           irftr           nzmax        irftr2
              3              3               0               8             0
*      dtxht(1)       dtxht(2)           dznht           hgapo         shelv
     3.0000e+00     1.0000e+01      5.0000e-03      0.0000e+00    0.0000e+00
*
* nhcomi* f           12e
* nhceli*             16           -16            -16e
* nhcomo* f           12e
* nhcelo*             17           -17            -17e
* nhcomi* f           22e
* nhceli*             16           -16            -16e
* nhcomo* f           22e
* nhcelo*             17           -17            -17e
* nhcomi* f           32e
* nhceli*             16           -16            -16e
* nhcomo* f           32e
* nhcelo*             17           -17            -17e
* dz     * f   1.0000e+00e
* grav   * f   0.0000e+00e
* rdx    * f   8.9767e+02e
* radrd  *     1.9680e-02     2.3020e-02     2.6360e-02e
* matrd  * f          9e
* nfax   * f          0e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
*
*************************************************************************
******* type              num              id        ctitle
rod                        936             936 $936$ st-gen-1,2,3 i.plenum
*          ncrx           ncrz            ittc            iext           m1d
              3              1               0               0             6
*        nopowr          nridr           modez          liqlev        iaxcnd
              1              0               1               0             0
*         idbci          idbco            hdri            hdro
              2              1      3.0090e+00      0.0000e+00
*           tlo            tvo             hlo             hvo
     3.0000e+02     3.0000e+02      0.0000e+00      0.0000e+00
*         nrods          nodes           irftr           nzmax        irftr2
              3              3               0               8             0
*      dtxht(1)       dtxht(2)           dznht           hgapo         shelv
     3.0000e+00     1.0000e+01      5.0000e-03      0.0000e+00    0.0000e+00
*
* nhcomi* f           12e
* nhceli*             -1             1              1e
* nhcomi* f           22e
* nhceli*             -1             1              1e
* nhcomi* f           32e
* nhceli*             -1             1              1e
* dz     * f   7.5182e-01e
* grav   * f   1.0000e+00e
* rdx    * f   1.0000e+00e
* radrd  *     1.5045e+00     1.6203e+00     1.7361e+00e
* matrd  * f          9e
```

```
* nfax   * f           0e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
*
*************************************************************************
*******   type               num              id       ctitle
rod                          937             937 $937$ st-gen-1,2,3 o.plenum
*          ncrx             ncrz            ittc          iext           m1d
              3                1               0             0             7
*        nopowr            nridr           modez        liqlev        iaxcnd
              1                0               1             0             0
*         idbci            idbco            hdri          hdro
              2                1      3.0090e+00    0.0000e+00
*           tlo              tvo             hlo           hvo
     3.0000e+02       3.0000e+02      0.0000e+00    0.0000e+00
*         nrods            nodes           irftr        nzmax        irftr2
              3                3               0             3             0
*     dtxht(1)         dtxht(2)           dznht         hgapo         shelv
     3.0000e+00       1.0000e+01      5.0000e-03    0.0000e+00    0.0000e+00
*
* nhcomi* f          12e
* nhceli*            18             -18           -18e
* nhcomi* f          22e
* nhceli*            18             -18           -18e
* nhcomi* f          32e
* nhceli*            18             -18           -18e
* dz     * f   7.5182e-01e
* grav   * f   1.0000e+00e
* rdx    * f   1.0000e+00e
* radrd  *     1.5045e+00    1.6203e+00    1.7361e+00e
* matrd  * f           9e
* nfax   * f           0e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
* rftn   * f   5.4211e+02e
*
*************************************************************************
*******   type               num              id       ctitle
rod                          938             938 $938$ st-gen-1,2,3 sec.dryer
*          ncrx             ncrz            ittc          iext           m1d
              3                2               0             0             8
*        nopowr            nridr           modez        liqlev        iaxcnd
              1                0               1             0             1
*         idbci            idbco            hdri          hdro
              2                2      6.0960e+00    6.1087e+00
*         nrods            nodes           irftr        nzmax        irftr2
              3                3               0             8             0
*     dtxht(1)         dtxht(2)           dznht         hgapo         shelv
     3.0000e+00       1.0000e+01      5.0000e-03    0.0000e+00    0.0000e+00
*
* nhcomi* f         105e
* nhceli*            -9               9            10           10e
* nhcomo* f         105e
* nhcelo*            -6               6             6            6e
* nhcomi* f         205e
* nhceli*            -9               9            10           10e
* nhcomo* f         205e
* nhcelo*            -6               6             6            6e
* nhcomi* f         305e
* nhceli*            -9               9            10           10e
* nhcomo* f         305e
* nhcelo*            -6               6             6            6e
* dz     * f   5.7542e+00e
* grav   * f   0.0000e+00e
* rdx    * f   1.0000e+00e
* radrd  *     3.0480e+00    3.0512e+00    3.0543e+00e
* matrd  * f           9e
```

```
514 * nfax   * f          0e
515 * rftn   * f    5.4211e+02e
516 * rftn   * f    5.4211e+02e
517 * rftn   * f    5.4211e+02e
```

PIPE components 12 and 100 and TEE components 105 and 190 are equivalent (except for one change) to their internal components of STGEN component 12 and have the same component numbers. The primary-coolant PIPE of STGEN component 12 has become PIPE component 12. The internal 1D hydraulic components unfold from the STGEN component with direct transfer of their array data to their separate components.

Only one change was made to TEE components 105 and 190. The TEE-component JCELL guideline of modeling no flow-area change between JCELL–1 and JCELL+1 was applied. Both TEE components violated this guideline in their STGEN defining form. JCELL = 5 in steam-dome TEE component 105, and JCELL = 2 in downcomer TEE component 190, were divided into 3 equal-size cells 5, 6, and 7 with JCELL = 6 in TEE component 105 and cells 2, 3, and 4 with JCELL = 3 in TEE component 190. All subsequent cell and interface numbers in both TEE components were increased by 2. This is shown in Fig. J-1 for the loop 1 remodeled TEE components from STGEN component 12.

The scalar data will need to be reorganized into the appropriate format of each 1D hydraulic component. Most of that scalar data are already defined by the STGEN component with different variable names. In the STGEN scalar data, if the primary-coolant flow channel has NCLP = 0 side-tube cells specified, JUN11, JUN12, and NCELL1 defines JUN1, JUN2, and NCELLS, respectively, of the primary-coolant PIPE. If NCLP > 0, JUN11, JUN12, JUNP, NCELL1, NCLP, JCLP, and COSP define JUN1, JUN2, JUN3, NCELL1, NCELL2, JCELL, and COST, respectively, of the primary-coolant TEE. The component number of this primary-coolant PIPE or TEE is assigned the component number of the STGEN. The NSCMP (Word 4 on Card Number 2) sets of secondary-component description parameters STYPE, NCLS, and NCLT on STGEN-data lines 21, 24, and 27 and their corresponding JSINT(1), JSINT(2), JSINT(3), and NUMS parameters on lines 57, 79, and 128 define: the secondary-side component type; NCELLS for a PIPE or NCELL1 for a TEE when NCLT > 0 and NCELL2 for a TEE; JUN1, JUN2, and JUN3 for a TEE; and the component number for each of the secondary-coolant PIPE or TEE components, respectively.

Because PIPE- and TEE-component wall heat transfer is not modeled as such by the STGEN component, NODES = 0 was defined for no wall heat transfer in the extracted PIPE and TEE components. This resulted in arrays QPPP, MATID, and TW not needing to be added to the array data and HOUTL = 0.0 W m^{-2} K^{-1}, and HOUTV = 0.0 W m^{-2} K^{-1} being defined in the scalar data. Power deposited in the liquid coolant was not modeled by a STGEN component, and so IPOW = 0 in the PIPE and IPOW1 = 0 and IPOW2 = 0 in the TEE components were defined.

The NSCMP (Word 4 on Card Number 2) internal 1D hydraulic components, their internal junctions, and the NTUBE + NGHT (Word 2 on Card Number 2 and Word 1 on Card Number 7) heat-transfer paths (to be modeled by HTSTR components) of a STGEN component are not counted as part of the NCOMP total number of components and

NJUN total number of junctions (Words 3 and 4 on Main-Data Card 4) of the system model. Converting STGEN components to HTSTR, PIPE, and TEE components will require that they be counted as part of NCOMP and NJUN. Component numbers, other than the STGEN component number that becomes the primary-coolant PIPE or TEE component number, will need to be added to the IORDER array of NCOMP component numbers. These changes are made in the transient-restart as well as steady-state calculation input-data TRACIN files.

Each STGEN heat-transfer path is a single-hydraulic-cell to single-hydraulic-cell convection-conduction-convection heat-transfer path through a two-sided structure. ICMP(I) and ICELL(I) define the hydraulic component number and cell number contacting the inner surface, and OCMP(I) and OCELL(I) define the hydraulic component number and cell number contacting the outer surface of heat-transfer path I. MATG(I) defines the structure material number, and RADIG(I) and THG(I) define the inner radius and thickness of the structure's annular cross-section in cylindrical geometry. STGEN heat-transfer paths whose material number and geometry dimensions are the same can be remodeled by a single HTSTR component. This also can be done even when RADIG(I) changes among heat-transfer paths I as long as RADIG(I) >> TH(I), the structure material and its thickness are the same, and the average heat-transfer surface area is conserved.

In STGEN component 12, NTUBE + NGHT = 14 + 28 = 42 heat-transfer paths were modeled. They have been remodeled by 9 HTSTR components as shown in Fig. J-1 for the loop 1 steam generator. First, consider the NTUBE = 14 heat-transfer paths between 14 primary-coolant cells and 14 secondary-coolant cells through the steam-generator tube wall that have been remodeled by a single HTSTR component 910. All 14 paths have the same tube material, tube inner radius, and wall thickness so they could be modeled by one HTSTR component. HTSTR component 910 has NCRZ = 14 axial intervals modeling each of those 14 paths, but evaluates 15 radial node rows with 2D radial and axial (IAXCND = 1) conduction heat-transfer coupling along cell edges. The STGEN component evaluates only radial-direction conduction that is cell centered in each heat-transfer path. This results in a difference in the numerical heat-transfer calculation even when axial conduction heat transfer is not evaluated (IAXCND = 0). The process of remodeling these STGEN heat-transfer paths with a HTSTR component, however, is physically equivalent when STGEN heat-transfer paths become HTSTR axial intervals. The axial length of the primary- and secondary-coolant cells defines the DZ axial intervals of HTSTR component 910. The RDX total number of physical-tube ROD elements is determined by dividing the WAIG(I) total inner-surface area of each I = 1 to 14 heat-transfer path by the inner-surface area of a single tube in that axial interval, i.e., RDX = WAIG(I) / [PI * 2.0 * RADIG(I) * DZ(I)] = 255.48 m^2 / [3.1415926 * 2.0 * 0.00984 m /tube * 1.332 m] = 3102.2 tubes. NODES = 3 radial nodes are modeled by both the STGEN and HTSTR as are other variables such as MATG(I) = 12 = MATRD and THG(I) = 0.00127 m = RADRD(NODES) – RADRD(1) that are defined equivalently.

(Note: Heat structure component numbers are for the loop-1 steam generator) where SLAB 931 and RODs 932 to 938 are for the NCRX = 3 first element ROD/SLAB

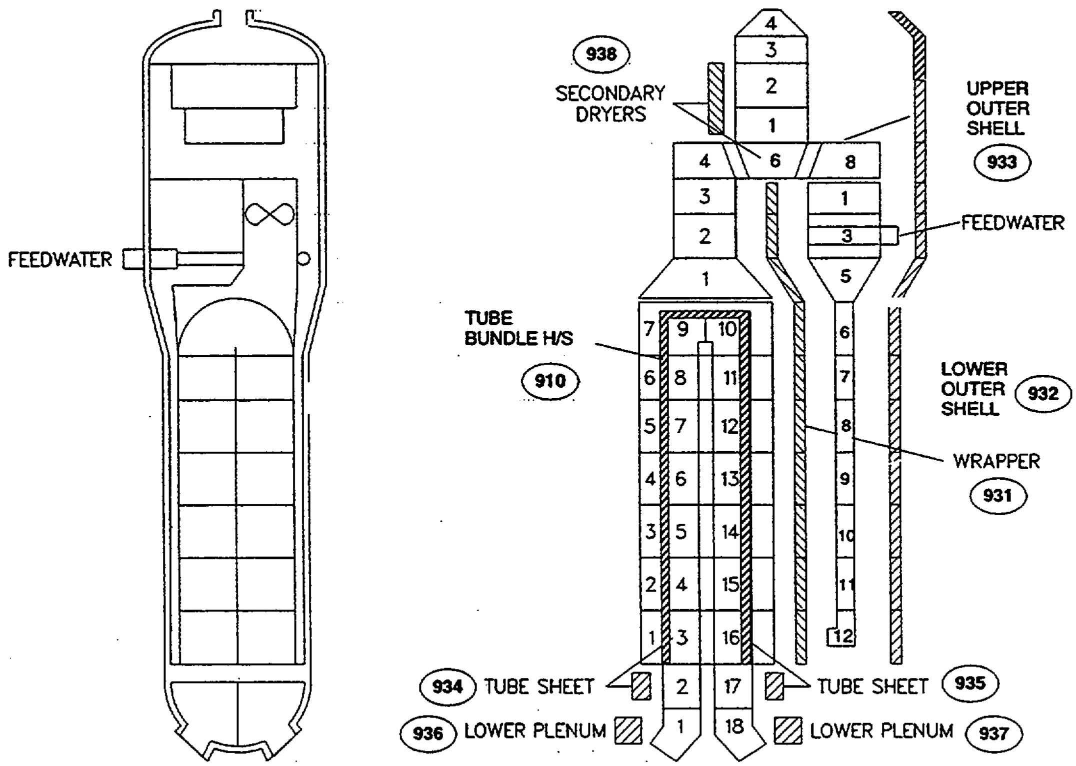

Fig. J-1 Hydraulic-cell noding and heat-transfer path diagram for the Westinghouse three-loop plant steam generators.

The numerical sign of NHCELO(J+1) input for HTSTR component 910 requires special consideration because of the U-tube design of the steam generator. See the NHCELI(I) and NHCELO(I) array descriptions in Section 6.3.3. Heat-transfer paths I = 1 to 7 = J and secondary-coolant cells J = 1 to 7 lie between node rows I and I+1. Node row I+1 and secondary-coolant cell J's larger interface number J+1 are at the same location so NHCELO(I+1) for outer-surface coupling to secondary-coolant PIPE component 100 is defined with a positive-value cell J number, i.e., NHCELO(I+1) = +J for I = 1 to 7 = J. Heat-transfer paths I = 8 to 14 = 15–J and secondary-coolant cells J = 7 to 1 lie between node rows I and I+1. Node row I+1 and secondary-coolant cell J's smaller interface number J are at the same location so NHCELO(I+1) is defined with a negative-value cell J number: i.e., NHCELO(I+1) = –J for I=8 to 14 = 15–J. NHCELO(1) = –1 is input because node row 1 and the smaller interface number of cell 1 are at the same location. NHCELO(16) = –1 is input but has no defining form because there are only 15 node rows. TRAC–M internally redefines the input values of NHCELO(1) and NHCELO(16). NHCELI(I) for inner-surface coupling to primary-coolant PIPE component 12 has the

NHCEL(I+1) = +J = I+2 defining form because node row I+1 and the larger interface number of cell J = I+2 are at the same location. NHCELI(1) = –3 is input because node row 1 and the smaller interface number of cell 3 are at the same location.

The NGHT = 28 remaining heat-transfer paths of STGEN component 12 are remodeled by 8 HTSTR components as shown in Fig. J-1. They are for the:

- wrapper wall separating the boiler and downcomer (7 paths from boiler cells 1 to 7 to downcomer cells 12 to 6, respectively) and the wrapper wall separating the steam dome and downcomer [3 paths from steam-dome cells 1 to 3 to downcomer cells 5 to 1, respectively, where JCELL = 2 (now 3) has become 3 cells], which have been remodeled by HTSTR component 931,
- lower outer shell of the downcomer (7 paths from downcomer cells 12 to 6 to the outside air), which have been remodeled by HTSTR component 932,
- upper outer shell of the downcomer (3 paths from downcomer cells 5 to 1 to the outside air) and steam dome [2 paths from steam-dome cells 8 and 12 (4 of side tube) to the outside air], which have been remodeled by HTSTR component 933,
- inlet and outlet tube sheet (2 paths from primary-coolant cells 3 and 17 to 2 and 16, respectively), which have been remodeled by HTSTR components 934 and 935,
- inlet and outlet lower plenum (2 paths from primary-coolant cells 1 and 18 to the outside air), which have been remodeled by HTSTR components 936 and 937, and
- steam-dome secondary dryers [2 paths from steam-dome cells 9 and 10 (1 and 2 of side tube) to steam-dome JCELL = 6], which have been remodeled by HTSTR component 938.

Some of the STGEN component 12 cell numbers in its ICELL and OCELL arrays are different in the new model of Fig. J-1 because the TEE JCELL-guideline for no flow-area change between JCELL–1 and JCELL+1 was applied in TEE components 105 and 190.

HTSTR component 931 models the annular cross-section, cylindrical wrapper wall as a SLAB element in Cartesian geometry. The boiler and steam-dome portions have different inner radii, so a SLAB was modeled that conserves the heat-transfer surface area at the midpoint of each annular cross-section thickness. The other 7 HTSTR components are modeled as ROD elements in cylindrical geometry. The flat tube sheet of HTSTR components 934 and 935 should have been modeled in Cartesian geometry. Its RADIG(I) = 0.01968 m (0.0646 ft, 0.775 in) = RADRD(1) inner-surface position modeled by both the STGEN and HTSTRs doesn't seem correct.

All NGHT = 28 heat-transfer paths have a structure of material type 9 (carbon steel, type A508). Only HTSTR components 934 and 935 and HTSTR components 936 and 937 have the same material thickness of RADRD(3) – RADRD(1) = 0.02636 m – 0.01968 m = 0.00668 m (0.02192 ft, 0.2630 in) and 1.7361 m – 1.5045 m = 0.2316 m (0.7598 ft, 9.118 in). These 4 HTSTR components could have been modeled as 2 HTSTR components with

twice their number of node intervals. While the same total number of node intervals (heat-transfer paths) would be modeled, modeling them with fewer HTSTR components reduces the number of subroutine calls and the calculative effort of TRAC-P. The execution-time savings is only a few percent so defining different HTSTR components for different named structures (as was done above) is justified for the ease of the user in understanding what the different HTSTR components model. The wrapper wall could have been modeled by 2 rather than 1 HTSTR component for the different radii boiler and steam-dome regions. In that case ROD-element rather than SLAB-element geometry definitely would have been appropriate.

To reduce the total number of HTSTR components, multiple hydraulic-component coupling is modeled by HTSTR components 931 to 938. For example, HTSTR component 931 models the boiler to downcomer and steam dome to downcomer wrapper wall of all three steam generators. It does this by defining M1D = 1 > 0 (Word 5 on Card Number 1) and the NCRX (Word 1 on Card Number 1) number of SLAB elements to be 3 rather than 1. The first SLAB element evaluates heat transfer through the wrapper wall of the loop 1 steam generator, the second SLAB element evaluates heat transfer through the wrapper wall of the loop 2 steam generator, and the third SLAB element evaluates heat transfer through the wrapper wall of the loop 3 steam generator. In this case, a single HTSTR component models three separate hardware structures that have the same material and geometry. Multiple hydraulic-component coupling by a HTSTR component is input specified by three different sets of the NHCOMI, NHCELI, NHCOMO, and NHCELO array data. Twenty-four rather than eight HTSTR components would have been required if multiple hydraulic-component coupling had not been modeled.

Remodeling a STGEN component by HTSTR, PIPE, and TEE components is not a simple process, but it is straightforward to do. Remodeling the hydraulic components is easiest because they unfold from the STGEN-component data with their identities and array-data blocks intact. Their STGEN scalar data need to be reformatted specifically to a PIPE or TEE component. Unfolding the STGEN component's heat-transfer path data into HTSTR ROD- or SLAB-element components is more complicated because portions of the heat-transfer path array data go to different HTSTR components. The number of HTSTR components depends upon the number of different structure material and geometry conditions among those NTUBE + NGHT heat-transfer paths of each STGEN component and among all STGEN components of the system model. Unlike hydraulic components, a HTSTR component can model different physical structures with separate calculative elements within itself as long as the material type and geometry of the different physical structures are the same. While this is somewhat complicated to organize during the remodeling process, it pays off in reduced calculative effort when fewer HTSTR components are needed to model the heat-transfer paths of all STGEN components in the system model.

APPENDIX K

XTV GRAPHICS VARIABLES

K.1. Introduction

Appendix Klists the variables that are written to the graphics-data TRCXTV file. Subroutine `xtvdr` orchestrates the creation of the graphics file; each data edit is written by the subroutine responsible for that particular component or data structure. Those variables containing the parenthetical "Header variable only" do not vary with time and appear only in the graphics header edit.

Initially variables are listed by subroutine rather than by component to prevent multiple listings of the variables output by subroutine `xtv1D`. The format of the appendix makes it easy to determine all possible variables for a given component while still making it clear which variables apply to particular components. Because the exact variables available from a given calculation are dependent on options and input parameters, we have not maintained the sequence of the variables, but we have alphabetized the variables for ease of reference. We have provided definitions, and as appropriate, the corresponding SI and English units. This listing is based on TRAC-M/F90 Version 3.0 and TRAC-M/F77 Version 5.5.2.

K.2. Global Variable Graphics

The global variables apply to the overall calculation as opposed to specific components or cells within a component. Subroutine `xtvgnpr` is responsible for these graphics variables, with the exception of `timet`, which is output by `xtvdr`.

Variable	Dimension	Description
`cputot`	1	Total CPU time (s) since time 0.0 s in the calculation.
`delt`	1	Timestep size (s).
`dprmax`	1	Maximum fractional pressure change over the current timestep (parameter used in the timestep-control logic).
`dtlmax`	1	Maximum liquid-temperature change (K, °F) over the current timestep (parameter used in the timestep-control logic).
`dtrmax`	1	Maximum HTSTR-component ROD or SLAB element wall temperature change (K, °F) over the current timestep.
`dtsmax`	1	Maximum saturation temperature change (K, °F) over the current timestep.
`dtvmax`	1	Maximum vapor-temperature change (K, °F) over the current timestep (parameter used in the timestep-control logic).
`timet`	1	Transient time (s) in the calculation.
`tnstep`	1	Total number of timesteps since time 0.0 s in the calculation.

K.3. Signal-Variable, Control-Block, and Trip-Signal Graphics

Subroutine `xtvcntl` is responsible for all of the signal variables, control blocks, and trip signals specified through input from the input-data file TRACIN and restart-data file TRCRST. Subroutine `xtvcntl` loops over all of the signal variables in the order of increasing magnitude of their ID numbers and similarly loops over all of the control blocks and all of the trips. The quantities written to the graphics file are:

- the parameter value of each signal variable at the current timestep along with a figure label having its signal-variable ID number, parameter title, and units of the signal-variable parameter,
- the output-parameter value from each control block at the current timestep along with a figure label of its control-block ID number and the units of the control-block output parameter, and
- the trip signal from each trip at the current timestep along with a figure label of its trip ID number and the units of the trip signal.

For TRAC-P to output control-block output-signal and trip-signal units to the control-block and trip-signal figure labels, the user must specify those units through input by units-name labels. This is done when one or more of the NAMELIST-variables I/O-units flags `iogrf`, `ioinp`, `iolab`, and `ioout` has a value of 1 to specify Engish units. Users desiring all input and output in SI units with control-block output-signal and trip-signal graphics labels with SI units should input NAMELIST variables `iolab` = 1 while leaving `inlab` = 0 (default value). Inputing `inlab` = 3 would output a comment-labeled input-data file `inlab` in English units.

Variable	Dimension	Description
`sv`	1	Signal-variable data (although the dimension of each is 1, there are `ntsv` of them and each has its own units-name label).
`cb`	1	Control-block output (although the dimension of each is 1, there are `ntcb` of them and each has its own units-name label based on the user-defined units-name label of `cbxmin` and `cbxmax`).
`ts`	1	Trip-signal data (although the dimension of each is 1, there are `ntrp` of them and each has its own units-name label based on the user-defined units name label of `setpt(i)`, `i`=1 to 2 or 4).

K.4. General One-Dimensional Hydraulic-Component Graphics

Subroutine `xtv1d` outputs the graphics-catalog variables that are common to all the 1-D hydraulic components (PIPE, PRIZER, PUMP, TEE, and VALVE). For TEE components,

the dimension of cell-centered variables includes space for a phantom cell between the main-tube and side-tube cells. This accounts for the fact that there are more interfaces than cells and side-tube values are stored after main-tube values. In some cases, the outputting of parameter values depends on user-specified options in the TRAC-P input-data TRACIN file that cause those parameters to be evaluated. Note that because of wall heat conduction (nodes), these components may be listed as 2D components in XTV when nodes > 2.

Variable	Dimension	Description
alpn	ncellt	Cell gas volume fractions (–)
alven	ncellt	Cell liquid-side interfacial heat-transfer coefficients (W K^{-1}, Btu °F^{-1} hr^{-1}) [HTC * interfacial area].
alvn	ncellt	Cell-flashing interfacial heat-transfer coefficients (W K^{-1}, Btu °F^{-1} hr^{-1}) [HTC * interfacial area].
am	ncellt	Cell noncondensable-gas masses (kg, lb_m).
chtan	ncellt	Cell noncondensable-gas interfacial heat-transfer coefficients (W K^{-1}, Btu °F^{-1} hr^{-1}) [HTC * interfacial area].
chtin	ncellt	Cell gas-side interfacial heat-transfer coefficients (W K^{-1}, Btu °F^{-1} hr^{-1}) [HTC * interfacial area].
cifn	ncellt+1	Interface interfacial-drag coefficients (kg m^{-4}, lb_m ft^{-4}).
concn	ncellt	Cell dissolved-solute concentration ratio [kg(solute) kg^{-1} (liquid), lb_m(solute) lb_m-1(liquid)].
fa	ncellt+1	Interface flow areas (m^2, ft^2) [Header variable only].
hgam	ncellt	Cell subcooled boiling heat flux (W m^{-2}, Btu ft^{-2} hr^{-1}).
hil	ncellt	Cell wall liquid heat-transfer coefficients (W m^{-2} K^{-1}, Btu ft^{-2} °F^{-1} hr^{-1}).
hiv	ncellt	Cell wall gas heat-transfer coefficients (W m^{-2} K^{-1}, Btu ft^{-2} °F^{-1} hr^{-1}).
htlsci	1	Inner-surface heat loss (W, Btu hr^{-1}) from the wall.
htlsco	1	Outer-surface heat loss (W, Btu hr^{-1}) from the wall.
id	1	Component ID number (Header variable only).
idr	ncellt	Cell wall heat-transfer regime numbers (–).
ncellt	1	Total number of cells, including phantom cell (Header variable only).
njun	1	Number of junctions on this component.
nlegs	1	Number of legs (side tubes) on this component.
pan	ncellt	Cell noncondensable-gas partial pressures (Pa, psia).
pinteg	1	Total heat transfer rate to the wall (w, Btu h^{-1}).
pn	ncellt	Cell total pressures (Pa, psia).

regnm	ncellt+1	Interface flow-regime numbers.
rmvm	ncellt+1	Interface fluid mass flows (kg s^{-1}, lb_m hr^{-1}).
rmvf	ncellt+1	Interface gas mass flows (kg s^{-1}, lb_m hr^{-1}).
roan	ncellt	Cell noncondensable-gas densities (kg m^{-3}, lb_m ft^{-3}).
roln	ncellt	Cell liquid densities (kg m^{-3}, lb_m ft^{-3}).
rom	ncellt	Cell mixture densities (kg m^{-3}, lb_m ft^{-3}).
rovn	ncellt	Cell gas densities (kg m^{-3}, lb_m ft^{-3}).
sn	ncellt	Cell plated-solute mass/fluid volume (kg m^{-3}, lb_m ft^{-3}).
tcen	1	Total heat convected to the fluid (W s, Btu).
tln	ncellt	Cell liquid temperatures (K, °F).
tsat	ncellt	Cell saturation temperatures (K, °F) based on the total pressures.
tssn	ncellt	Cell saturation temperatures (K, °F) based on the steam partial pressures.
tvn	ncellt	Cell gas temperatures (K, °F).
twan	1	Absolute error in the total heat convected to the fluid (W s, Btu).
twen	1	Effective error in the total heat convected to the fluid (W s, Btu).
twn	nodes* ncellt	Node-cell wall temperatures (K, °F) in the order: node 1 to NODES for cell 1, node 1 to NODES for cell 2,etc.
type	1	Component type (Header variable only).
vln	ncellt+1	Interface liquid velocities (m s^{-1}, ft s^{-1}).
vol	ncellt	Cell volumes (m^3, ft^3) [Header variable only].
vvn	ncellt+1	Interface gas velocities (m s^{-1}, ft s^{-1}).
wfl	ncellt+1	Interface friction factors (–).
x	ncellt	Cell upper bounds. (m, ft) [Header variable only].

K.4.1. BREAK Component Graphics.

Subroutine xtvbrak outputs all graphics variables for the BREAK component.

Variable	Dimension	Description
alpn	1	BREAK-cell gas volume fraction (–).
bsa	1	Time-integrated noncondensable-gas mass flow (kg, lb_m).
bsmass	1	Time-integrated mass flow (kg, lb_m) into the BREAK cell.
bxa	1	Noncondensable-gas mass flow (kg s^{-1}, lb_m hr^{-1}).
bxmass	1	Mass flow (kg s^{-1}, lb_m hr^{-1}) into the BREAK cell.

concn	1	BREAK-cell dissolved-solute concentration ratio [kg(solute) kg^{-1}(liquid), lb_m(solute) lb_m-1(liquid)].
enth	1	BREAK-cell fluid enthalpy (W s kg^{-1}, Btu lb_m-1).
fa	2	BREAK-interface flow areas (m^2, ft^2) [Header variable only].
id	1	Component ID number (Header variable only).
ncellt	1	Total number of cells (should be 1) [Header variable only].
pan	1	BREAK-cell noncondensable-gas partial pressure (Pa, psia).
pn	1	BREAK-cell total pressure (Pa, psia).
tln	1	BREAK-cell liquid temperature (K, °F).
tvn	1	BREAK-cell gas temperature (K, °F).
type	1	Component type (Header variable only).
vol	1	BREAK-cell volume (m^3, ft^3) [Header variable only].
x	1	BREAK-cell upper bound (m, ft) [Header variable only].

K.4.2. FILL Component Graphics.

Subroutine `xtvfill` outputs all graphics variables for the FILL component.

Variable	Dimension	Description
alpn	1	FILL-cell gas volume fraction (–).
concn	1	FILL-cell dissolved-solute concentration ratio [kg(solute) kg^{-1}(liquid), lb_m(solute) lb_m-1(liquid)].
enth	1	FILL-cell fluid enthalpy (W s kg^{-1}, Btu lb_m-1).
fa	2	FILL-interface flow areas (m^2, ft^2) [Header variable only].
fxmass	1	Mass flow (kg s^{-1}, lb_m hr^{-1}) out of the FILL cell.
id	1	Component ID number (Header variable only).
ncellt	1	Total number of cells (should be 1) [Header variable only].
pan	1	FILL-cell noncondensable-gas partial pressure (Pa, psia).
pn	1	FILL-cell total pressure (Pa, psia).
tln	1	FILL-cell liquid temperature (K, °F).
tvn	1	FILL-cell gas temperature (K, °F).
type	1	Component type (Header variable only).
vln	1	FILL-interface liquid velocity (m s^{-1}, ft s^{-1}).
vol	1	FILL-cell volume (m^3, ft^3) [Header variable only].
vvn	1	FILL-interface gas velocity (m s^{-1}, ft s^{-1}).
x	1	FILL-cell upper bound (m, ft) [Header variable only].

K.4.3. HTSTR (Heat-Structure) Component ROD- or SLAB-Element Graphics. Subroutine `xtvht` outputs all graphics variables for the HTSTR component ROD or SLAB elements.

Variable	Dimension	Description
alreac	1	Gas volume-fraction reactivity (–).
cepwn	2	Outer-surface and inner-surface heat-transfer difference (W, Btu h^{-1}).
dbreac	1	Dissolved- and plated-solute reactivity (–).
hrfli	nzmax	Liquid heat-transfer coefficient (W m^{-2} K^{-1}, Btu ft^{-2} $°F^{-1}$ hr^{-1}) for the inner surface of the ROD or SLAB elements.
hrflo	nzmax	Liquid heat-transfer coefficient (W m^{-2} K^{-1}, Btu ft^{-2} $°F^{-1}$ hr^{-1}) for the outer surface of the ROD or SLAB elements.
hrfvi	nzmax	Gas heat-transfer coefficient (W m^{-2} K^{-1}, Btu ft^{-2} $°F^{-1}$ hr^{-1}) for the inner surface of the ROD or SLAB elements.
hrfvo	nzmax	Gas heat-transfer coefficient (W m^{-2} K^{-1}, Btu ft^{-2} $°F^{-1}$ hr^{-1}) for the outer surface of the ROD or SLAB elements.
id	1	Component ID number (Header variable only).
ihtfi	nzmax	Heat-transfer regime numbers for the inner surface of the ROD or SLAB elements.
ihtfo	nzmax	Heat-transfer regime numbers for the outer surface of the ROD or SLAB elements.
nodes	1	Number of ROD-radial or SLAB-thickness heat-transfer nodes (first level only).
nrods	1	Total number of ROD or SLAB elements evaluated by the HTSTR component.(Header variable only)
nzmax	1	Maximum number of rows of nodes in the axial direction of the HTSTR component (Header variable only).
pgreac	1	Programmed reactivity (–).
powli	ncrz	Inner-surface heat transfer to the liquid (W, Btu h^{-1}).
powlo	ncrz	Outer-surface heat transfer to the liquid (W, Btu h^{-1}).
powvi	ncrz	Inner-surface heat transfer to the gas (W, Btu h^{-1}).
powvo	ncrz	Outer-surface heat transfer to the gas (W, Btu h^{-1}).
rftn	nodes* nzmax	ROD- or SLAB-element temperatures (K, °F), ordered node 1 to node NODES for row 1, node 1 to node NODES for row 2, etc.
rmckn	1	Reactor multiplication constant K_{eff} (–).

rpower	1	Reactor power (W, Btu hr^{-1}).
rzht	ncrz+1	Axial positions of the rows of nodes (m, ft).
stnui	nzmax	Inner-surface Stanton number (–) of the ROD or SLAB element.
stnuo	nzmax	Outer-surface Stanton number (–) of the ROD or SLAB element.
tcefni	1	Inner-surface total heat transfer to the fluid (W s, Btu).
tcefno	1	Outer-surface total heat transfer to the fluid (W s, Btu).
tcreac	1	Coolant-temperature reactivity (–).
tfreac	1	Fuel-temperature reactivity (–).
tldi	nzmaxz	Inner-surface liquid temperatures (K, °F) at bubble departure.
tldo	nzmaxz	Outer-surface liquid temperatures (K, °F) at bubble departure.
tpowi	1	Total power across the inner surface of the heat-structure component. (W, Btu hr^{-1}).
tpowo	1	Total power across the inner surface of the heat-structure component. (W, Btu hr^{-1}).
trhmax	1	Maximum temperature (K, °F) of the supplemental ROD or SLAB elements.
tramax	1	Maximum temperature (K, °F) of the average power ROD or SLAB elements.
twani	1	Inner-surface absolute error in the heat transfer to the fluid (W s, Btu).
twano	1	Outer-surface absolute error in the heat transfer to the fluid (W s, Btu).
tweni	1	Inner-surface effective error in the heat transfer to the fluid (W s, Btu).
tweno	1	Outer-surface effective error in the heat transfer to the fluid (W s, Btu).
type	1	Component type (Header variable only).
zht	nzmax	Axial positions (m, ft) of the rows of nodes in the ROD or SLAB elements.

K.4.4. PIPE Component Graphics.

In addition to a call to `xtv1d`, subroutine `xtvpipe` outputs graphics variables specific to the PIPE component.

Variable	Dimension	Description
cpow	1	Heater power (W, Btu hr^{-1}) to the fluid.
qout	1	Liquid volume discharged (m^3, ft^3) at the exit (interface ncells+1) when the accumulator flag iacc > 0.
vflow	1	Volumetric fluid flow (m^3 s^{-1}, gpm) at the exit (interface ncells+1) when the accumulator flag iacc > 0.
z	1	Water level (m, ft) in the PIPE component (assumes the component is vertically oriented with cell 1 at the top) when the accumulator flag iacc > 0.

K.4.5. PLENUM Component Graphics.

Subroutine xtvplen outputs all graphics variables specific to the PLENUM component.

Variable	Dimension	Description
alpn	1	Cell gas volume fraction (–).
am	1	Cell noncondensable-gas mass (kg, lb_m).
concn	1	Cell dissolved-solute concentration ratio [kg(solute) kg^{-1}(liquid), lb_m(solute) lb_m-1(liquid)].
dx	npljn	Cell lengths (m, ft) associated with each PLENUM-component junction (Header variable only).
id	1	Component ID number (Header variable only).
ncellt	1	Total number of cells (should be 1) [Header variable only].
npljn	1	Number of junctions (Header variable only).
pan	1	Cell noncondensable-gas partial pressure (Pa, psia).
pn	1	Cell total pressure (Pa, psia).
roan	1	Cell noncondensable-gas density (kg m^{-3}, lb_m ft^{-3}).
roln	1	Cell liquid density (kg m^{-3}, lb_m ft^{-3}).
rom	1	Cell mixture density (kg m^{-3}, lb_m ft^{-3}).
rovn	1	Cell gas density (kg m^{-3}, lb_m ft^{-3}).
sn	1	Cell plated-solute mass/fluid volume (kg m^{-3}, lb_m ft^{-3}).
tln	1	Cell liquid temperature (K, °F).
tsat	1	Cell saturation temperature (K, °F) based on the total pressure.
tvn	1	Cell gas temperature (K, °F).
type	1	Component type (Header variable only).
vol	1	Cell volume (m^3, ft^3) [Header variable only].

K.4.6. PRIZER (Pressurizer) Component Graphics.

In addition to a call to xtv1d, subroutine xtvprzr outputs graphics variables specific to the PRIZER component.

Variable	Dimension	Description
flow	1	Volumetric flow (m^3 s^{-1}, gpm) at the exit (interface ncells+1) of the PRIZER.
qin	1	Heater/sprayer power (W, Btu hr^{-1}).
qout	1	Liquid volume discharged (m^3, ft^3) at the exit (interface ncells+1) of the PRIZER.
z	1	Water level (m, ft) in the PRIZER component (assumes the component is vertically oriented with cell 1 at the top).

K.4.7. PUMP Component Graphics.

In addition to a call to xtv1d, subroutine xtvpump outputs graphics variables specific to the PUMP component.

Variable	Dimension	Description
alpha	1	Gas volume fraction donored across the second (pump-impeller) interface (weighted 10% new, 90% old).
delp	1	PUMP ?P (Pa, psia) across the second (pump-impeller) interface (pressure of cell 2 minus pressure of cell 1).
flow	1	Volumetric fluid flow (m^3 s^{-1}, gpm) donored across the second (pump-impeller) interface.
head	1	PUMP head (Pa m^3 kg^{-1} or m^2 s^{-2} or N m kg^{-1}, lb_f ft lb_m-1) from the homologous curves and two-phase degrada-tion multiplier.
mflow	1	Fluid mass flow (kg s^{-1}, lb_m hr^{-1}) across the second (pump-impeller) interface.
omegan	1	Pump-impeller rotational speed (rad s^{-1}, rpm).
rho	1	Fluid mixture density (kg m^{-3}, lb_m ft^{-3}) donored across the second (pump-impeller) interface.
smom	1	Momentum source (Pa, psia) applied at the second (pump-impeller) interface based on the PUMP head.
torque	1	PUMP hydraulic torque (Pa m^3, lb_f ft) from the homolo-gous curves and two-phase degradation multiplier.

K.4.8. TEE Component Graphics.

In addition to a call to xtv1d, subroutine xtvtee outputs graphics variables specific to the TEE component.

Variable	Dimension	Description
powr1	1	Heater power (W, Btu hr^{-1}) to the main-tube fluid.
powr2	1	Heater power (W, Btu hr^{-1}) to the side-tube fluid.

K.4.9. VALVE Component Graphics.

In addition to a call to xtv1d, subroutine xtvvlve outputs graphics variables specific to the VALVE component.

Variable	Dimension	Description
area	1	Adjustable valve-interface flow area (m^2, ft^2).

K.5. Three-Dimensional VESSEL Component Graphics

Subroutine xtvvsl outputs graphics variables to the VESSEL component. The cell and interface data are written on a 3D basis in ROW MAJOR format, unlike TRCGRF which used a level format. Like the 1D variables, Interface variables have one more value than cell variables on the face axis. For example vlnz, the z direction liquid velocity, has nrsx*ntsx*(nasx+1) values. The VESSEL variables output to graphics are very much dependent on the options selected and parameters set in the VESSEL input-data, in NAMELIST, and in other general options. The following abbreviations are used for dimensions in this section:

ncells = nrsx*ntsx*nasx (values at every cell)
xrfaces = (nrsx+1)*ntsx*nasx (values at each x/r face, incl. ic0m)
ytfaces = nrsx*(ntsx+1)*nasx (values at each y/θ face, incl. jc0m)
zfaces = nrsx*ntsx* (nasx+1) (values at each z face, incl. kc0m)

Variable	Dimension	Description
alpn	ncells	Cell gas volume fractions(-).
alven	ncells	Cell liquid-side interfacial heat-transfer coefficients (W K^{-1}, Btu $°F^{-1}$ hr^{-1}) [area folded in].
alvn	ncells	Cell flashing interfacial heat-transfer coefficients (W K^{-1}, Btu $°F^{-1}$ hr^{-1}) [area folded in].
am	ncells	Cell noncondensable-gas masses (kg, lb_m).
chtan	ncells	Cell noncondensable-gas interfacial heat-transfer coefficients (W K^{-1}, Btu $°F^{-1}$ hr^{-1}) [area folded in].
chtin	ncells	Cell vapor-side interfacial heat-transfer coefficients (W K^{-1}, Btu $°F^{-1}$ hr^{-1}) [area folded in].
cimfr	1	Reactor-core inlet mass flow (kg s^{-1}, lb_m hr^{-1}).
cimfrl	1	Reactor-core inlet liquid mass flow (kg s^{-1}, lb_m hr^{-1}).

cimfrv	1	Reactor-core inlet gas mass flow (kg s^{-1}, lb_m hr^{-1}).
cixr	ncells	Radial or x-direction interfacial-drag coefficients (kg m^{-4}, lb_m ft^{-4}).
ciyt	ncells	Azimuthal or y-direction interfacial-drag coefficients (kg m^{-4}, lb_m ft^{-4}).
ciz	ncells	Axial interfacial-drag coefficients (kg m^{-4}, lb_m ft^{-4}).
comfr	1	Reactor-core region outlet mass flow (kg s^{-1}, lb_m hr^{-1}).
comfrl	1	Reactor-core outlet liquid mass flow (kg s^{-1}, lb_m hr^{-1}).
comfrv	1	Reactor-core outlet gas mass flow (kg s^{-1}, lb_m hr^{-1}).
concn	ncells	Cell dissolved-solute concentration ratio [kg(solute) kg^{-1}(liquid), lb_m(solute) lb_m-1(liquid)].
corelq	1	Reactor-core liquid volume fraction.
dcflow	1	Downcomer mass flow (kg s^{-1}, lb_m hr^{-1}) (sums the axial flow out of the downcomer at level IDCL).
dclqvl	1	Downcomer liquid volume fraction.
faxr	xrfaces	Interface fluid flow areas (m^2, ft^2) [Header variable only].
fayt	ytfaces	Interface fluid flow areas (m^2, ft^2) [Header variable only].
faz	zfaces	Interface fluid flow areas (m^2, ft^2) [Header variable only].
gamn	ncells	Vapor (steam) generation rate (kg m^{-3}, lb_m ft^{-3}).
hgam	ncells	Cell subcooled boiling heat flux (W m^{-2}, Btu ft^{-2} hr^{-1}).
icj	ncsr	1-D hydraulic component numbers connected to source-connection junctions (Header variable only).
id	1	Component ID number(Header variable only).
isrc	ncsr	Cell numbers to which source-connection junctions are connected (Header variable only).
isrf	ncsr	Face code to which source-connection junctions are connected (Header variable only).
isrl	ncsr	Level numbers to which source-connection junctions are connected (Header variable only).
nasx	1	Number of axial levels (Header variable only).
ncsr	1	Number of VESSEL source-connection junctions to 1-D hydraulic components (Header variable only).
nrsx	1	Number of radial rings or x-direction cells (Header variable only).
nsrl	nasx	Number of source-connection junctions on each level (Header variable only).

ntsx	1	Number of azimuthal segments or y-direction cells (Header variable only).
pan	ncells	Cell noncondensable-gas partial pressures (Pa, psia).
pcore	1	Reactor-core volume-averaged pressure (Pa, psia).
pdc	1	Downcomer volume-averaged total pressure (Pa, psia).
plp	1	Lower-plenum volume-averaged total pressure (Pa, psia).
pn	ncells	Cell total pressures (Pa, psia).
pup	1	Upper-plenum volume-averaged total pressure (Pa, psia).
qhstot	1	Total HTSTR-component heat transfer (W, Btu hr^{-1}) to the fluid of the VESSEL component.
qsl	ncells	Htstr-component heat transfer (W, Btu hr^{-1}) to the fluid in each VESSEL cell.
r	nrsx	r upper bound (m, ft) of each radial ring or cell (Header variable only).
roan	ncells	Cell noncondensable-gas densities (kg m^{-3}, lb_m ft^{-3}).
roln	ncells	Cell liquid densities (kg m^{-3}, lb_m ft^{-3}).
rom	ncells	Cell mixture densities (kg m^{-3}, lb_m ft^{-3}).
rovn	ncells	Cell gas densities (kg m^{-3}, lb_m ft^{-3}).
sn	ncells	Cell plated-solute mass/fluid volume (kg m^{-3}, lb_m ft^{-3}).
t	ntsx	θ upper bound (rad, deg) of each azimuthal segment or sector (Header variable only).
tcilmf	1	Time-integrated reactor-core inlet liquid mass flow (kg, lb_m).
tcivmf	1	Time integrated reactor-core inlet gas mass flow (kg, lb_m).
tcolmf	1	Time integrated reactor-core outlet liquid mass flow (kg, lb_m).
tcore	1	Reactor-core mass-averaged liquid temperature (K, °F).
tcovmf	1	Time integrated reactor-core outlet gas mass flow (kg, lb_m).
tdc	1	Downcomer mass-averaged liquid temperature (K, °F).
tln	ncells	Cell liquid temperatures (K, °F).
tlp	1	Lower-plenum mass-averaged liquid temperature (K, °F).
tsat	ncells	Cell saturation temperatures (K, °F) based on the total pressures.
tscore	1	Reactor-core average saturation temperature (K, °F) based on the reactor-core volume-averaged total pressure.

tsdc	1	Downcomer average saturation temperature (K, °F) based on the downcomer volume-averaged total pressure.
tslp	1	Lower-plenum average saturation temperature (K, °F) based on the lower-plenum volume-averaged total pressure.
tsup	1	Upper-plenum average saturation temperature (K, °F) based on the upper-plenum volume-averaged total pressure.
tup	1	Upper-plenum mass-averaged liquid temperature (K, °F).
tvn	ncells	Cell gas temperatures (K, °F).
type	1	Component type (Header variable only).
vcore	1	Reactor-core liquid mass (kg, lb_m).
vdclq	1	Downcomer liquid mass (kg, lb_m).
vlnxr	xrfaces	Liquid radial or x-direction velocities (m s^{-1}, ft s^{-1}).
vlnyt	ytfaces	Liquid azimuthal or y-direction velocities (m s^{-1}, ft s^{-1}).
vlnz	zfaces	Liquid axial velocities (m s^{-1}, ft s^{-1}).
vlpliq	1	Lower-plenum liquid volume fraction.
vlplm	1	Lower-plenum liquid mass (kg, lb_m).
vlplq	1	Liquid mass below downcomer (kg, lb_m).
vlqmss	1	VESSEL-component liquid mass (kg, lb_m).
vmfrl	ncells	Liquid mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 1].
vmfrlr	xrfaces	Liquid radial mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 3].
vmfrlt	ytfaces	Liquid azimuthal mass flows (kg s^{-1}, lb_m hr^{-1}) [NAME-LIST variable imfr = 3].
vmfrlz	zfaces	Liquid axial mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 3].
vmfrv	ncells	Gas mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 1].
vmfrvr	xrfaces	Gas radial mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 3].
vmfrvt	ytfaces	Gas azimuthal mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 3].
vmfrvz	zfaces	Gas axial mass flows (kg s^{-1}, lb_m hr^{-1}) [NAMELIST variable imfr = 3].

vol	ncells	Cell fluid volumes (m^3, ft^3) [Header variable only].
vsflow	1	Fluid mass flow (kg s^{-1}, lb_m hr^{-1}) summed over all VESSEL-component source-connection junctions.
vupliq	1	Upper-plenum liquid volume fraction.
vuplm	1	Upper-plenum liquid mass (kg, lb_m).
vvnxr	xrfaces	Gas radial or x-direction velocities (m s^{-1}, ft s^{-1}).
vvnyt	ytfaces	Gas azimuthal or y-direction velocities (m s^{-1}, ft s^{-1}).
vvnz	zfaces	Gas axial velocities (m s^{-1}, ft s^{-1}).
x	nrsxx	upper bound (m, ft) of each x-direction cell (Header variable only).
y	ntsx	y upper bound (m, ft) of each y-direction cell (Header variable only).
z	nasx	z upper bound (m, ft) of each axial level or cell (Header variable only).

APPENDIX L

TRAC-M/F90 ERROR MESSAGES

Subroutine ERROR handles errors diagnosed in TRAC-M and uses the level number associated with each error listed below to determine its course of action.

Level	Actions
–4	TRAC-M evaluation stopped by TRAC-M user.
–2	TRAC-M steady-state nonconvergence warning message.
1, 3	Fatal error; stop the TRAC-M evaluation.
2	Nonfatal error (warning only); continue the TRAC-M evaluation. Note that input errors can generate a warning, but set a flag to terminate TRAC-M execution after all input has been processed.
4	Fatal error; add a data-dump to the TRCDMP file and stop the TRAC-M evaluation.

Error messages, listed below, are written to the TRCOUT and TRCMSG files and to the terminal. The message begins with the name of the subroutine, bounded by asterisks (* · · · *), that detected the error. Because of this format we have used the subroutine name to alphabetize the following list of error messages.

Appendix L corresponds toTRAC-M/F90, Version 3.0. It is based on an earlier Appendix L that was written for TRAC-P, Version 5.4.21. To assist users of other TRAC versions, we have retained error messages that are no longer in Version 3.0 in *italics*. If an error message occurs that is not found in this list, its absence was an oversight in preparing this documentation, or it is a new error message added to the version of TRAC you are running. In this situation, we suggest that you inspect the coding statements in the subroutine identified in the message to find where the error message was generated. The test that lead to the error message will tell you of the error that TRAC encountered.

Subroutine	Level	Error Message	Explanation
AICOMP	*1*	*CODING ERROR*	*The LENPT1 size of the PTAB common block pointer table for the hydraulic component is greater than KPTTMP = 300 storage-array dimension.*
AIPLEN	*1*	*CELL-EDGE VARIABLES NOT AVAILABLE*	*Cell-edge (interface) variables are not defined by the PLENUM component for access by FIND.*

Subroutine	Level	Error Message	Explanation
BFGRF	*1*	*MEMORY OVERFLOW*	*Free space in the A array from LFREE to LLAST is not sufficient to hold the packed data for output to the TRCGRF file.*
BFIN	1	DATA SET EOF ERROR	An illegal end-of-file was found when the data were read.
BFIN	1	DATA SET TYPE ERROR	An error occurred when the data were read in the binary format.
BFOUT	1	DATA SET TYPE ERROR	An error occurred when the data were written in a binary format.
BITS	*1*	*ILLEGAL BIT SPECIFIED*	*An attempt was made to set bit beyond the word length.*
BITS	*1*	*ILLEGAL INDEX IN COMPUTED GO TO STATEMENT*	*Variable ITYPE was not equal to 1, 2, or 3. This will only occur if there is a coding error.*
BREAKX	1	BK TABLE LOOKUP ERROR	An error exists in interpolating a break table.
CBSET	1	C-BLOCK ID NOT FOUND TO SET NFLG	The first input parameter ID number for the control block could not be found in the list on control blocks so that it could be flagged with this control block's new flag.
CBSET	1	C-BLOCK ID NOT FOUND TO SET OFLG	The first input parameter ID number for this control block could not be found in the list of control blocks so that it could be flagged with this control block's old flag.
CBSET	1	CNTL.BLK. ID NOT FOUND	One of the control-block input parameters has a negative ID number that could not be found in the list of control blocks.

Subroutine	Level	Error Message	Explanation
CBSET	1	ERROR IN TABLE LOOKUP	An error was detected by subroutine LININT while it was linearly interpolating in the control-block FNG1 table.
CBSET	1	SIG. VAR. ID NOT FOUND	One of the control-block input parameters has a positive ID number that could not be found in the list of signal variables.
CHBD	2	BOUNDARY ERROR DETECTED	Adjacent components have mismatched geometry.
CHECKSIZE	1	STATIC ARRAY SIZE TOO SMALL	One of TRAC-M's remaining statically allocated arrays is too small.
CHF	1	TCHF FAILED TO CONVERGE	The calculation failed to converge on a unique CHF wall temperature.
CHKSR	2	VESSEL SOURCE LOCATION ERROR	A vessel to 1D source connection was either specified on a cell that does not exist or on a face that does not exist.
CHOKE	1	CHARACTERISTIC SOLUTION DID NOT CONVERGE	The two-phase characteristic solution using a quick-solution search was bounded, but complete convergence could not be obtained within allowed iterations.
CHOKE	1	CONVERGENCE FAILED IN GREV	The system's subroutine GREV has trouble calculating all the eigenvalues of the two-phase characteristic solution.
CHOKE	2	LARGEST CHARACTERISTIC ROOT WAS COMPLEX	An informative message is printed under debug mode only.

Subroutine	Level	Error Message	Explanation
CHOKE	2	NEGATIVE DFLDP CALCULATED, ASSUMED ZERO	The calculated derivative $\partial V_l/\partial r$ was negative because of round-off error, while it should be $\geq 0.0\ s^{-1}$. Therefore, the deri-vative was set to $0.0\ s^{-1}$.
CHOKE	2	NEGATIVE DFVDP CALCULATED, ASSUMED ZERO	The calculated derivative $\partial V_l/\partial r$ was negative because the round-off error should be > 0.0. Thus, the derivative was set to 0.0.
CHOKE	2	ONLY APPROXIMATE SOLUTION OBTAINED	The normal two-phase choking solution maintains constant phasic slip. However, because of convergence problems, this condition could not be satisfied, but rather the relative velocity between the phases was approxi-mately maintained.
CHOKE	2	QUICK SOLUTION SEARCH FAILED	An informative message is printed under debug mode only.
CIHTST	1	HEAT STRUCTURES INPUT ERROR	Heat structure components are input in the wrong order. First, HTSTRs with M1D = 0 are input followed by HTSTRs with their M1D magnitude sequentially increasing.
CIRADH	*1*	*LOGIC PROBLEM*	*Call FIND issued an error code when attempting to set up the radiation model enclosure data-base.*
CIRADR	*1*	*LOGIC PROBLEM*	*Call FIND issued an error code when attempting to set up the radiation model enclosure data-base.*
CIVSSL	1	CONNECTIONS COMPUTED AFTER VESSEL	The component calculational sequence must compute the connections before the vessel.

Subroutine	Level	Error Message	Explanation
CIVSSL	1	IORDER PROBLEM	The calculational sequence must compute the component connected to the vessel before it calculates the vessel.
CIVSSL	1	JUNCTION PROBLEM	A component adjacent to the VESSEL cannot be found.
CIVSSL	1	VESSEL CONNECTED TO A FILL	A VESSEL cannot be connected to a FILL.
CIVSSL	1	VESSEL CONNECTED TO BREAK	A VESSEL cannot be connected to a BREAK.
CONBLK	1	BAD CNTL-BLOCK OPERATION NUMBER	A control-block operation number does not lie between 1 and 61.
CONBLK	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	Variable ICBN was incorrectly defined. This will only occur if here is a coding error.
CONBLK	1	IMPROPER LLAG BLOCK CONSTANTS	The lead-lag transfer function control block 30 has a first constant that is negative or a second constant that is zero or negative.
CONBLK	1	IMPROPER SOTF BLOCK CONSTANTS	The second-order transfer function control block 51 has a first constant that is negative or a second constant that is zero or negative.
CONBLK	1	INVALID CNTL-BLOCK INPUT VALUES	A control block is defined with invalid input parameter values.
CONBLK	1	INVALID DEAD-FUNCTION CONSTANTS	Control block deadband function 11 has a second constant that is less than the first constant.
CONBLK	1	NEGATIVE LAG CONSTANT	A first-order lag Laplace transform function 26 control block has a nonphysical lag constant with a negative value.

Subroutine	Level	Error Message	Explanation
CORE1	1	BAD IDROD FOR ADDITIONAL RODS	TRAC-P cannot find a cell number that matches IDROD.
CORE1	1	CON. BLK ID NOT FOUND	The power-shape table's independent variable has a negative ID number that could not be found in the list on control blocks.
CORE1	2	ERROR IN M1D SEQUENCE FOR HT. STRUCT.	HTSTR components with M1D = 0 need to be input before HTSTRs with M1D ¦ 0.
CORE1	4	REFLOOD CANNOT LOCATE ZAGS IN CORE	The reflood model's ZAGS axial position in the VESSEL is not between the bottom and top axial-interface positions of the reactor-core region.
CORE1	1	SIG. VAR ID NOT FOUND	The power-shape table's independent variable has a positive ID number that could not be found in the list of signal variables.
CORE3	1	BAD IDROD FOR ADDITIONAL RODS	TRAC-M cannot find a cell number that matches IDROD.
CSSetLuIdx	2	UNITS LABEL STRING NOT FOUND	A unit label index for a control block, signal variable, or trip is not in TRAC-M's database.
CTAIN1	*1*	*CONTAINMENT MODULE NOT YET IMPLEMENTED*	*Containment component will be in a future TRAC-P version.*
CTAIN2	*1*	*CONTAINMENT MODULE NOT YET IMPLEMENTED*	*Containment component will be in a future TRAC-P version.*
CTAIN3	*1*	*CONTAINMENT MODULE NOT YET IMPLEMENTED*	*Containment component will be in a future TRAC-P version.*

Subroutine	Level	Error Message	Explanation
DELAY	1	ERROR IN DELAY TIME TABLE LOOKUP	An error was detected by subroutine LININT when it tried to linearly interpolate the time delay table on a control block 100.
DMPIT	3	DUMP FILE DEFINE ERROR	File TRCDMP could not be created.
DMPIT	3	TYPE NOT RECOGNIZED	An invalid component type was encountered.
DMPVLT	1	COMPONENT TYPE NOT RECOGNIZED	There was an incorrect call to DMPVLT to dump a component VLT.
ELGR	2	FORM LOSS VALUE TOO HIGH	The input value of a form loss was such that when the code converted it into an equivalent FRIC, the FRIC value exceeded 10^{20}. A FRIC value exceeding 10^{20} will invoke the steam sep-arator model at the cell edge under consideration. Obviously, such was not the user's intention, otherwise the user would have input a form-loss value exceeding 10^{20} in the first place.
ENDDMP	2	DUMP FILE NOT CLOSED	An error occurred during the closing of the TRCDMP file.
ENDGRF	2	GRAPHICS FILE NOT	An error occurred during the closing of the TRCGRF file.
EOVLY	2	OVERLAY UNLOAD ERROR	Illegal overlay sequence exists.
EVALDF	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	An undefined variable was passed to subroutine EVALDF.
EVALDF2D	1	ILLEGAL ITYPE	A call was made to EVALDF2D for the wrong data (presently only a metal temperature test is made).

Subroutine	Level	Error Message	Explanation
EVFXXX	1	NEED LOCAL DIM.GT.50	Local array FXXXO is dimensioned to be 50; for components with more than 50 mesh cells, subroutine EVFXXX cannot evaluate a QPPP factor for each mesh cell.
EVFXXX	1	TABLE LOOKUP ERROR	Subroutine LININT encount-ered an error while trying to linearly interpolate the com-ponent-action table value when the controlling trip is OFF after being ON.
EVLTAB	1	CNTL. BLOCK NOT FOUND	The negative ID number that defines the independent vari-able of the component-action table was not specified in the list of control blocks.
EVLTAB	1	SIGNAL VAR. NOT FOUND	The positive ID number that defines the independent vari-able of the component-action table was not specified in the list of signal variables.
EVLTAB	1	TABLE LOOKUP ERROR	Subroutine LININT encounter-ed an error when interpolating the component-action table.
FBRCSS	2	CON. BLK. ID NOT FOUND	The monitored parameter of a CSS type 5 controller is a control block whose negative ID number could not be found in the list of control blocks.
FBRCSS	2	MORE 18 BREAKS + VALVES	Pressure adjustment by a CSS type 5 controller needs to be applied to more than 18 BREAK and VALVE components. All their ID numbers cannot be saved in an storage array dimensioned 18.

Subroutine	Level	Error Message	Explanation
FBRCSS	2	MORE 50 BRANCH PATHS	The number of branch paths on the secondary side of a steam-generator that have not been investigated yet (connected to branch paths already investi-gated) exceeds the local IIP, IJP, and IKP array dimension of 50.
FBRCSS	2	NO BREAK COMPONENTS	Pressure adjustment by a CSS type 5 controller to a steam generator cannot be applied when there is no hydraulic coupling to a BREAK component.
FBRCSS	2	SIG. VAR. ID NOT FOUND	The monitored parameter of a CSS type 5 controller is a signal variable whose positive ID number could not be found in the list of signal variables.
FEMOM	2	*JCELL FLOW-AREA CHANGE*	*A flow-area change occurs beween JCELL–1 and JCELL+1 but the JCELL-interface motion equations do not evaluate its reversible flow loss.*
FILLX	1	GENSTATE FILL TABLE LOOKUP ERROR	There are zero entries in the FILL table.
GETBIT	1	ILLEGAL BIT SPECIFIED	The specified bit position is either too small or too large.
GETCRV	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	An undefined pump curve index was passed to subroutine GETCRV.
GetGenTable	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for FLT data.
GetPumpTab	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for PUMP VLT data.
GetRodTab	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for HTSTR VLT data.

Subroutine	Level	Error Message	Explanation
GetTeeTab	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for TEE VLT data.
GetValveTab	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for VALVE VLT data.
GetVessTab	1	VARIABLE NAME NOT RECOGNIZED	An incorrect call was made for VESSEL VLT data.
GRAF	*1*	*DATA TYPE ERROR*	*There is an invalid data type in the graphics catalog.*
GRFPUT	*2*	*ERROR IN GRAPHICS OUTPUT*	*Integer is too large to be packed into a 15-bit word.*
GRFPUT	*1*	*ERROR: GRAPHICS EDIT TOO LARGE*	*The graphics edit is too large and cannot be written. A FORTRAN modification is required.*
HASH	2	FIRST LETTER NOT Z	The first character letter of a z-named variable is not the letter z.
HASH	2	NONALPHABETIC ARRAY	A variable name character-string label is not in alphabetical order.
HOUT	4	OUTER ITERATION DID NOT CONVERGE	The outer-iteration procedure failed three consecutive times.
HTSTR3	1	NODES .GT. NRFMX	Maximum number of radial heat conduction nodes has been exceeded. Either the TRAC-P parameter NRFMX must be increased or NODES must be decreased.
HTSTR3	1	NZMAX .GT. NZFMX	Maximum number of axial heat conduction nodes has been exceeded. Either the TRAC-P parameter NZFMX must be increased or NZMAX must be decreased.

Subroutine	Level	Error Message	Explanation
HTSTRP	1	BAD IDROD FOR ADDITIONAL RODS	The IDROD location for an additional ROD/SLAB element could not be found in the IDROD locations for average ROD/SLAB elements.
HVWEBB	1	FAILURE TO CONVERGE IN WEBB-CHEN	The iteration to solve for the two-phase friction factor in the Webb-Chen correlation failed.
ICOMP	1	FATAL INPUT ERROR(S)	An error was encountered during component data initialization causing JFLAG. NE. O at the end of subroutine ICOMP.
ICOMP	*1*	*FRICTION LOSS HIGHER THAN TURBINE OUTPUT*	*The friction torque coefficients specified for the turbine are so large that the friction loss exceeds the normal design power from all stages.*
ICOMP	1	INCONSISTENT JUNCTION NUMBERS	Inconsistent specification of junction numbers was made.
ICOMP	1	JUNCTION COUNT ERROR	The number of junctions specified is inconsistent with the number found.
ICOMP	1	JUNCTION NUMBERS WRONG	The junctions are assigned incorrectly.
ICOMP	2	LOOP SOURCE CONN. DIFF. DIRECTIONS	The VESSEL source connections of a component loop have cell-face connections to different directions. To evaluate this model, NAMELIST variable NOSETS must be set to 1, which results in the timestep being constrained by the material-courant limit in the VESSEL components.
ICOMP	*1*	*TURBINE STAGES INCONSISTENT WITH INPUT*	*The user specified component numbers of the associated turbine stages under stage 1. This specification is not consistent with the other TURB compo-nents input.*

Subroutine	Level	Error Message	Explanation
ICOMP	1	UNRECOGNIZED COMPONENT	The component type was not recognized.
ICOMP	*1*	*WRONG TURB COMPONENT NUMBER ON VALVE*	*The VALVE component for IVTY option of 5 or 6 requires a TURB component number. This number is inconsistent with the TURB components input.*
IEEECVT	*1*	*IEEE CONVERSION ENCOUNTERED AN ERROR IN ROUTINE IEEECVT*	*Conversion of graphics data to the IEEE format failed.*
IGRAF	*1*	*COMPONENT TYPE NOT RECOGNIZED*	*An invalid component type was encountered.*
IGRAF	*1*	*GRAPHICS FILE ALLOCATION FAILURE*	*An I/O error occurred while allocated space was sought for graphics file.*
IHPSS1	1	200 TOO SMALL FOR NIC	The NIC array in common block HPSSD (that saves the hydraulic component numbers that have no hydraulic-path steady-state initialization applied to them) needs more storage space than its dimension of 200.
HPSS1	1	CALL FIND CSCODE .NE. 0	An error code was returned by subroutine FIND when called.
IHPSS1	1	PLENUM ENERGY INFLOW .NE. OUTFLOW	The fluid energy inflow differs from the fluid energy outflow from a PLENUM component by more than 1% based on hydraulic path steady-state initialization input data.
IHPSS1	1	PLENUM MASS INFLOW .NE. OUTFLOW	The fluid mass inflow to differs from the fluid mass outflow from a PLENUM component by more than 1% based on hydralic path steady-state initialization input data.

Subroutine	Level	Error Message	Explanation
IHPSS1	1	POWER W/O END POINTS	The mesh-cell range defining a power source or sink within a hydraulic path doesn't have one or both of its end-point cells defined.
IHPSS1	1	UNDEF THERMO LOCATION	The thermal-hydraulic condition location is undefined for the hydraulic path.
IHPSS3	1	DIMENSION 99 .LT. NCSR	The number of VESSEL source-connection junctions exceeds the temporary-storage dimension of 99 for local arrays FLWM and FLWE.
IHPSS3	*1*	*CALL FIND CSCODE .NE. 0*	*An error code was returned by subroutine FIND when called.*
IHPSS3	1	VESSEL MASS INFLOW .NE. OUTFLOW	The fluid mass inflow differs from the fluid mass outflow from a VESSEL component by more than 1% based on hydraulic path steady-state initialization input data.
INIT	2	FAVOL & FA TOO LARGE	For a large change in volume-averaged flow areas across two adjacent cells, a flow loss must also be input for the involved junction. This can be accomplished by either inputting a form loss or setting NFF to < 0 for a 1D component or CFZL to < 0 for a 3D component.
INIT	2	FAVOL CHANGE TOO LARGE	For a large change in volume-averaged flow areas across two adjacent cells, a flow loss must also be input for the involved junction. This can be accomplished by either inputting a form loss or setting NFF to < 0 for a 1D component or CFZL to < 0 for a 3D component.

Subroutine	Level	Error Message	Explanation
INIT	2	INTERFACE FA TOO LARGE	The flow area of a particular cell face cannot be larger than either of the two adjoining volume-averaged flow areas.
INPUT	2	CBETA MUST BE BETWEEN –1 & 1	The Bankoff interpolation constant (β) for interpolating between Wallis characteristic length dimension and Kutalatze characteristic length dimension must be between –1 and 1 in value.
INPUT	2	CCFLC IS .LE. ZERO	The intercept for the CCFL correlation must be > 0.
INPUT	2	CCFLM IS .LE. ZERO	The slope for the CCFL correlation must be > 0.
INPUT	2	DIAH MUST BE GT 0.0	The diameter of a single hole in the perforated plate of the CCFL model must be > 0.
INPUT	2	DUPLICATE COMP NUMBERS IN IORDER	Two components with the same number were found in the TRACIN file.
INPUT	1	FATAL INPUT ERROR(S)	A fatal input error was found when an input or restart file was read.
INPUT	2	GAMMA MUST BE GT 0.0	The ratio of open-plate flow area to total-plate flow area in the CCFL model must be > 0.0.
INPUT	2	HYDRO CMP NUM .GE. HT-ST CMP NUM	The component numbers for all HTSTR components must be larger than the largest hydraulic component number.
INPUT	2	ILLEGAL MATERIAL ID NUMBER	Invalid material ID number specified.

Subroutine	Level	Error Message	Explanation
INPUT	1	INOPTS NAMELIST DATA NOT FOUND	The NAMELIST option was specified; however, the NAMELIST data for group INOPTS are not in the TRACIN file.
INPUT	1	INSUFFICIENT MEMORY TO PROCEED PAST INPUT PROCESSING	Insufficient memory exists to proceed past the input processing stage.
INPUT	2	NCCFL IS OUT OF BOUNDS	The number of CCFL parameter sets input is $0 \leq NCCFL \leq 10$.
INPUT	2	NHOLES MUST BE GT 0	The number of holes in the perforated plate of the CCFL model must be > 0.
INPUT	1	NO SPACE FOR BUFFERS	Insufficient LCM is available for I/O buffers.
INPUT	2	NPATHS < 1 & STDYST = 3 OR 4	A hydraulic-path steady-state initialization is to be performed by STDYST = 3 or 4, but no hydraulic-path data is specified.
INPUT	2	NUMVC NEEDS DIM > 50	The component numbers of all VALVES that have their adjustable flow area closed and are not controlled by CSS controllers are saved in array NUMVC as information for subroutine FBRCSS. The total number of such VALVE components exceeds the local NUMVC array dimension of 50.
INPUT	2	SOLUBILITY PARAMETERS NOT REASONABLE	The solubility parameter entered for option ISOLCN does not define a reasonable linear relationship between solubility and temperature or may generate negative solubilities.
INPUT	2	STDYST = 2 OR 4 AND NCONTR < 1	The constrained steady-state option requires at least one steady-state controller to be specified.

Subroutine	Level	Error Message	Explanation
INPUT	2	TP MUST BE GT 0.0	The thickness of the perforated plate in the CCFL model must be > 0.0 m (0.0 ft).
IROD	1	BAD ENEFF	The total effective decay-heat energy fraction, defined by summing the EDH array, is < 0.0 or > 0.5.
IROD	2	BAD POWER-SHAPE TABLE	Linear interpolation of the axial power-shape table by subroutine LININT failed.
IROD	1	BAD FUEL-ROD POWER SUM	Evaluating the heat-structure component volume-integrated power gave a negative value.
IRODL	1	HS NOT ALLOW IN PLENUM	A heat-structure component cannot be connected to a plenum component.
IRODL	1	NAMELIST VARIABLE NVPOW IS TOO SMALL	The total number of VESSEL components coupled to power-ed HTSTR components is greater than the value of NAME-LIST variable NVPOW that was used to dimension storage for array A(LJUN) in subroutine INPUT.
ITEE	1	INVALID GEOMETRY FOR OFFTAKE MODEL	The geometry specified for the TEE component offtake model is invalid.
IVLVE	1	INVALID VALVE LOCATION	The valve interface where the flow area is adjustable does not lie between two cells within the VALVE component.
JFIND	1	JUNCTION PROBLEM	A junction number could not be located in the junction array.
JUNSOL	1	INVALID JUNCTION NUMBER	Junction number JN of component NUM was not found in the JUN(I,J) array.

Subroutine	Level	Error Message	Explanation
LOAD	2	ARRAY FILLED – OPERATION END NOT FOUND ON ARRAY CARD NO. XXXX OR NEXT CARD	Subroutine LOAD has filled up an array, but the letter "E" was not found at the end of the array input.
LOAD	2	ARRAY FILLED BUT OPERATION END NOT FOUND ON ARRAY CARD NO. XXXX	Subroutine LOAD has filled up an array, but the letter "E" was not found at the end of the array input.
LOAD	2	ARRAY FILLED BUT OPERATION END NOT FOUND – SEE INPUT CARDS XXXX THRU XXXX	Subroutine LOAD has filled up an array, but the letter "E" was not found at the end of the array input.
LOAD	2	DATA OVERFLOWED ARRAY ON ARRAY CARD NO. XXXX – REPEAT COUNT RESET TO ONE	When the array data were read, a repeat operation overfilled the array.
LOAD	2	DATA OVERFLOWED ARRAY ON INPUT CARD NO. XXXX – REPEAT COUNT RESET TO ONE	When the array data were read, a repeat operation overfilled the array.
LOAD	2	ERROR – UNEXPECTED NAMELIST DATA ENCOUNTERED	When the array data were loaded NAMELIST data were found.
LOAD	2	INPUT ERROR ENCOUNTERED ON CARD NO. XXXX – REST OF COMPONENT SKIPPED	Array-reading routine found an error flag on a card set by the free-format input-option preprocess or routine. Execution of TRAC-P stops after the entire input deck is processed.
LOAD	2	INPUT ERROR ON CARD NO XXXX – REAL DATA ENCOUNTERED IN AN INTEGER ARRAY	Real data were found in an integer array.

Subroutine	Level	Error Message	Explanation
LOAD	2	INPUT ERROR – NEW COMPONENT WAS ENCOUNTERED UNEXPECTEDLY ON CARD NO. XXXX	When the array data for a component were loaded, data for an additional component or an "END" card was specified.
LOAD	2	INTEGER RATHER THAN REAL VALUE	An integer value was found when real values are expected.
LOAD	2	INTEGER INTERPOLATION NOT ALLOWED – SEE ARRAY CARD NO. XXXX	When an integer array was read, an interpolation operation was specified.
LOAD	2	INTEGER INTERPOLATION NOT ALLOWED – SEE INPUT CARD NO. XXXX	When an integer array was read, an interpolation operation was specified.
LOAD	2	NOT ENOUGH DATA TO FILL ARRAY – DATA ENDS ON ARRAY CARD NO. XXXX	Subroutine LOAD encountered an "E" end of operation before the array was filled.
LOAD	2	NOT ENOUGH DATA TO FILL ARRAY. SEE INPUT CARDS XXXX THRU XXXX	Subroutine LOAD encountered an "E" end of operation before the array was filled.
LOAD	2	OPERATION E ENCOUNTERED BUT INTERPOLATION INCOMPLETE – SEE INPUT CARD XXXX	When the array data were read, an end flag "E" was specified before both endpoints of an interval to be interpolated were read.
LOAD	2	OPERATION END ENCOUNTERED BUT INTERPOLATION INCOMPLETE – SEE ARRAY CARD XXXX	When the array data were read, an end flag "E" was specified before both endpoints of an interval to be interpolated were read.
LOAD	2	REPEAT COUNT LESS THAN ONE – ARRAY CARD NO. XXXX – COUNT RESET TO ONE	When the array data were read, a repeat count of < 1 was found.
LOAD	2	REPEAT COUNT LESS THAN ONE – INPUT CARD NO. XXXX – COUNT RESET TO ONE	When the array data were read, a repeat count of < 1 was found.

Subroutine	Level	Error Message	Explanation
LOAD	2	REPEAT LEVEL CARD MISPLACED	When the array data were read, a repeat-level card was found.
LOAD	2	UNDEFINED OPERATION - "XXXX" ON ARRAY CARD NO. XXXX – REPEAT COUNT SET TO ONE	When the array data were read, an undefined load operation was specified.
LOAD	1	UNEXPECTED END-OF-FILE REACHED	An unexpected end-of-file was found when reading array data.
LOAD	2	ZERO OR FEWER INTERPO-LATIONS – ARRAY CARD NO XXXX – OPERATION TREATED AS BLANK	When the array data were read, an interpolation count of < 1 was specified.
LOAD	2	ZERO OR FEWER INTERPO-LATIONS – INPUT CARD NO XXXX – OPERATION TREATED AS BLANK	When the array data were read, an interpolation count of < 1 was specified.
LOCPMP	*1*	*VARIABLE NAME NOT RECOGNIZED*	*A error occurred when the user tried to locate a PUMP variable in its VLTAB common block.*
LOCTEE	*1*	*VARIABLE NAME NOT RECOGNIZED*	*A programming error occurred when the user tried to locate the position of a TEE variable in its common block.*
LOCTRB	*1*	*VARIABLE NAME NOT RECOGNIZED*	*A programming error occurred when the user tried to locate the position of a TURBINE variable in its common block.*
LOCVLV	*1*	*VARIABLE NAME NOT RECOGNIZED*	*A programming error occurred when the user tried to locate the position of a VALVE variable in its common block.*
LTOPP	1	CODING ERROR IN LTOPP	The subroutine input argument FACE is defined to be neither LEFT or RIGHT.

Subroutine	Level	Error Message	Explanation
MANAGE	*1*	*BAD LEVEL/ROD NUMBER*	*The requested VESSEL level or ROD/SLAB-element number does not exist.*
MANAGE	*1*	*ILLEGAL INDEX IN COMPUTED GO TO*	*An invalid entry option was sent to subroutine MANAGE in variable INOPTS. This occurs if there is a coding error.*
MATSOL	1	BAD BANDED-MATRIX FACTORIZATION	The LU matrix-decomposition factorization of a banded matrix failed.
MATSOL	1	BAD CAPACITANCE-MTX FACTORIZATION	The LU matrix-decomposition factorization of the capacitance matrix (a full matrix) failed.
MFROD	1	ILLEGAL MATERIAL ID NUMBER	The material ID specified is not valid.
MFROD	1	INTERFACE .NE. NCRZ + 1	The last heat-transfer coarse node at hydraulic cell interfaces must be equal to NCRZ + 1.
MSTRCT	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	An undefined or invalid material type number has been passed to subroutine MSTRCT.
MSTRCT	1	INCORRECT TABULAR MAT. I.D.	A wall-material identifier could not be located.
MSTRCT	2	TEMPERATURE OUTSIDE TABLE RANGE	Wall temperature is outside the range of the tabular data.
NAMLST	2	ALP HAS OUT-OF-RANGE VALUE	When specifying a default value for gas volume fractions using the NAMELIST data, the allowable input-value range is $0.0 \leq ALP \leq 1.0$.
NAMLST	2	CCIF HAS OUT-OF-RANGE VALUE	When specifying a constant two-phase flow interfacial drag coefficient (when NIFSH = 1) using NAMELIST data, the allowable input-value range is $0.0 < CCIF$.

Subroutine	Level	Error Message	Explanation
NAMLST	2	CFZ3 HAS OUT-OF-RANGE VALUE	When specifying a default value for 3D loss coefficients using the NAMELIST data, the allowable input-value range is $0.0 \leq CFZ3$.
NAMLST	2	CHM1# HAS OUT-OF-RANGE VALUE	When specifying subcooled multipliers for the choked-flow model using NAMELIST data, the allowable input-value range is $0.0 < CHM1\#$.
NAMLST	2	CHM2# HAS OUT-OF-RANGE VALUE	When specifying two-phase multipliers for the choked-flow model using NAMELIST data, the allowable input-value range is $0.0 < CHM2\#$.
NAMLST	2	DTSTRT HAS OUT-OF-RANGE VALUE	When specifying an initial time-step size using NAMELIST data, the allowable input-value range is $DTSTRT = -1$ or $0.0 < DTSTRT$.
NAMLST	2	FDFHL HAS OUT-OF-RANGE VALUE	The allowable input-value range for the Forslund-Rohsenow multiplier NAME-LIST variable FDF-HL is $0.0 \leq FDFHL \leq 1.0$.
NAMLST	2	HD3 HAS OUT-OF-RANGE VALUE	When specifying a default value for 3D hydraulic diameters using the NAMELIST data, the allowable input-value range is $0.0 \leq HD3$.
NAMLST	2	HSTN HAS OUT-OF-RANGE VALUE	When specifying a default value for heat-structure temperatures in 3D components using the NAMELIST data, the allowable input-value range is $0.0 \leq HSTN$.
NAMLST	2	HTCWL HAS OUT-OF-RANGE VALUE	When specifying a constant wall to liquid heat-transfer coefficient (ICONHT = 1) using NAME-LIST data, the allowable input-value range is $0.0 < HTCWL$.

Subroutine	Level	Error Message	Explanation
NAMLST	2	HTCWV HAS OUT-OF-RANGE VALUE	When specifying a constant wall to gas heat-transfer coefficient (ICONHT = 1) using NAMELIST data, the allowable input-value range is 0.0 < HTCWV.
NAMLST	2	IADDED HAS OUT-OF-RANGE VALUE	When adding the numerical-solution status-parameter message to the TRCMSG and TTY files using NAMELIST data, the allowable input-value range is 0 ≤ IADDED.
NAMLST	2	IBLAUS HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IBLAUS are 0 or 1.
NAMLST	2	ICDELT HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ICDELT are 0 and 1.
NAMLST	2	ICFLOW HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ICFLOW are 0, 1, and 2.
NAMLST	2	ICONHT HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ICONHT are 0 and 1.
NAMLST	2	IDIAG HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IDIAG are 0, 1, 2, 3, and 4.
NAMLST	2	IEEEG HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IEEEG are 0 and 1.
NAMLST	2	IELV HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IELV are 0 and 1.
NAMLST	2	IGAS HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IGAS are 1, 2, and 3.

Subroutine	Level	Error Message	Explanation
NAMLST	2	IGEOM3 HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IGEOM are 0 and 1.
NAMLST	2	IHOR HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IHOR are 0, 1, and 2.
NAMLST	2	IKFAC HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IKFAC are 0 and 1.
NAMLST	2	IMFR HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IMFR are 1 and 3.
NAMLST	2	INLAB HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable INLAB are 0 and 3.
NAMLST	2	INVAN HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable INVAN are 0 and 3.
NAMLST	2	IOFFTK HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IOFFTK are 0 and 1.
NAMLST	2	IOGRF HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IOGRF are 0 and 1. **Note:** In TRAC-M/F90, Version 3.0, IOGRF=2 selects TRCXTV output in XDR format, in SI units.
NAMLST	2	IOINP HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IOINP are 0 and 1.
NAMLST	2	IOLAB HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IOLAB are 0 and 1.

Subroutine	Level	Error Message	Explanation
NAMLST	2	IOOUT HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IOOUT are 0 and 1.
NAMLST	2	IPOWR HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IPOWR are –1, 0, and 1.
NAMLST	2	IRESET HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IRESET are 0 and 1.
NAMLST	2	ISOLCN HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ISOLCN are 0 and 1.
NAMLST	2	ISTOPT HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ISTOPT are 0, 1, and 2.
NAMLST	2	ITHD HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable ITHD are 0 and 1.
NAMLST	2	IUNLAB HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable IUNLAB are in the range $0 \leq$ IUNLAB ≤ 100.
NAMLST	2	IUNOUT HAS OUT-OF-RANGEVALUE	The allowable input values for NAMELIST variable IUNOUT are 0 and 1.
NAMLST	2	LEVSTG HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable LEVSTG are 0 and 1.
NAMLST	2	MHTLI HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MHTLI are 0 and 1.
NAMLST	2	MHTLO HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MHTLO are 0 and 1.

Subroutine	Level	Error Message	Explanation
NAMLST	2	MHTVI HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MHTVI are 0 and 1.
NAMLST	2	MHTVO HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MHTVO are 0 and 1.
NAMLST	2	MWFL HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MWFL are 0 and 1.
NAMLST	2	MWFV HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable MWFV are 0 and 1.
NAMLST	2	NDIA1 HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NDIA1 are 1 and 2.
NAMLST	2	NENCL HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NENCL are in the range $0 \leq NENCL \leq MAXENC$ where MAXENC is data initialized with the value 50. **Note:** The thermal radiation model is not available in TRAC-M/F90, Version 3.0.
NAMLST	2	NEWRFD HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NEWRFD are 0 and 1. **Note:** TRAC-M/F77, Version 5.5.2 has additional options for NEWRFD.
NAMLST	2	NFRC1 HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NFRC1 are 1 and 2.
NAMLST	2	NFRC3 HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NFRC3 are 1 and 2.

Subroutine	Level	Error Message	Explanation
NAMLST	2	NHTSTR HAS OUT-OF-RANGE VALUE	When specifying the number of HTSTR components using NAMELIST data, the allowable input-value range is NHTSTR ≥ 0.
NAMLST	2	NIFSH HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NIFSH are 0 and 1.
NAMLST	2	NLT HAS OUT-OF-RANGE VALUE	When specifying the number of hydraulic-component loops using NAMELIST data, the allowable input-value range is NLT ≥ 1.
NAMLST	2	NOAIR HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NOAIR are 0 and 1.
NAMLST	2	NOAIR .NE. 1 WHEN IEOS .EQ. 1	NAMELIST variable NOAIR must equal 1 when the IEOS = 1 option (gas phase has noncondensable gas throughout the system model) is selected.
NAMLST	2	NOSETS HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NOSETS are 0, 1, and 2.
NAMLST	2	NRSLV HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NRSLV are 0 and 1.
NAMLST	2	NSDL & NSDU HAVE OUT-OF-RANGE VALUES	When specifying the first and last timestep at which a short edit is to be printed to the TRCOUT file with additional diagnostics using NAMELIST data, the allowable input-value range is NSDL = –1 and NDSU = –1 or $0 \leq$ NSDL $\leq$ NSDU.

Subroutine	Level	Error Message	Explanation
NAMLST	2	NSEND HAS OUT-OF-RANGE VALUE	When specifying a calculation end time using the NAMELIST data, the allowable input-value range is NSEND ≥ 0.0 or NSEND = –1.
NAMLST	2	NSPL & NSPU HAVE OUT-OF-RANGE VALUES	When specifying the first and last timestep at which a short edit is to be printed to the TRCOUT file with additional diagnostics using NAMELIST data, the allowable input-value range is NSPL = –1 and NSPU = –1 or 0 ≤ NSPL ≤ NSPU.
NAMLST	2	NVGRAV HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NVGRAV are 0 and 1.
NAMLST	2	NVPOW HAS OUT-OF-RANGE VALUE	The allowable input values for NAMELIST variable NVPOW are 0 ≤ NVPOW (NVPOW is the number of VESSEL com-ponents that are coupled to powered HTSTR components).
NAMLST	2	P HAS OUT-OF-RANGE VALUE	When specifying a default value for initial pressures using the NAMELIST data, the allowable input-value range is 0.0 Pa (0.0 psia) ≤ P ≤ 4.5000E+07 Pa (6.5267E+03 psia).
NAMLST	2	PA HAS OUT-OF-RANGE VALUE	When specifying a default value for initial noncondensable-gas partial pressures using the NAMELIST data, the allowable input-value range is 0.0 Pa (0.0 psia) ≤ P ≤ 4.5000E+07 Pa (6.5267E+03 psia).

Subroutine	Level	Error Message	Explanation
NAMLST	2	QPPP HAS OUT-OF-RANGE VALUE	When specifying a default value for volumetric heat distribution in the walls of 1D components using NAMELIST data, the allowable input-value range is 0.0 $W/m^3 \leq$ QPPP.
NAMLST	2	TIMDL & TIMDU HAVE OUT-OF-RANGE VALUES	When specifying the times to begin and end a debug printout using NAMELIST data, the allowable input-value ranges are TIMDL and TIMDU $\geq$ 0.0 s or TIMDL and TIMDU = –1.0.
NAMLST	2	TL HAS OUT-OF-RANGE VALUE	When specifying a default value for initial liquid temperatures using the NAMELIST data, the allowable input-value range is 2.7315E+02 K (3.2000E+01°F) $\leq$ TL $\leq$ 7.1395E+02 K (8.2544E+02°F).
NAMLST	2	TPOWR HAS OUT-OF-RANGE VALUE	When specifying the time at which the core-power initialization at its steady-state level is activated using NAMELIST data, the allowable input-value range is TPOWR $\geq$ 0.0 s.
NAMLST	2	TSDLS, TSDUS HAVE OUT-OF-RANGE VALUEs	The allowable value range for NAMELIST variable TSDLS is –1 or 0 < TSDLS $\leq$ TSDUS.
NAMLST	2	TSDLT, TSDUT HAVE OUT OF-RANGE VALUES	The allowable value range for NAMELIST variable TSDLT is –1 or TSDLT $\leq$ TSDUT.
NAMLST	2	TV HAS OUT-OF-RANGE VALUE	When specifying a default value for initial vapor temperatures using the NAMELIST data, the allowable input-value range is 2.7315E+02 K (3.2000E+01°F) $\leq$ TV $\leq$ 3.0000E+03 K (4.9403E+03°F).

Subroutine	Level	Error Message	Explanation
NAMLST	2	TW HAS OUT-OF-RANGE VALUE	When specifying a default value for initial wall temperatures using the NAMELIST data, the allowable input-value range is TW > 0.0 K (–4.5967E+02°F).
NAMLST	2	VL HAS OUT-OF-RANGE VALUE	When specifying a default value for initial liquid velocities using the NAMELIST data, the allowable input-value range is $\lvert VL \rvert$ < 1.0000E+04 m s^{-1} (3.2808E+04 ft s^{-1}).
NAMLST	2	VV HAS OUT-OF-RANGE VALUE	When specifying a default value for initial gas velocities using NAMELIST data, the allowable input-value range is $\lvert VV \rvert$ < 1.0000E+04 m s^{-1} (32808.0 ft s^{-1}).
NAMLST	2	XTVRES HAS OUT-OF-RANGE VALUE	
NXTCMP	2	CARD NO. XXXX SKIPPED -- DATA FOR NEW COMPONENT OR END CARD EXPECTED	When the component data were read, no new component or end-of-file was found after the completion of the current compo-nent data.
NXTCMP	1	END-OF-FILE REACHED WHEN SEARCHING FOR NEXT COMPONENT	When the data for a new component were read, an end-of-file was found.
OFFTKE	1	INVALID GEOMETRY FOR OFFTAKE MODEL	The geometry specified for the TEE component offtake model is invalid.
OUT1D	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.
OUT3D	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.

Subroutine	Level	Error Message	Explanation
OUT3D	*1*	*EXTRA ELEMENTS OUTSIDE BANDWIDTH*	*The number of matrix rows having nonzero elements out-side the VESSEL-matrix band-width exceeds LDIM, the maximum dimension for the order of the capacitance matrix.*
OUTER	4	FATAL ERROR	A fatal error occurred.
POST	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.
POST3D	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.
POST3D	*1*	*EXTRA ELEMENTS OUTSIDE BANDWIDTH*	*The number of matrix rows having nonzero elements out-side the VESSEL-matrix band-width exceeds LDIM, the maximum dimension for the order of the capacitance matrix.*
POSTER	*1*	*NO SCM SPACE FOR CYLHT*	*Insufficient SCM is available.*
PREFWD	*1*	*SCM TO SMALL FOR SCRATCH ARRAYS*	*Insufficient memory exists for the temporary vectors used by sub-routine PREFWD.*
PREINP	2	INPUT ERROR DETECTED IN TRACIN. CARD NUMBER XXXX	The free-format input-option preprocess or routine found an input error. Possible causes include an invalid character (for example, the = character in 1.0E=07), the omission of the first (format-option switch) card, or a simple typographical error (only written for first 50 such cards).
PREP1D	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.
PREP3D	1	COMPONENT TYPE NOT RECOGNIZED	Invalid component type was encountered.

Subroutine	Level	Error Message	Explanation
PREP3D	*1*	*EXTRA ELEMENTS OUTSIDE BANDWIDTH*	*The number of matrix rows having nonzero elements out-side the VESSEL-matrix band-width exceeds LDIM, the maxi-mum dimension for the order of the capacitance matrix.*
PrintVarDesc			
PrintVarDesc			
PrintVarDesc			
PrintVarDesc			
PrintVarDesc			
PTRSPL	*1*	*INSUFFICIENT MEMORY FOR PLENUM POINTERS*	*Insufficient memory exists for initializing PLENUM pointers.*
PUMPD	1	CANNOT LOCATE HEAD CURVE	The PUMP regime is outside the database.
PUMPD	1	CANNOT LOCATE TORQUE CURVE	The PUMP regime is outside the database.
PUMPSR	1	ERROR IN ROUTINE PUMPX	An error was encountered when a pump head or torque was evaluated.
PUMPSR	*1*	*INSUFFICIENT SCM SPACE*	*Insufficient SCM is available for the PUMP calculation.*
PUMPSR	2	PUMP BELOW OMTEST	The pump-impeller rotational speed has fallen below the pump-impeller rotational speed OMTEST specified by input.
PUMPSR	1	PUMP SPEED NOT FOUND	The signal-variable or control-block ID number NPMPSD that defines the initial pump-im-peller rotational speed directly could not be found in the signal-variable or control-block list of ID numbers.

Subroutine	Level	Error Message	Explanation
R1MACH	1	*I OUT OF BOUNDS*	*The number of machine con-stants (required for the determi-nation of eigenvalues) should be at least 1 but should not exceed 5. This number is out of bounds.*
RBREAK	2	ERROR IN TABLE SPECIFICATIONS	Incompatible BREAK options were selected.
RBREAK	2	IBTY INCONSISTENT WITH ISOLUT	A solute-concentration table cannot be used at a BREAK unless the solute-tracker flag ISOLUT = 1.
RBREAK	2	PAIN MUST NOT BE GREATER THAN PIN	The noncondensable-gas partial pressure at the BREAK may not exceed the total pressure at the BREAK.
RBREAK	2	*VLT EXCEEDS ITS LIMIT - SEE TRCOUT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change dimension VLT in GENVLT.*
RCNTL	2	# OF SET PT. FAC. TABLES .GT. 300 DIM	The number of setpoint factor tables is greater than the local dimension of array IFSP (300), which stores the setpoint factor-table ID numbers.
RCNTL	2	# OF T.S.E. OR T.C.T. .GT. 300 DIM.	The number of trip-signal expressions or trip-controlled trips is greater than the local dimension of array ISEN(300) or array ITCN(300). These arrays are used to store the signal ID numbers that are compared with the signal ID numbers in the input.
RCNTL	2	ABSCISSA VALUES NOT INCREASING	The control-block table independent variable values must be in increasing order.

Subroutine	Level	Error Message	Explanation
RCNTL	2	BAD CBLK TABLE STORAGE	The total number of control-block FNG1 table values exceeds the number of values specified by NTCF (Main-Control Card Number 5).
RCNTL	2	BAD COMPONENT NUMBER	The component number that defines a signal variable could not be found in the IORDER array that defines all components in the system model.
RCNTL	2	BAD PI/PID CONSTANTS	The CBDT, CBTAU, and CBWT constants for PI/PID-controller control blocks need to be input defined with the value ranges 0.0 s < CBDT, 0.0 s ≤ CBTAU, and 0.0 ≤ CBWT ≤ 1.0.
RCNTL	2	BAD SIG. EXP. OPERATOR	The arithmetic-operator ID number for a subexpression within the signal-expression definition has an invalid input value of < 1 or > 8.
RCNTL	2	BAD TRIP # DEFINING T-C-T SIGNAL	When specifying the number of trip ID numbers whose ISET set-status values are summed or multiplied to evaluate the trip-controlled signal, the allowable input-value range is 2 ≤ INTN ≤ 10.
RCNTL	2	BAD TRIP SIGNAL-RANGE TYPE VALUE	When specifying a signal-range type number using the trip-defining variable input, the allowable input values for ISRT are ± 1, ± 2, ± 3, ± 4, and ± 5.
RCNTL	2	BAD TRIP ID DEFINITION	A trip ID has an absolute value that is 0 or > 9999.

Subroutine	Level	Error Message	Explanation
RCNTL	2	*BAD USER-DEFINED UNITS STORAGE*	*Computer-memory storage for 100 user-defined units-name labels is not sufficient for the IUNLAB user-defined units-name labels that are input.*
RCNTL	2	CBXMIN UNITS .NE. CBXMAX UNITS	The units-name label of CBXMIN and CBXMAX must be the same.
RCNTL	2	INVALID TRIP SET STATUS DEFINED	The trip set-status variable ISET has an invalid input value.
RCNTL	2	NEGATIVE LAPLACE CONST	The control-block Laplace-transform lead or lag constants input defined by CBCON1 or CBCON2 need to be $\geq$ 0.0 s.
RCNTL	2	SET POINT FACT. TAB. # PAIRS .GT. 10	The set point factor table has more than 10 data pairs.
RCNTL	2	SET PT. FAC. TABLE DIM. TOO SMALL	The number of setpoint factor-table parameters is less than the storage allocated for such parameters by variable NTSF.
RCNTL	2	TRIP-CONTROL TRIP DIM. TOO SMALL	The number of trip-controlled trip-signal parameters is less than the storage allocated for such parameters by variable NTCT.
RCNTL	2	TRIPS DOING DUMPS DIM. TOO SMALL	The number of trip IDs that produce restart dumps is greater than the storage allocated for such parameters by variable NTDF.
RCNTL	2	TRIP SIGNAL EXP. DIM. TOO SMALL	The number of trip signal-expression parameters is greater than the storage allocated for such parameters by variable NTSE.
RCOMP	2	GRAV IS OUTSIDE RANGE (–1.0D0, 1.0D0)	When specifying a gravity term, the allowable input-value range is $-1.0 \leq$ GRAV ≤ 1.0.

Subroutine	Level	Error Message	Explanation
RCOMP	2	ICFLG MUST BE .LE. 5	Only five sets of multipliers are allowed in the choked-flow model.
RCOMP	2	ICONC & ISOLUT ARE INCONSISTENT	Solute concentrations were entered with ISOLUT = 0.
RCOMP	2	INCONSISTENT VALUES FOR ICFLG	All nonzero values of ICFLG must be the same in a given component.
RCOMP	2	LCCFL MUST BE GE 0 AND LE NCCFL	When specifying the CCFL calculation for a component, the allowable input-value range is $0 \leq LCCFL \leq NCCFL$.
RCOMP	*2*	*NEGATIVE FRIC. GE. -1.0E+20 NOT ALLOWED*	*An additive friction-factor $< -10^{20}$ can be used to select the liquid-separator model. In all other cases, the additive friction factor must be positive.*
RCOMP	2	NFF MUST BE 0, 1, –1, OR –100	The only NFF options in TRAC-P are 0, 1, –1, or –100.
RCOMP	2	PA MUST EQUAL 0 IF NOAIR = 1	If the NAMELIST option NOAIR = 1 was selected, then all non-condensable-gas partial pressures must be input as 0.
RCOMP	2	PA MUST NOT BE GREATER THAN P	The noncondensable-gas partial pressure may not exceed the total pressure for a hydro-dynamic cell.
RCOMP		WFMFL	
RCOMP		WFMFV....	
RDCOMP	1	COMPONENT TYPE NOT RECOGNIZED	An invalid component type was specified.
RDDIM	2	ILLEGAL PUMP CURVE OPTION	An illegal PUMP option was specified on PUMP Card Number 9.

Subroutine	Level	Error Message	Explanation
RDREST	1	COMPONENT DATA NOT FOUND	Data for a specific component were not found in the input or the restart file.
RDREST	1	DUMP NOT FOUND ON RESTART FILE	The restart-data dump at the time specified in the input file is not in the restart file.
RDREST	*1*	*FILE TRCRST DOES NOT EXIST*	*Component data were omitted from the input deck, and a restart-data dump file to ini-tialize the missing components cannot be found.*
RDREST	1	IBLAUS FROM TRCRST AND TRACIN DIFFER	NAMELIST variable IBLAUS in the input- and restart-file data differ. IBLAUS must be set to 0 or 1 in both files.
RDREST	1	IELV FROM TRCRST AND TRACIN DIFFER	The cell-centered elevation options in the input- and restart-file data differ. The IELV parameter must be set either to 0 or 1 in both files.
RDREST	1	IKFAC FROM TRCRST AND TRACIN DIFFER	The K-factor options in the input- and restart-file data differ. The IKFAC parameter must be set either to 0 or 1 in both files.
RDREST	1	INCOMPATIBLE RESTART FILE FORM	The component's fixed-length table length of DLNFLT must equal the genDumpSize length of the fixed-length common block.
RDREST	1	ISOLUT FROM TRCRST AND TRACIN DIFFER	The solute-tracking options in the input- and restart-file data differ. The ISOLUT parameter must be set either to 0 or 1 in both files.
RDREST	1	ITHD FROM TRCRST AND TRACIN DIFFER	The HTSTR-component heat-transfer diameter options in the input- and restart-file data dif-fer. The ITHD parameter must be set either to 0 or 1 in both files.

Subroutine	Level	Error Message	Explanation
RDREST	1	NCCFL FROM TRCRST AND TRACIN DIFFER	The NCCFL number of CCFL parameter sets in the input- and restart-file data differ. The NC-CFL parameter must be set either to 0 or the same positive value in both files.
RDREST	1	NDIA1 FROM TRCRST AND TRACIN DIFFER	The 1D hydraulic component heat-transfer diameter options in the input- and restart-file data differ. The NDIA1 parameter must be set either to 1 or 2 in both files.
RDREST	1	NEWRFD FROM TRCRST AND TRACIN DIFFER	The reflood model options in the input- and restart-file data differ. The NEWRFD para-meter must be set either to 0 or 1 in both files.
RDREST	1	NFRC1 FROM TRCRST AND TRACIN DIFFER	The 1D hydraulic component forward and reverse form-loss coefficient option in the input- and restart-file data differ. The NFRC1 parameter must be set either to 1 or 2 in both files.
RDREST	1	NFRC3 FROM TRCRST AND TRACIN DIFFER	The 3D VESSEL component forward and reverse form-loss coefficient option in the input- and restart-file data differ. The NFRC3 parameter must be set either to 1 or 2 in both files.
RDREST	1	NO DUMPS ON FILE	Incomplete dumps are specified in the TRCRST file.
RDREST	1	NOSETS FROM TRCRST AND TRACIN DIFFER	NAMELIST variable NOSETS in the input- and restart-file data differ. The NOSETS para-meter must be set either to 0, 1, or 2 in both files.
RDREST	*1*	*INCOMPATIBLE RESTART FILE FORM*	*The restart file cannot be used with this TRAC-P version.*

Subroutine	Level	Error Message	Explanation
RDREST	1	RESTART FILE HAS OPENING ERROR	An I/O error occurred when the restart file was opened.
RDREST	1	TYPE NOT RECOGNIZED IN RESTART	An invalid component type was specified.
READI	2	BAD STRING LENGTH	Invalid string length from call to subroutine RJUSTL.
READI	1	ILLEGAL INDEX IN COMPUTED GO TO	The number of integer variables specified on an input card must not exceed 5.
READI	2	INPUT ERROR ON CARD NO. XXXX -- ENCOUNTERED UNEX-PECTED LOAD DATA	A load operation error was found when integer data in I14 format were read.
READI	2	INPUT ERROR-- NEW COMPONENT OR END ENCOUNTERED UNEX-PECTEDLY ON CARD NO. XXXX	Data for a new component were found before all of the data for the current component were read.
READI	2	INPUT ERROR ON CARD NO. XXXX -- REAL DATA ENCOUNTERED IN INTEGER FIELD	Real data were found when integer data in I14 format were read.
READI	2	INPUT ERROR -- UNEXPECTED NAMELIST DATA ENCOUNTERED	When integer data in I14 format were read, NAMELIST data were found.
READI	2	REPEAT LEVEL CARD MISPLACED	A repeat-level card was found when integer data in I14 format were read.
READI	1	UNEXPECTED END-OF-FILE REACHED	An end-of-file was found when I14-format integer data were read.
READI	2	UNEXPECTED NAMELIST DATA ENCOUNTERED	Unrecognizable data was read that probably is NAMELIST data.

Subroutine	Level	Error Message	Explanation
READR	2	BAD STRING LENGTH	Invalid string length from call to subroutine RJUSTL.
READR	1	ILLEGAL INDEX IN COMPUTED GO TO	The number of real variables specified on an input card must not exceed 5.
READR	2	INPUT ERROR-- NEW COMPONENT OR END ENCOUNTERED UNEX-PECTEDLY ON CARD NO. XXXX	Data for a new component were found before all of the data for the current component were read.
READR	2	INPUT ERROR ON CARD NO. XXXX -- ENCOUNT-ERED UNEXPECTED LOAD DATA	A load operation was found when reading nonarray real data in E14.4 format.
READR	2	INTEGER RATHER THAN REAL VALUE	
READR	2	INPUT ERROR -- UN-EXPECTED NAMELIST DATA ENCOUNTERED	When reading real data in E14.4 format, NAMELIST data were found.
READR	2	REPEAT LEVEL CARD MISPLACED	A REPEAT LEVEL card was found when reading real data in E14.4 format.
READR	1	UNEXPECTED END-OF-FILE REACHED	An end-of-file was found when reading E14.4-format real data.
REBRK	*1*	*FATAL ERROR*	*An error stopped the processing of restart data.*
REBRK	*2*	*LCM OVERFLOW*	*Insufficient LCM is available for the BREAK data from the restart file.*
REBRK	*2*	*POINTER TABLE MISMATCH*	*The BREAK pointer table does not match the restart-file data.*
RECNTL	2	BAD COMPONENT NUMBER	The component number defining a signal variable could not be found in the IORDER array of all components in the system model.

Subroutine	Level	Error Message	Explanation
RECNTL	1	CONTROL BLOCKS EXCEED DIMENSION	The amount of control-block data in the input and restart files exceeds its storage allocation on Main-Data Card 5.
RECNTL	1	CONTROL PARA. STORAGE TOO SMALL	The variable storage that was allocated by the input data for the signal variables, control blocks, and trips is too small to contain the remaining data from the restart file.
RECNTL	1	NUMBER TRIPS EXCEEDS DIMENSION	The number of trips with different ID numbers from the input and the restart files exceeds the input data-storage dimension.
RECNTL	1	SET-PT-FACTOR TABLES EXCEED DIM.	The number of different set-point factor-table ID numbers in the input and restart files exceeds the input data-storage dimension.
RECNTL	1	SIG. VARIABLES EXCEED DIMENSION	The number of signal variables with different ID numbers in the input and restart files exceeds the input data-storage dimension.
RECNTL	1	TIME STEP DATA EXCEED DIMENSION	The number of trip-controlled timestep data sets with different ID numbers in the input and restart files exceeds the input data-storage dimension.
RECNTL	1	TOO MANY DMP TRIPS FROM RESTART	The number of trip ID numbers in the input and restart files exceeds the input data-storage dimension. These trip ID numbers when set ON generate restart dumps.
RECNTL	1	TOO MANY SETPOINT-FACTOR TABLES	The number of setpoint factor tables in the restart file exceeds the data-storage dimension.

Subroutine	Level	Error Message	Explanation
RECNTL	1	TOO MANY SP. TIME-STEP DATA SETS	The number of trip-controlled timestep data sets in the restart file exceeds the input data-storage dimension.
RECNTL	1	TOO MANY TRIPS GENERATING DUMPS	The number of trip ID numbers in the restart file exceeds the input data-storage dimension. These trip ID numbers when set ON generate restart-data dumps.
RECNTL	1	TRIP-SIGNAL EXPS. EXCEED DIMEN.	The number of signal-expression ID numbers in the input and restart files exceeds the input data-storage dimension.
RECNTL	1	TRP-CONT-TRP SIGNALS EXCEED DIM.	The number of trip-controlled trip ID numbers with different ID numbers in the input and restart files exceeds the input data-storage dimension.
REFILL	*1*	*FATAL ERROR*	*An error stopped the processing of the input data.*
REFILL	*2*	*LCM OVERFLOW*	*Insufficient LCM is available for the FILL data from the restart file.*
REFILL	*2*	*POINTER TABLE MISMATCH*	*The FILL pointer table does not match the restart-file data.*
REFILL	*2*	*SCM OVERFLOW*	*Insufficient SCM is available for this FILL.*
REHTST	*2*	*POINTER TABLE SIZE HAS MISMATCH*	*The HTSTR pointer table does not match the restart-file data.*
RENC	*1*	*MEMORY SETUP FOR RADIATION MODEL BAD*	*The LENDRD pointer for storing radiation-model data does not equal the IFREE pointer for available A array free space.*

Subroutine	Level	Error Message	Explanation
RENC1	*1*	*PROBLEM FINDING UNIQUE TOTAL FACES*	*The NUTFCE number of faces found doesn't equal the NTMP expected number of unique faces in the radiation model.*
REPIPE	*2*	*POINTER TABLE MISMATCH*	*The PIPE pointer table does not match the restart-file data.*
REPLEN	*2*	*POINTER TABLE MISMATCH*	*The PLENUM pointer table does not match the restart-file data.*
REPRZR	*2*	*POINTER TABLE MISMATCH*	*The PRIZER (pressurizer) pointer table does not match the restart-file data.*
REPUMP	*2*	*POINTER TABLE MISMATCH*	*The PUMP pointer table does not match the restart-file data.*
RETEE	*2*	*POINTER TABLE MISMATCH*	*The TEE pointer table does not match the restart-file data.*
RETURB	*2*	*POINTER TABLE MISMATCH*	*The TURB (turbine) restart pointers do not match the restart-file data.*
REVLVE	*2*	*POINTER TABLE MISMATCH*	*The VALVE pointer table does not match the restart-file data.*
REVSSL	*2*	*POINTER TABLE MISMATCH*	*The VESSEL pointer table does not match the restart-file data.*
REVSSL	*2*	*VESSEL TOO LARGE*	*A VESSEL component being modelled is too large for the current parameter statement dimensions of TRAC-P.*
RFDBK	1	CORE NZ+1000 INTERFACE NOT FOUND	The hydraulic-cell interface NZ in the powered-core region could not be located in the A(LIDHT) array.
RFILL	2	BAD FILL TYPE OPTION	An illegal FILL option was specified on FILL Card Number 2.
RFILL	2	BAD TRIP ID DEFINITION	An invalid trip ID of < –9999 or > 9999 was specified.

Subroutine	Level	Error Message	Explanation
RFILL	2	IFSV = 0 WHEN IFTY .GT. 3	A FILL table, based on IFTY > 4, cannot be defined because no table independent-variable ID number was specified.
RFILL	2	INCONSISTENT INIT AND TABLE FLOW	The initial values for the FILL table and for the FILL initial state are not equal.
RFILL	2	PAIN MUST NOT BE GREATER THAN PIN	The noncondensable-gas partial pressure is greater than the total pressure in a FILL.
RFILL	*2*	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RHTSTR	*2*	*ADIA. SURF. CANNOT BE A PART OF RADI. ENCL*	*A surface with an adiabatic b.c. cannot have energy exchange from a radiation enclosure.*
RHTSTR	2	DIMENSION NRFMX .LT. NODES	Maximum number of radial heat conduction nodes has been exceeded. Either the TRAC-P parameter NRFMX must be increased or NODES must be decreased.
RHTSTR	2	DIMENSION NZFMX .LT. NCRZ + 1	Maximum number of axial heat conduction nodes has been exceeded. Either the TRAC-P parameter NZFMX must be increased or NCRZ and/or NZMAX must be decreased.
RHTSTR	2	EITHER IDBCI OR IDBCO MUST BE 2	Either the inner surface or the outer surface of the HTSTR must have a boundary condition coupled to specified cells in one or more hydraulic components.
RHTSTR	*1*	*ENCLOSURES ARE RESTRICTED TO HAVE NRODS = 1*	*NRODS & NCRX must be 1 for HTSTR components with radiation-enclosure heat transfer.*

Subroutine	Level	Error Message	Explanation
RHTSTR	2	FISPHI CANNOT BE .LT. ZERO	The number of fissions per initial fissile atom must be positive in value.
RHTSTR	2	GRAV IS OUTSIDE RANGE (–1.0D0, 1.0D0)	When specifying a gravity term, the allowable input-value range is $-1.0 \leq GRAV \leq 1.0$.
RHTSTR	2	HDRI MUST BE GREATER THAN ZERO	The thermal diameter for the inner surface of the HTSTR ROD or SLAB must be > 0.0 m (0.0 ft).
RHTSTR	*2*	*HYDRO-CELL INFO GIVEN FOR ENCLOSURE FACE DOES NOT AGREE WITH THAT GIVEN EARLIER*	*The inner- or outer-surface hydraulic and radiation information have inconsistent cell numbers.*
RHTSTR	2	HDRO MUST BE GREATER THAN ZERO	The thermal diameter for the outer surface of the HTSTR ROD or SLAB must be > 0.0 m (0.0 ft).
RHTSTR	2	HOT PATCHES ONLY IN ONE SLAB	Hot patch modelling is allowed only in one SLAB at this time.
RHTSTR	2	HTMLI IS OUT SIDE RANGE (0.9D0,1.1D0)	The input for a heat transfer design-multiplier factor is incorrect.
RHTSTR	2	HTMLO IS OUT SIDE RANGE (0.9D0,1.1D0)	The input for a heat transfer design-multiplier factor is incorrect.
RHTSTR	2	HTMVI IS OUT SIDE RANGE (0.9D0,1.1D0)	The input for a heat transfer design-multiplier factor is incorrect.
RHTSTR	2	HTMVO IS OUT SIDE RANGE (0.9D0,1.1D0)	The input for a heat transfer design-multiplier factor is incorrect.
RHTSTR	*1*	*INSUFFICIENT MEMORY TO CONTINUE INPUT PROCESSING*	*Insufficient computer memory exists to continue input processing.*

Subroutine	Level	Error Message	Explanation
RHTSTR	2	IRFTR .NE. 0 TO MODEL HOT PATCHES	Hot patch modelling requires the axial fine-mesh option to be selected.
RHTSTR	2	IRFTR IS GT 0 BUT MHTL(V)S ARE NOT 0	Option for input specifying wall-to-liquid or vapor heat transfer multiplicative design factors for HTSTR components is not consistent with reflood trip.
RHTSTR		M1D VALUE NOT IN CORRECT SEQUENCE	There is an input error for a neutronics calculation group.
RHTSTR	2	NEWRFD .EQ. 1 MODELS HOT PATCHES	Hot patch modelling requires the new reflood model option to be selected.
RHTSTR	2	NHCELI(1) SET EQUAL TO -NHCELI(2)	TRAC-M has internally reset HTSTR/hydro coupling.
RHTSTR	2	NHCELO(1) SET EQUAL TO -NHCELO(2)	TRAC-M has internally reset HTSTR/hydro coupling.
RHTSTR	2	NHCOMI(1) SET EQUAL TO NHCOMI(2)	TRAC-M has internally reset HTSTR/hydro coupling.
RHTSTR	2	NHCOMO(1) SET EQUAL TO NHCOMO(2)	TRAC-M has internally reset HTSTR/hydro coupling.
RHTSTR	2	NO INNER-SF. PRESSURE	There is an incorrect specification for a CSS type-5 controller.
RHTSTR	2	NO OUTER-SF. PRESSURE	There is an incorrect specification for a CSS type-5 controller.
RHTSTR	2	NODES MUST BE GREATER THAN 0	There is a HTSTR input error.
RHTSTR	*1*	*NOT ENOUGH MEMORY FOR A(LRFTN)*	*Insufficient memory exists to load the temperature array.*
RHTSTR	2	NRODS MUST BE GREATER THAN 0	There is a HTSTR input error.

Subroutine	Level	Error Message	Explanation
RHTSTR	2	NZMAX .LT. NCRZ + 1 + SUM(NFAX(I))	The maximum number of rows of nodes in the axial direction must be greater than the sum of all the fine-mesh and coarse-mesh nodes.
RHTSTR	2	Q235 CANNOT BE .LE. TO ZERO	The energy per fission from ^{235}U must be positive.
RHTSTR	2	Q238 CANNOT BE .LE. TO ZERO	The energy per fission from ^{238}U must be positive.
RHTSTR	2	Q239 CANNOT BE .LE. TO ZERO	The energy per fission from ^{239}Pu must be positive.
RHTSTR	2	QAVG CANNOT BE .LE. TO ZERO	The average energy per fission must be positive.
RHTSTR	2	R239PF CANNOT BE .LE. TO ZERO	The atoms of ^{239}U produced per fission must be positive.
RHTSTR	2	RANS CANNOT BE .LE. TO ZERO	The multiplier applied to the ANS79 decay heat must be positive.
RHTSTR	2	ROD RADII NOT MONO. INCREASING	Indicates input values for which RADRD(I) ≥ RADRD(I+1).
RHTSTR	2	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT*
RHTSTR	2	Z(K) NOT MONOTONIC	The axial location of heat-trans-fer nodes must be monotonically increasing in value along the length of the HTSTR ROD OR SLAB element.
RKIN	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	An invalid value for IRPWTY has occurred.
RLEVEL	2	NEGATIVE CFZV, CFRL, CFRV VALUE	These Vessel input arrays cannot have negative values.

Subroutine	Level	Error Message	Explanation
RODHT	1	NRPWR GREATER THAN LOCAL DIM 50	A hardwired dimension was exceeded in the HTSTR heat conduction calculation.
RODHT	1	SINGULAR MATRIX IN BANSOL	An error has occurred within subroutine BANSOL during the solution for the new HTSTR temperatures.
RPIPE	2	INCONSISTENT INIT AND TABLE POWER	The initial values for the PIPE power-to-fluid table POWTB and for the PIPE power-to-fluid variable POWIN are not equal.
RPIPE	2	INCONSISTENT INIT AND TABLE QPPPF	The initial values for the PIPE power-to-wall table QP3TB and for the PIPE power-to-wall variable QP3IN are not equal.
RPIPE	*2*	*VLT SIZE E EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RPLEN	2	ICONC & ISOLUT ARE INCONSISTENT	Solute concentrations were entered when ISOLUT = 0
RPLEN	1	JUNS1 AND JUNS2 INCOMPATIBLE	The number of junctions on each side of the PLENUM cell should be either 0 or positive in value.
RPLEN	1	NPLJN .LE. JUNS1	The number of side 1 junctions must be less than the total number of PLENUM junctions.
RPLEN	1	NPLJN .LE. JUNS2	The number of side 2 junctions must be less than the total number of PLENUM junctions.
RPLEN	2	PA MUST NOT BE GREATER THAN P	The noncondensable-gas partial pressure may not exceed the total pressure for a hydro-dynamic cell.

Subroutine	Level	Error Message	Explanation
RPLEN	2	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RPRIZR	2	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RPUMP	2	BAD QPPP-FACTOR TABLE PARAMETER	Invalid scalar parameters input for the QPPP component action.
RPUMP	2	BAD SPEED-TABLE PARAMETER	Invalid scalar parameters input for the pump-speed component action.
RPUMP	2	BAD TRIP ID DEFINITION	An incorrect trip ID of 0, < –9999, or > 9999 was specified.
RPUMP	2	FRIC(2) .NE. 0.	The value for FRIC(2) must be 0.0 in the PUMP.
RPUMP	2	INCONSISTENT INIT AND TABLE QPPPF	The initial values for the power--to-wall table QP3TB and for the power-to-wall variable QP3IN are not equal.
RPUMP	2	INCONSISTENT INIT AND TABLE SPEED	The initial values for the pump-speed table and for the pump speed are not equal.
RPUMP	2	IPMPSV .NE. 0	The independent-variable ID number for the pump-speed table should not be defined for PUMP type 2.
RPUMP	2	NCELLS .LT. 2	An incorrect number of PUMP fluid cells was specified. The PUMP must have at least two fluid cells.
RPUMP	2	NPMPRF .NE. 0	The number of the rate-factor table's entry pairs should be zero for PUMP type 2.

Subroutine	Level	Error Message	Explanation
RPUMP	2	NPMPSV .NE. O	The independent-variable ID number for the rate-factor table assigned to the pump-speed table should not be defined for PUMP type 2.
RPUMP	2	NPMPTB .NE. 0	The number of the pump-speed table's entry pairs should be zero for PUMP type 2.
RPUMP	2	PUMP TYPE NOT RECOGNIZED	An incorrect PUMP type was specified.
RPUMP	2	TYPE 0 PUMP MUST HAVE SPEED CONTROLLER	The ID number of the signal-variable or control-block parameter (NPMPSD) that defines the pump-impeller rotational speed initially when the con-trolling trip is OFF is invalid for a type 0 PUMP (IPMPTY = 0).
RPUMP	*2*	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RROD1	2	BAD INPUT FOR FP235 AND FP238	The input values of FP235 and FP238 and the value of FP239 = 1.0 – FP235 – FP238 must lie in the value range $0.0 \leq FP\# \leq 1.0$ for # = 235, 238, and 239.
RROD1	2	BAD INPUT FOR Q235	Q235 must have a value that lies in the value range QLOW = $180.0 \leq Q235 \leq 220.0$ = QHIGH.
RROD1	2	BAD INPUT FOR Q238	Q238 must have a value that lies in the value range QLOW = $180.0 \leq Q238 \leq 220.0$ = QHIGH.
RROD1	2	BAD INPUT FOR Q239	Q239 must have a value that lies in the value range QLOW = $180.0 \leq Q239 \leq 220.0$ = QHIGH.

Subroutine	Level	Error Message	Explanation
RROD1	2	BAD INPUT FOR QAVG	QAVG must have a value that lies in the value range QLOW = 180.0 ð QAVG ð 220.0 = QHIGH.
RROD1	2	BAD TRIP ID DEFINITION	The trip ID number must not be 0, <–9999, or >9999.
RROD1	2	INCONSISTENT REACT-POWER TABLE	The IRPWSV independent variable for the reactivity-power table must be specified when IRPWTY = 3, 4, 7, 13, 14, or 17.
RROD1	2	INCONSISTENT REACT-POWER TRIP	The trip ID number IRPWTR that controls the evaluation of the reactivity-power table must be specified when IRPWTY = 3, 4, 7, 13, 14, or 17.
RROD1	2	IPWRAD HAS OUT-OF-RANGE VALUE	Allowable input values for IPWRAD are 0 and 1.
RROD1	2	IPWDEP HAS OUT-OF-RANGE VALUE	Allowable input values for IPWDEP are –1, 0, or 1.
RROD1	2	INVALID REACT-POWER TYPE OPTION	When specifying the neutronic point-kinetics or reactor-power option, the allowable input-value range for IRPWTY is $1 \leq$ IRPWTY ≤ 7 or $11 \leq$ IRPWTY ≤ 17.
RROD1	2	NOT ENOUGH FUEL RODS	The total number of ROD or SLAB elements defined by NRODS cannot be less than the number of different average (power) ROD or SLAB elements defined by NCRX.
RROD2	2	BAD ENTRY IN FP235/FP239 TABLE	When specifying the fractions of fission power associated with ^{235}U and ^{239}U fission, the allowable input-value range for FP235 and FP239 is $0.0 \leq$ FP235 ≤ 1.0 and $0.0 \leq$ FP239 ≤ 1.0. In addition, it is assumed that FP235 + FP239 + FP238 = 1.0.

Subroutine	Level	Error Message	Explanation
RROD2	2	INCONSISTENT HEATED LENGTHS	The total length for the independent variable for the axial-power profile must equal the length of the HTSTR-compo-nent ROD or SLAB element.
RROD2	2	INCONSISTENT RADIAL HEATED LENGTHS	The total length for the independent variable for the radial-power profile must equal the RADRD(NODES) – RADRD(1) radial or slab width of the HTSTR-component ROD or SLAB element.
RROD2	2	INIT & TABLE REACT-POWER UNEQUAL	The initial value of power-reactivity must be the same as the interpolated table value.
RROD2	*2*	*NEED MORE STORAGE TO LOAD FP239*	*Insufficient temporary storage exits to load the FP239 data. NHIST must be decreased.*
RROD2	*2*	*NEED MORE STORAGE FOR PHIST*	*Insufficient temporary storage exits to load the PHIST data.*
RROD2	2	REQUIRE 0.0D0 .LT. FTD .LE. 1.0D0	When specifying the fraction of the theoretical fuel density, the allowable input-value range is $0.0 < FTD \leq 1.0$.
RROD2	2	RPWRT(K) NOT MONOTONIC	The elements of array RPWRT do not monotonically increase.
RROD2	2	ZPWZT(K) NOT MONOTONIC	The axial locations along the HTSTR ROD or SLAB elements at which axial-power shape relative power densities are defined must increase mono-tonically.
RSTVLT	1	COMPONENT TYPE NOT RECOGNIZED	There is an incorrect call to RSTVLT for reading a restart VLT.

Subroutine	Level	Error Message	Explanation
RTEE	1	ICBS1 AND ICBS2 MUST BE .GT. 0	When modelling a SEPD (separator) component, the control-block ID numbers that define carryover and carryunder must be negative.
RTEE	2	INCONSISTENT INIT AND TABLE POWER1	The TEE primary-side initial values for the power-to-fluid table POWTB and for the power-to-fluid variable PWIN1 are not equal (also written for SEPD).
RTEE	2	INCONSISTENT INIT AND TABLE POWER2	The TEE secondary-side initial values for the power-to-fluid table POWTB and for the power-to-fluid variable PWIN2 are not equal (also written for SEPD).
RTEE	2	INCONSISTENT INIT & TABLE QPPPF1	The TEE primary-side initial values for the power-to-wall table QP3TB and for the power-to-wall variable QPIN1 are not equal (also written for SEPD).
RTEE	2	INCONSISTENT INIT & TABLE QPPPF2	The TEE secondary-side initial values for the power-to-wall table QP3TB and for the power-to-wall variable QPIN2 are not equal (also written for SEPD).
RTEE	2	INCONSISTENT VALUES FOR ICFLG	All nonzero values of ICFLG must be the same in the TEE (also written for SEPD).
RTEE	2	IOFFTK .NE. 0 OR 1	When specifying the offtake model option, the allowable input values for NAMELIST variable IOFFTK are 0 and 1 (also written for SEPD).
RTEE	1	INVALID VALUE OF ISTAGE	When modelling a SEPD (separator) component, the allowable input values for the separator-type option ISTAGE are –3, –2, 0, 1, 2, and 3.

Subroutine	Level	Error Message	Explanation
RTEE	2	JCELL NOT ON TEE PRIMARY SIDE	JCELL must have a value in the. range 1 ≤ JCELL ≤ NCELL1 (also written for SEPD).
RTEE	2	NFF .LT. 0 AT JCELL PRIMARY INTERFACES	NFF should not have a negative value for JCELL interfaces on the main tube because no flow-area change is assumed between JCELL and JCELL+–1 (also written for SEPD).
RTEE	2	NFF .LT. 0 AT JCELL SECONDARY INTERFACE	NFF should not have a negative value for the JCELL interface on the side tube because no flow-area change is assumed between JCELL and side-tube cell 1 (also written for SEPD).
RTEE	2	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LEN-DIM in BLKDAT and to change the dimension in GENVLT.*
RTTR	1	CODING ERROR NO. 1 IN RTTR	The LEFT JCELL–1/2 interface of JCELL has a fluid name that is not LIQUID or VAPOR.
RTTR	1	CODING ERROR NO. 2 IN RTTR	The RIGHT JCELL+1/2 interface of JCELL has a fluid name that is not LIQUID or VAPOR.
RTTR	3	CODING ERROR NO. 3 IN RTTR	The interface of JCELL is not JCELL–1/2 or JCELL+1/2.
RTURB	2	*# STAGES .LT. 1*	*A TURB (turbine) component must have at least one stage.*
RTURB	2	*INCONSISTENT INIT AND TABLE GEN POWER*	*The turbine power table's initial power and the initial operating power POWOP have different values.*
RTURB	2	*NCELLS .LT. 3*	*The number of cells in the TURB component is incorrect; this component must have at least three cells.*

Subroutine	Level	Error Message	Explanation
RTURB	2	*POWER TABLE PARAM. BAD*	*Direct power into the coolant table is defined, but its independent-variable ID number is zero.*
RTURB	2	*STAGE DESIGN PRESSURE RATIO .GT. 1.0*	*The stage downstream design pressure input specified by PRES2 must be greater than the stage upstream design pressure input specified by PRES1.*
RTURB	2	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RVLVE	2	BAD FIRST VALVE TABLE	A second VALVE table is defined while a first VALVE table is not defined.
RVLVE	2	BAD QPPPF TABLE SIGNAL	The QPPP-factor table is defined, but its IVSV independent-variable ID is zero.
RVLVE	2	BAD OVERRIDING TRIP VALVE ADJUST RATE	The overriding trip's VALVE adjustment rate is negative.
RVLVE	2	BAD OVERRIDING TRIP VALVE RANGE	The overriding trip's minimum and maximum VALVE closure states do not lie between 0.0 and 1.0.
RVLVE	2	BAD OV TRIP VALVE TYPE	An overriding trip is defined, but its VALVE type IVTYOV is not 0 or 1.
RVLVE	2	BAD TRIP ID DEFINITION	An invalid trip ID number of 0, < –9999, or > 9999 was specified.
RVLVE	2	BAD VALVE TABLE DEFINE	The number of pair entries in the first VALVE table is inconsistent with the VALVE option IVTY value.
RVLVE	2	BAD VALVE TABLE MAX ADJUST RATE	The VALVE's maximum adjustment rate is negative.

Subroutine	Level	Error Message	Explanation
RVLVE	2	BAD VALVE TABLE SIGNAL	The signal-variable ID number defining the VALVE table's independent variable is inconsistent with the VALVE option IVTY value.
RVLVE	2	BAD VALVE TABLE TRIP	A nonzero trip ID number is input when the VALVE type option indicates no trip control, or a zero trip ID number is input when the VALVE is to be trip controlled.
RVLVE	2	BAD VALVE TYPE OPTION	The VALVE option parameter IVTY has an input value outside the 0 to 6 defined range.
RVLVE	2	FAVLVE & XPOS INVALID	The input values of FAVLVE and XPOS are both outside their 0.0 to 1.0 physical range.
RVLVE	2	INCONSISTENT INIT & FIRST TABLE	The first VALVE table's initial value and the initial FAVLVE or XPOS valve-closure state have different values.
RVLVE	2	INCONSISTENT INIT & SECOND TABLE	The second VALVE table's initial value and the initial FAVLVE or XPOS valve-closure state have different values.
RVLVE	2	INCONSISTENT INIT & TABLE QPPPF	The QPPP-factor table's initial value and the initial QPPP factor QFPIN have different values.
RVLVE	*2*	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT file to increase LENDIM in BLKDAT and to change the dimension in GENVLT.*
RVSSL	2	CORE AXIAL FLOW BLOCKED	The core-region flow area in the axial direction is zero at a VESSEL level causing axial-flow blockage through the core plane.

Subroutine	Level	Error Message	Explanation
RVSSL	1	END-OF-FILE REACHED READING LEVEL DATA	An end-of-file was encountered while reading VESSEL level data.
RVSSL	1	I/0 ERROR	An error occurred in an input routine while looking for a repeat card.
RVSSL	2	ICONC & ISOLUT ARE INCONSISTENT	The input values for ICONC and ISOLUT = 0 are not consistent.
RVSSL	2	ILLEGAL REPEAT LEVEL NUMBER USED	An illegal level number was read from a REPEAT LEVEL card.
RVSSL	1	ILLEGAL VALUE FOR IVSSBF	The only allowed values for IVSSBF are 0, 2, 20, and 22.
RVSSL	2	INCONSISTENT CORE DEFINING DATA	Indicates either NASX < IDCU or NRSX < IDCR or IDCL $\geq$ IDCU when a downcomer reg-ion is present (IDCU $\neq$ 0, IDCL $\neq$ 0, IDCR $\neq$ 0).
RVSSL	2	INCONSISTENT CORE DIM PARAMETERS	The reactor-core region model parameters ICRU, ICRL, and ICRR are defined inconsistently.
RVSSL	2	INCONSISTENT LEVEL ELEVATIONS	Indicates there are input values of $z_k \geq z_{k+1}$.
RVSSL	2	INCONSISTENT RING RADII	Indicates there are input values of $r_i \geq r_{i+1}$ $(x_i \geq x_{i+1})$.
RVSSL	2	INCONSISTENT THETA ANGLES	Indicates there are input values of $\theta_j \geq {}_{j+1}$ $(y_j \geq y_{j+1})$.
RVSSL	*1*	*INSUFFICIENT MEMORY FOR INPUT*	*Insufficient computer memory exists to load the VESSEL input data.*
RVSSL	2	LAST THETA ANGLE IS INCORRECT	When specifying the last θ_{NTSX} angle, the allowable input values for θ_{NTSX} are 30, 45, 60, 90, 120, 180, or 360 degrees if the NTSX azimuthal interface has fluid-flow area between sectors 1 and NTSX.

Subroutine	Level	Error Message	Explanation
RVSSL	2	NEWRFD = 1 TO MODEL SPACER GRIDS	To model spacer grids within the VESSEL reactor-core region, the reflood model must be selected by NEWRFD = 1.
RVSSL	2	NSGRID MUST BE .GE. 0	The number of spacer grids in the VESSEL core region cannot be negative.
RVSSL	2	PAN MUST EQUAL 0.0D0 IF NOAIR = 1	If the NOAIR = 1 NAMELIST option was selected, then all noncondensable-gas partial pressures must be input as zero.
RVSSL	2	PAN MUST NOT BE GREATER THAN PN	The noncondensable-gas partial pressure is greater than the total pressure in a cell of a VESSEL level.
RVSSL	*2*	*VESSEL TOO LARGE*	*The VESSEL dimensions are larger than the maximum allowed by the TRAC-P parameter constants NXRMX, NYTMX, and NZMX. These parameters must be increased or the VESSEL size reduced.*
RVSSL	*2*	*VLT SIZE EXCEEDS ITS LIMIT*	*Instructions were given in the TRCOUT to increase file LENDIM in BLKDAT and to change the dimension in GENVLT.*
RVSSL	2	VWFMLY LT 0.9D0 OR GT 1.1D0	The input value for VWFMLY must lie between 0.9 and 1.1.
RVSSL	2	VWFMLZ LT 0.9D0 OR GT 1.1D0	The input value for VWFMLZ must lie between 0.9 and 1.1.
RVSSL	2	VWFMLX LT 0.9D0 OR GT 1.1D0	The input value for VWFMLX must lie between 0.9 and 1.1.
RVSSL	2	VWFMVY LT 0.9D0 OR GT 1.1D0	The input value for VWFMVY must lie between 0.9 and 1.1.
RVSSL	2	VWFMVZ LT 0.9D0 OR GT 1.1D0	The input value for VWFMVZ must lie between 0.9 and 1.1.

Subroutine	Level	Error Message	Explanation
RVSSL	2	VWFMVX LT 0.9D0 OR GT 1.1D0	The input value for VWFMVX must lie between 0.9 and 1.1.
SCLMOM	2	INCONSISTENT BD FLW-AREA RATIOS	The ratio of the interface flow area to its adjacent mesh-cell flow area at the VESSEL-com-ponent outer-wall boundary does not have its value defined the same as the ratio for the interface one mesh-cell distance outside the wall boundary. These values must be equal and positive when an internal boundary condition is defined.
SEPD1	1	CNTL. BLOCK NOT FOUND	There is an incorrect control block specification for the steam/water separator with ISTAGE = 1.
SEPD1	1	NEED .GE. 2 CONTROL BLOCKS	There is an incorrect control block specification for the steam/water separator with ISTAGE = 1.
SETLCM	*1,2*	*A-ARRAY OVERFLOW (CALLED BY SUBPROGRAM AAAA)*	*A subroutine of TRAC-P has requested more computer mem-ory than is available.*
SETLCM	*1,2*	*CANNOT EXPAND MEMORY (CALLED BY SUBPROGRAM AAAA)*	*A subroutine of TRAC-P has requested more computer mem-ory than is available.*
setRod (SetRodTab)	1	variable name not recognized	There was an incorrect call to SetRodTab to change a value in a HTSTRVLT.
SETTYPE	1	UNRECOGNIZED INPUT TYPE	There was an incorrect call to SETTYPE for TRAC-M's internal component-type identification.
SGEEV	1	JOB .NE. 0 AND N .GT. LDV	The user has requested eigen-vector calculation in addition to the eigenvalues. However, the leading dimension of array V, where eigenvectors are stored, is less than the order of the input matrix A.

Subroutine	Level	Error Message	Explanation
SGEEV	2	LDA .GT. LDV, ELEMENTS OF A OTHER THAN THE N BY N INPUT ELEMENTS HAVE BEEN CHANGED	The leading dimension of array V, where eigenvectors are stored, should be equal to the order of input matrix A. If this is not the case, the elements of A are rearranged.
SGEEV	2	LDA. LT. LDV, ELEMENTS OF V OTHER THAN THE N BY N OUTPUT ELEMENTS HAVE BEEN CHANGED	The leading dimension of array V, where eigenvectors are stored, should be equal to the order of input matrix A. If this is not the case, the elements of A are rearranged.
SGEEV	1	N .GT. LDA	The N order of input matrix A exceeds the leading dimension LDA of A.
SGEEV	1	N .LT. 1	The N order of input matrix A is < 1.
SGEFST	1	ITASK IS LESS THAN 1	The ITASK option number should be positive valued.
SGEFST	1	LDA IS LESS THAN N	The N order of input matrix A exceeds the leading dimension LDA of A.
SGEFST	1	N IS LESS THAN 1	The N order of input matrix A is < 1.
SGEFST	1	SINGULAR MATRIX A - NO SOLUTION	Matrix A is singular and cannot be inverted.
SGEFST	2	SOLUTION MAY HAVE NO SIGNIFICANCE	The number of significant digits of accuracy in the solution is estimated to be ≤ 0.
SOUND	2	CANNOT CONVERGE FOR MAXIMUM VAPOR FLOW	The iterative solution did not converge to determine the choking point when iterating on the cell-edge pressure while maximizing the mass flux.

Subroutine	Level	Error Message	Explanation
SOUND	2	CANNOT CONVERGE ON PA AT THE CELL EDGE	Cannot converge on the non-condensable-gas partial pressure while the conditions at the cell edge are estimated from the cell-center values.
SOUND	2	CANNOT FIND POSITIVE FLOW PRESSURE	When the flow is maximized by iteration of the cell-edge pressure, no physically realistic pressure value gives positive flow. This should never happen except under some extreme nonequilibrium conditions.
SOUND	2	CANNOT FIND THE EQUILIBRIUM CONDITION	Calculating the thermodynamic equilibrium condition in the presence of a noncondensable gas requires an iterative type solution, which did not con-verge.
SOUND	2	CANNOT FIND THE MAXIMUM FLOW POINT	When the flow is maximized by iteration of the cell-edge pressure, the decrease in pressure (down to physically realistic values) always keeps increasing the flow. Thus, the choking condition is never determined.
SOUND	2	CANNOT LOCATE SATURATION LINE	Saturation conditions could not be found corresponding to an isentropic expansion from the cell center to the choking plane.
SOUND	2	SOUND SPEED SOLUTION DID NOT CONVERGE	The iterative solution did not converge to determine the choking point when iterating on the cell-edge pressure while maximizing the mass flux.
SRTLP	1	SRTLP FAILURE	SRTLP failed because of an error in the component input data related to not finding a junction number match. See TRCOUT for additional information.

Subroutine	Level	Error Message	Explanation
StbVel1D	2	JCELL FLOW-AREA CHANGE	A flow-area change occurs be-ween JCELL−1 and JCELL+1 but the JCELL-interface motion equations do not evaluate its reversible flow loss.
STEADY	1	FAVOL CHANGE TOO LARGE	The change in volume-averaged flow area across an interface was found to be too large without an input-specified form loss at that interface.
STEADY	−2	STEADY-STATE SOLUTION NOT CONVERGED	The problem did not reach a steady-state solution within the specified timestep-data domains.
SVSET	1	TRIP ID NOT FOUND	The trip ID number assigned to a signal variable (defining the trip-signal or set-status value) could not be found in the list of trip ID numbers.
SVSET1	1	ILLEGAL INDEX IN COMPUTED GO TO	The computed GO TO index, based on the signal-variable parameter ISVN, does not have a valid value.
SVSET1	1	INVALID SIG.-VAR. PARAM. NUMBER	The signal-variable parameter ISVN does not have a valid value based on definable parameters for a 1D hydraulic component.
SVSET3	1	ILLEGAL INDEX IN COMPUTED GO TO	The computed GO TO index, based on the signal-variable parameter ISVN, does not have a valid value.
SVSET3	1	INVALID SIG.-VAR. PARAM. NUMBER	The signal-variable parameter ISVN does not have a valid value based on definable parameters for a 3D VESSEL component.
SVSET3	1	TOO FEW LEVELS DIMENSIONED FOR	A VESSEL component has more than 50 levels and arrays VOLLEV and DZLEV are dimensioned in subroutine SVSET3 for a maximum of 50 levels.

Subroutine	Level	Error Message	Explanation
SVSETH	1	ILLEGAL INDEX IN COMPUTED GO TO	The computed GO TO index, based on the signal-variable parameter ISVN, does not have a valid value.
SVSETH	1	INVALID SIG.-VAR. PARAM. NUMBER	The signal-variable number ISVN does not have a valid value based on definable parameters for a HTSTR component.
]SVSETH	1	NO POWER IN THIS HEAT STRUCTURE	The signal-variable parameter reactor power (ISVN = 18) or reactor period (ISVN = 19) cannot be defined for a nonpowered (NOPOWR = 1) HTSTR component.
TEE1	1	CNRL. BLOCK NOT FOUND	The control block ID specified as part of the separator model could not be found.
TEE1	1	NEED .GE. 2 CONTROL BLOCKS	At least two control blocks are needed for the separator model.
TEEMET	1	CODING ERROR IN TEEMET	Code-developer message for TEE momentum source logic.
TEEMF1	1	CODING ERROR IN TEEMF1	Code-developer message for TEE momentum source logic.
TEEMOM	1	CODING ERROR IN TEEMOM	Code-developer message for TEE momentum source logic.
TF3DS	1	NMS = 10 IN PARSET1 IS TOO SMALL	The number of source connections to a single 3D VESSEL cell has exceeded 10. The parameter NMS must be increased.
THERMO (THERMD)	2	LIQ. TEMP .LT. DATA FIT & LOW LIM	The D_2O liquid temperature in some cell has fallen below CEOSLP(32) = 2.769364E+02 K (38.81442°F).

Subroutine	Level	Error Message	Explanation
THERMO (THERMD)	2	LIQ TEMP .GT. DATA FIT & UP LIM	The D_2O liquid temperature in some cell has risen above CEOSLP(33) = 5.7800E+02 K (580.73°F).
THERMO (THERMD)	2	PRESSURE .LT. DATA FIT & LOW LIM	The D_2O pressure in some cell has fallen below CEOSLP(30) = 6.6010E+02 Pa (0.0957394 psia).
THERMO (THERMD)	2	PRESSURE .GT. DATA FIT & UP LIM	The D_2O pressure in some cell has risen above CEOSLP(31) = 1.0000E+07 Pa (1450.377 psia).
THERMO (THERMD)	2	VAP TEMP .LT. DATA FIT & LOW LIM	The D_2O gas temperature in some cell has fallen below CEOSLP(34) = 2.769364E+02 K (38.81442°F).
THERMO (THERMD)	2	VAP TEMP .GT. DATA FIT & UP LIM	The D_2O gas temperature in some cell has risen above CEOSLP(35) = 3.0000E+03 K (4940.33°F).
THERMO (THERMD)	2	VAP TEMP .GT. DATA FIT RANGE	The D_2O gas temperature in some cell has risen above 9.3285E+02 K (1219.46°F) but is below the upper-limit temperature of CEOSLP(35) = 3.0000E+03 K (4940.33°F).
THERMO (THERMH)	2	LIQUID TEMP LIMIT EXCEEDED	The H_2O liquid temperature in some cell has fallen below CEOSLP(32) = 2.7315E+02 K (32.0°F) or has risen above CEOSLP (33) = 7.1394E+02 K (825.42°F).
THERMO (THERMH)	2	PRESSURE LIMIT EXCEEDED	The H_2O pressure in some cell has fallen below CEOSLP(30) = 1.0000E+00 Pa (1.4504E-04 psia) or risen above CEOSLP(31) = 4.5000E+07 Pa (6526.7 psia).

Subroutine	Level	Error Message	Explanation
THERMO (THERMH)	2	VAPOR TEMP LIMIT EXCEEDED	The H_2O gas temperature in some cell has fallen below CEOSLP(34) = 2.7315E+02 K (32.0°F) or risen above CEOSLP(35) = 3.0000E+03 K (4940.3°F).
TIMCHK	2	TERMINATING DUE TO TIME LIMIT	The CPU time limit was reached before the end of the problem.
TIMSTP	4	CANNOT REDUCE TIMESTEP FURTHER	The timestep was reduced to the minimum allowed, and the outer iteration failed to converge.
TIMSTP	1	INTEGER RATHER THAN REAL VALUE	The timestep data was input with an integer value rather than real value for one or more of the timestep-data parameters.
TRAC	*1*	*NO SPACE FOR VERSION INFORMATION*	*The character data space for version information needs to be expanded.*
TRAC	*2*	*THIS EXECUTABLE HAS MEMORY PRESET TO ZERO*	*Los Alamos recommends that the computer memory be preset to negative indefinite.*
TRANS	1	FAVOL CHANGE TOO LARGE	The change in volume-averaged flow area across an interface was found to be too large without input-specifying a form loss at that interface.
TRIP	1	INVALID TRIP ID NUMBER	A trip ID number could not be found in the list of NTRP trips.
TRIP	1	THERE ARE NO TRIPS	A trip ID number is defined but the NTRP total number of trips is ≤ 0.
TRIPS	1	CONTROL BLOCK/s NOT INITIALIZED	After 10 evaluation passes, one or more control blocks could not have their XOUT output signal initialized because of an implicitly coupled signal loop.

Subroutine	Level	Error Message	Explanation
TRPSET	1	CNTL BLOCK NOT FOUND	A control-block ID number that defines a subexpression argument value for the trip signal could not be found in the list of control-block ID numbers.
TRPSET	1	CNTL SIGNAL NOT FOUND	A control-block ID number that defines the trip signal could not be found in the list of control-block ID numbers.
TRPSET	1	EXP. SIGNAL NOT FOUND	A signal-variable ID number that defines a subexpression argument value for the trip signal could not be found in the list of signal-variable ID numbers.
TRPSET	1	ILLEGAL INDEX IN COMPUTED GO TO STATEMENT	An incorrect value was assigned to the trip signal-expression variable ISE. This will occur only if there is a coding error.
TRPSET	1	SET-P-FACTOR TABLE ID NOT FOUND	The setpoint-factor table's ID number was not found in the list of setpoint-factor table ID numbers.
TRPSET	1	SIGNAL EXP. NOT FOUND	A signal-expression ID number that defines the trip signal could not be found in the list of signal-expression ID numbers.
TRPSET	1	S-P-FAC TABLE CON BLK NOT FOUND	The control-block ID number that defines the setpoint-factor table's independent variable was not found in the list of control-block ID numbers.
TRPSET	1	S-P-FAC TABLE SIG VAR NOT FOUND	The signal-variable ID number that defines the setpoint-factor table's independent variable was not found in the list of signal-variable ID numbers.

Subroutine	Level	Error Message	Explanation
TRPSET	2	TOO MANY PENDING ISET CHANGES	There are too many delay-time pending set-status changes for a trip.
TRPSET	1	TRIP-CONT-TRIP SIGNAL NOT FOUND	The trip-controlled-trip signal ID number that defines the trip-controlled-trip signal could not be found in the list of trip-controlled-trip signal ID numbers.
TRPSET	1	TRIP ID NO. NOT FOUND	The trip ID number used to define the trip-controlled-trip signal could not be found.
TRPSET	1	TRIP SIGNAL NOT FOUND	A signal-variable ID number that defines the trip signal could not be found in the list of signal-variable ID numbers.
UNCNVT	2	BAD UNITS CONVERSION FLAG	Invalid value for type of units conversion defined by IU.
UNCNVT	2	LABEL STRING NOT FOUND	A match could not be found between the string label input and the variable-name labels in array LABELS.
UNCNVTS	1	PASSED WRONG DIMENSIONS TO UNCNVTS	UNCNVTS is the scalar interface to units-conversion routine UNCNVT.
UNNUMB	2	UNIT LABEL STRING NOT FOUND	A match could not be found between the string label input and the variable-name labels in array LABELS.
UNNUMB	2	VARIABLE LABEL STRING NOT FOUND	A label was not found in array Labels for a real variable requiring units conversion
UNSVCB	2	BAD CB ID	A control block needs to be input along with the trip or component data, which need units conversion defined by the control block when IOINP = 1 or IOLAB = 1.

Subroutine	Level	Error Message	Explanation
UNSVCB	2	BAD SV ID	A signal variable needs to be input along with the trip or component data, which need units conversion defined by the signal variable when IOINP = 1 or IOLAB = 1.
UNSVCB	2	INVALID ID NUMBER	An ID number of 0 is an invalid ID number for a signal variable or control block.
VLVEX	*2*	*TURBINE CANNOT MEET POWER DEMAND*	*The turbine has been overloaded so much that with the governing valve fully open, it still cannot meet the power demand. This situation could sometimes temporarily occur under highly transient conditions when the steam flow through the turbine has not caught up with the power demand.*
VSSL1	1	VENT VALVE TABLE LOOKUP ERROR	An error was encountered while trying to interpolate in the vent-valve table.
VSSL2	*1*	*EXTRA ELEMENTS OUTSIDE BANDWIDTH*	*The number of matrix rows having nonzero elements out-side the VESSEL-matrix band-width exceeds LDIM, the maximum dimension for the order of the capacitance matrix.*
WIR	2	BAD IDHOLL LETTER	The individual letters in string IDHOLL should be either "I" or "R".
WIR	2	BAD VALUE FOR NWORDS	NWORDS < 1 or NWORDS > 5.
XTVBI3E	*1*	*ERROR CALLING CRAY2IEG*	*Cray-library routine CRAY2IEG was called to convert data to the IEEE format, and an error was encountered during its execution.*

Subroutine	Level	Error Message	Explanation
XTVINIT	1	ERROR OPENING TRCXTV	The OPEN statement for I/O channel 90 assigned to file TRCXTV failed.
ZPWRCI	1	NZPWZ GREATER THAN LOCAL DIM 99	The dimension of local arrays PWC, PWL, and PWR is 99 and needs to be ≥ NZPWZ.

APPENDIX M

INPUT FOR MULTIPLE QUENCH FRONT REFLOOD MODEL

TRAC-M/F77 contains a model for core reflood that treats simultaneous top-down and bottom-up quenching (Refs. M-1 and M-2). A few changes to the input specifications for file TRACIN are required to use this model, and to use the closure relation optimization method that was developed as a part of the TRAC-M/F77 reflood effort. These changes can be divided into those that affect the standard TRAC-M input and those that involve new variables. The following description of those changes has been adapted from Ref. M-1. Ref. M-1 should be consulted for additional information on the use of the optimizer (including additional files the optimizer uses).

M.1. Changes to Standard TRAC-M Input

NAMELIST flag inopt on Main-Data Card 2 must be set to 2 to activate the NAMELIST group rafopts variables, which have been added for the model's optimization logic (see Section M.2. for a description of these variables).

The NAMELIST group inopts variable NEWRFD has had its range extended to represent the following:

Variable	Value Range	Description	Default Value
newrfd	0	MOD 1 closure and original data storage	0
	1	original MOD2 reflood model and original data storage	
	2	MOD 1 closure and new data storage with multiple quench fronts	
	3	new reflood closure and new data storage with multiple quench fronts	

A new INOPTS namelist variable, IPATCH, has been added.

Variable	Value Range	Description	Default Value
ipatch	>largest hydro #,<1000	Heat Structure component having hot patches. Only one such Heat Structure is allowed. The user is also required to set idbco=1.	0

A new variable has been added to the HTSTR component Data Card 4. The variable, ICWTMP, is a flag that keeps the heat structure's temperature constant with time.

Card Number 4. (Format 2I14,2E14.6,I14) IDBCI,IDBCO,HDRI,HDRO,ICWTMP

Columns	Variable	Description
1-56	unchanged	unchanged
57-70	ICWTMP	Controller flag to keep constant temperatures over time. Default is off. Turned on by inputting integer 1.

The variable IPATCH was originally input on Heat Structure Card 5. This card is changed to eliminate this input.

Card Number 5. (Format E14.6) WIDTH

Columns	Variable	Description
1-14	WIDTH	unchanged

The variables ZLOBOT, ZLPTOP, ZUPBOT, and ZUPTOP for the hot patches' axial locations were originally input as card 6, this changes that to two cards, one for the lower patch and one for the upper. In addition, the hot patch temperatures are added to each respective card.

Card Number 6a. (Format 3E14.6) ZLPBOT,ZLPTOP,TLP

Columns	Variable	Description
1-14	ZLPBOT	Elevation of the lower hot patches' bottom
14-28	ZLPTOP	Elevation of the lower hot patches' top.
29-42	TLP	Temperature of the lower hot patches

Card Number 6b. (Format 3E14.6) ZUPBOT,ZUPTOP,TUP

Columns	Variable	Description
1-14	ZUPBOT	Elevation of the upper hot patches' bottom.
14-28	ZUPTOP	Elevation of the upper hot patches' top
29-42	TUP	Temperature of the upper hot patches

M.2. New TRAC-M Input

In addition to the standard-TRAC-M input changes, new input variables are required for optimization. These are input within the RAFOPTS namelist option. They are as follows:

ntune—number of parameter values to read from *rafin* by TRAC-M.

irafset—indicates closure coefficient set to use;

1 = Conditional (default)

2 = Absolute.

raftime—zero or greater value indicates TRAC-M to read *rafin* values; negative value indicates TRAC-M to ignore values in *rafin*.

rafopt—value of 1 indicates TRAC-M to activate closure parameter logic.

An example of this type of input for a Winfrith optimization run is as follows:

```
free format
*
*************
* main data *
*************
*
*       numtcr          ieos          inopt          nmat
            16             0              2             1
*
****************************************************************
****************************************************************
****************************************************************
*****                                                      *****
*                                                              *
*     winfrith-upflow post-CHF heat transfer experiment        *
*     test 405 : xeo = subcooled (xeo=-0.0167 at dryout point) *
*               p    = 2.2200E+05 Pa                           *
*               g    = 1.9960E+03 kg/m**2-s                    *
*               P    = 2.2180E+03 watts                        *
*                                                              *
*****                                                      *****
****************************************************************
****************************************************************
*
*
*****************
* namelist data *
*****************
*
 &rafopts  ntune=48,    irafset=1,    raftime=0.0,    rafopt=1.0 &
 &inopts  icflow=0, nhtstr=1, nrslv=1, ipatch=999, newrfd=1,
  ipowr=-1, tpowr=0.0, idiag=1, iadded=10 &
*
*        dstep         timet
          etc.
etc.
```

REFERENCES

M-1 R. A. Nelson, Jr., D. A. Pimentel, S. J. Jolly-Woodruff, and J. W. Spore, "Reflood Completion Report, Volume I: A Phenomenological Thermal-Hydraulic Model of Hot Rod Bundles Experiencing Simultaneous Bottom and Top Quenching and an Optimization Methodology for Closure Development," Los Alamos National Laboratory report LA-UR-98-3043 (April 1998).

M-2 B. E. Boyack, J. F. Lime, D. A. Pimentel, J. W. Spore, and T. D. Knight, "Reflood Completion Report, Volume II: Developmental Assessment of a New Reflood Model for the TRAC-M/F77 Code," Los Alamos National Laboratory report LA-UR-98-3043 (April 1998).

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10. SUPPLEMENTARY NOTES

F. Odar, NRC Project Manager

11. ABSTRACT *(200 words or less)*

The Transient Reactor Analysis Code (TRAC) was developed to provide advanced best-estimate predictions of postulated accidents in light-water reactors. The TRAC-P program has provided this capability for pressurized water reactors and for many thermal-hydraulic test facilities for approximately 20 years. However, the maintenance and portability of TRAC-P had become cumbersome because of the historical nature of the code and the inconsistent use of standardized FORTRAN. Thus, the Modernized TRAC (TRAC-M) was developed by recoding the TRAC-P algorithms to take advantage of the advanced features available in the FORTRAN 90 programming language while conserving the computational models available in the original code. The User's Manual is one of four describing various features of TRAC-M/F90. The User's Manual describes the components and control systems modeled in TRAC-M and gives detailed information the user needs to prepare an input-data file and carry out neutronic-thermal-hydraulic simulations using TRAC-M. This release of the TRAC-M/F90 User's Manual is consistent with TRAC-M/90, Version 3.0. Also, areas are described where TRAC-M/F90, Version 3.0 differs from TRAC-M/F77, Version 5.5.2, and input specifications are provided for both codes.

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