NUREG/CR-5254
BNL-NUREG-52168

Bias in Peak Clad Temperature Predictions Due to Uncertainties in Modeling of ECC Bypass and Dissolved Non-Condensable Gas Phenomena

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Prepared for
U.S. N[illegible]ear Regulatory Commission

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NUREG/CR-5254
BNL-NUREG-52168
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Bias in Peak Clad Temperature Predictions Due to Uncertainties in Modeling of ECC Bypass and Dissolved Non-Condensable Gas Phenomena

Manuscript Completed: April 1990
Date Published: September 1990

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NRC FIN A3952

ABSTRACT

The U.S. Nuclear Regulatory Commission (USNRC), its contractors and consultants have developed a methodology for evaluating Code Scaling, Applicability and Uncertainty (CSAU). The CSAU method is systematic, practical and auditable, and it has been demonstrated by applying it to the TRAC-PF1/MOD1, Version 14.3 code and its analysis of a Large Break Loss of Coolant Accident (LBLOCA) for a Westinghouse four-loop plant. In applying the methodology, the accident course is divided into three different phases, namely: Blowdown, Refill and Reflood. There are two distinct peaks in the clad temperature history, one in the Blowdown Phase and one in the Reflood Phase. The Peak Clad Temperature (PCT) of the Blowdown Phase is governed by fuel characteristics. The peak clad temperature of the Reflood Phase is governed by the phenomena affecting the Refill Phase as the clad temperature continues to rise almost adiabatically during the Refill phase. Specifically, the second PCT is affected by critical break flow, two-phase pump degradation and the phenomena related to Emergency Core Cooling System (ECCS) in the downcomer and lower plenum of the reactor vessel.

This report describes a general method for estimating the effect on the Reflood Phase PCT from systematic errors (biases) associated with the modelling of the ECCS and dissolved nitrogen, and the application of this method in estimating biases in the Reflood Phase PCT (second PCT) predicted by the TRAC/PF1/MOD1, Version 14.3. The bias in the second PCT due to the uncertainty in the existing code models for ECCS related phenomena is -19°K (-34°F). The negative bias implies that the code models for this phenomena are conservative. The bias in the second PCT due to the lack of modelling of dissolved N_2 in the code is estimated to be 9.9°K (17.8°F). The positive bias implies that the absence of dissolved N_2 model makes the code prediction of PCT non-conservative.

The bias estimation in this report is a major exception among all other uncertainty and bias assessments performed in conjunction with the CSAU methodology demonstration, because this bias estimation benefitted from using full-scale test data from the full-scale Upper Plenum Test Facility (UPTF). Thus, the bias estimates presented here are unaffected by scale distortions in test facilities. Data from small size facilities were also available and an estimate of bias based on these data will be conservative.

EXECUTIVE SUMMARY

Introduction

The Large Break Loss of Coolant Accident (LBLOCA) is a design basis accident for licensing purposes. The licensee is required to demonstrate that during a hypothetical LBLOCA the emergency core cooling system (ECCS) will provide adequate core cooling to prevent damage to the fuel cladding. In August of 1988, the U.S. Nuclear Regulatory Commission (USNRC) published new guidelines for assessing the adequacy of the ECCS. The revised guidelines allow the licensee to predict LBLOCA events with a best estimate computer code, provided the uncertainty in predicting safety parameters, such as the peak clad temperature, is quantified with a high level of confidence.

The USNRC has developed a methodology [TPG, 1989] for evaluating Code Scaling, Applicability and Uncertainty (CSAU). This method was demonstrated by applying it to the TRAC-PF1/MOD1 Version (14.3) code and by its analysis of LBLOCA for a Westinghouse four-loop plant [TPG, 1989]. In applying the methodology, one divides the accident course into three different phases, namely, Blowdown, Refill, and Reflood. There are two distinct peaks in clad temperature history, one in the Blowdown Phase and one in the Reflood Phase. The Peak Clad Temperature (PCT) of the Blowdown Phase is governed by fuel characteristics [Shaw et al., 1988; Wulff, 1987]. The Peak Clad Temperature of the Reflood Phase is governed by the phenomena affecting the Refill Phase, as the clad continues to heat up during the Refill Phase. Specifically, the second PCT is affected by critical break flow, two-phase pump degradation and ECCS-related phenomena in the downcomer and lower plenum of the reactor vessel [Shaw et al., 1988]. This report addresses ECCS- and N_2-related phenomena and also deals with the effect that the modeling of these phenomena has on the PCT of the Reflood Phase.

Objective of the Research Program

The objective of the analysis described in this document is to present a general method for estimating the effects on PCT from systematic errors associated with the modeling of ECCS and dissolved nitrogen, and to apply this method to the TRAC code.

Specifically, as part of a CSAU application, the purpose is to estimate the biases in the TRAC-PF1/MOD1, Version 14.3 prediction of PCT in the Reflood Phase due to:

1) uncertainties in modeling ECC bypass phenomena in the downcomer and lower plenum, and

2) the lack of a model for dissolved nitrogen N_2.

The biases in PCT to be estimated arise from systematic modeling errors in TRAC causing errors in the prediction of the time at which, after blowdown, the lower plenum is again full of liquid delivered by ECCS. This time occurs at the end of the Refill Phase and the beginning of liquid injection into the core, which, in turn, terminates the rise in clad temperature in and thereby controls PCT. The bias estimates developed in this analysis are used to shift the probability distribution of PCT uncertainty as obtained from the statistical analysis of stochastic uncertainties [TPG, 1989].

Summary of Procedure

During the Refill Phase, the core is voided and the cladding heats up until the lower plenum is full of liquid and some of the liquid begins to enter the core. The bias in the PCT prediction is due to the bias in predicting the duration of the Refill Phase. The longer the Refill Phase lasts, the larger will be the PCT. The Refill Phase is shown to be divided into four phenomenologically distinct periods, namely the Complete Bypass Period, the Delay Period, the Counter Current Flow Period, and the No-Bypass Period. The net bias in predicting the duration of the Refill Phase is obtained from predicting the sum of the four biases. The bias in the PCT is then estimated by multiplying the total bias in the duration predicted for the Refill Phase by the average clad heatup rate during the Refill Phase. The heatup rate is obtained from the reference calculation of the plant, using the TRAC computer code.

Bias Due to ECC Bypass Phenomena Modeling

The bias in the PCT due to ECC bypass phenomena modeling is estimated by using ECC bypass data from the full-scale Upper Plenum Test Facility (UPTF) [Siemens, A. G, 1987; Damarell, 1988a, 1988b, 1988c; Wolfe, 1988a, 1988b], which models the upper plenum and downcomer components of a reactor vessel without scale distortion. We have estimated the three discrepancies in the prediction of (i) the critical steam-flow rate (i.e., the steam flow rate below which there would be liquid delivery to the lower plenum given sufficient time), (ii) the delay in the delivery of liquid to the lower plenum from the time of injection, and (iii) the rate of liquid delivery to the lower plenum, and have converted them into the bias of the Refill Phase time period. The resulting bias in PCT is estimated by multiplying the cladding heatup rate by the bias in the Refill Phase time period, as explained above. No corrections are needed to account for scale distortion in the test data.

Bias Due to the Lack of a Model of Dissolved N_2

The N_2-related bias in PCT is obtained by developing a separate model of the reactor system, accounting for the effect of the dissolved N_2. This is accomplished by performing a TRAC calculation for UPTF Test 6 conditions with and without N_2 injection. The biases in the durations of the four periods listed earlier are estimated from the effect of N_2 on the critical steam flow rate, on the delay in delivery of liquid to the lower plenum, and on the rate of liquid delivery to the lower plenum. This bias in the prediction of the duration of the Refill Phase is obtained by summing the four biases. The bias in PCT is estimated by multipying the cladding heatup rate by the bias in the Refill Phase period. Again, no corrections are needed to account for scale distortion in the test data.

Summary of Results

The bias in the PCT due to the uncertainty in the existing TRAC models for bypass phenomena is -19°K (-34°F). The negative bias implies that the code is conservative in modelling the bypass phenomena and, relative to ECCS effects, predicts PCT too high. This bias will be subtracted from the overall PCT uncertainty.

The Refill Phase was divided into four phenomenologically different periods. The largest contribution to the bias is from the Delay Period (-17.7°K) during which the ECC is accumulating in the cold legs and the downcomer region of the reactor. The Counter Current Flow Period was surprisingly small (0.5 s) and contributed only -1.3°K to the total bias in PCT. The most important parameter during the Delay Period is the critical steam flow rate. Since the data for determining this critical steam flow rate are sparse, more data are needed, particularly at high steam flow rates. Furthermore, additional test data are needed to provide a meaningful statistical analysis.

The bias in PCT due to the lack of modeling effects of dissolved N_2 in the TRAC code is 9.9°K (17.8°F). This bias was computed in part with bounding calculations. The positive value of the bias implies that the inclusion of a dissolved N_2 model would lead to a code prediction of a higher PCT. It is recommended that a model of dissolved N_2, based on the variation in the solubility of the non-condensable gas (i.e., Henry's model), be included in the code. The code has a model of non-condensable gas, but it does not allow for mass transfer of gas from or to the liquid phase.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure | Page

LIST OF TABLES

NOMENCLATURE

CSAU	Code Scalability, Applicability and Uncertainty
DC	Downcomer
ECC	Emergency Core Coolant
ECCS	Emergency Core Cooling System
LP	Lower Plenum
m	Inventory, kg
$\dot{m}$	Filling rate
$\delta\dot{m}$	Bias in filling rate
PCT	Peak Clad Temperature
δPCT	Bias in Peak Clad Temperature
PWR	Pressurized Water Reactor
R_{ECC}	Ratio of ECC injection rates, without N_2 and with N_2
$R_{\dot{m}LP}$	Ratio of predicted to observed lower plenum filling rates
R_t	Rates of predicted to observed durations of the Delay Period
$R_{t,th}$	Ratio of durations of Delay Period without N_2 and with N_2
T	Temperature
t	Time
t_A	Time at which lower plenum inventory is lowest
t_{AB}	Duration of Filling Period, t_B-t_A
t_{AE}	Duration of Counter Current Flow Period, t_E-t_A
t_B	Time at which lower plenum is full, end of Refill Phase
t_D	Time at which steam flow to the downcomer is equal to critical steam flow rate
t_{DA}	Duration of Delay Period; t_A-t_D
t_E	Time at which the steam flow to downcomer ends
t_{EB}	Duration of No-Bypass Period, t_B-t_E

t_I	Time at which ECC injection begins
t_{IA}	Duration of Bypass Period; $t_A - t_I$
t_{IB}	Duration of Refill Phase, $t_B - t_I$
t_{ID}	Duration of Complete Bypass Period, $t_D - t_I$
t_{ij}	Duration, $t_j - t_i$
δt_{ij}	Bias in time period t_{ij}
Wgc	Critical steam flow rate

<u>Subscripts</u>

AB	Lower plenum Filling Period
AE	Counter Current Flow Period
A'	Point on clad temperature history curve
act	Actual or expected for PWR
B'	Point on clad temperature history curve
C	Clad
CL	Cold Leg
DA	Delay Period
EB	No-Bypass Period
exp	Experimental
IB	Refill Phase
ID	Complete Bypass Period
LP	Lower Plenum
$\dot{m}$LP	Lower Plenum filling rate
N_2	N_2 dissolution considered (Chapter 4 only)
NPP	Nuclear Power Plant
pred	Predicted or calculated
SET	Separate Effects Test
th	Based only on calculation

ACKNOWLEDGEMENTS

The authors would like to thank the members of the Technical Program Group, Dr. B. Boyack of LANL, Dr. R. Duffey of INEL, Professor P. Griffith of MIT, Drs. G. Lellouche and S. Levy of S. Levy, Inc., Mr. G. Wilson of INEL, and Dr. N. Zuber of NRC, for technical discussions, suggestions and support for this effort. Numerous technical suggestions and the advice of Professor I. Catton of UCLA are greatly appreciated. The bulk of the TRAC calculations was done by Dr. H. Stampf of LANL whose expertise in the code contributed greatly to this report. The authors would like to extend their appreciation to Dr. J. Guppy of BNL for continuous support of this project. Finally, the extraordinary patience and fine typing of Mrs. L. Hanlon and Mrs. N. [illegible]iemon is highly appreciated.

1. INTRODUCTION

1.1 Background

The Large Break Loss of Coolant Accident (LBLOCA) is a design basis accident that must be analyzed for licensing purposes. The licensee has to demonstrate that during a hypothetical LBLOCA the Emergency Core Cooling System (ECCS) will provide adequate cooling to the core and prevent damage to the fuel cladding. With inadequate core cooling, there is a possibility for core heatup, oxidation of the zirconium fuel rod cladding and cladding rupture, leading eventually to a release of radiation into the reactor vessel.

In 1974, the USNRC set up rules for assessing the performance of ECCS for light water reactors under LBLOCA conditions. These rules consist of acceptance criteria, listed in the Code of Federal Regulation, Title 10, Section 50.46 (10 CFR 50.46); constraints in the method of analyzing the ECCS performance are listed in the accompanying Appendix K. The acceptance criteria focus on maintaining the integrity of the cladding.

Since 1974, there has been extensive research in reactor thermohydraulics and development of Best Estimate (BE) computer codes. The results of these BE codes indicate that the ECCS rules are conservative [Rohatgi, et al., 1986]. To account for the technological advances made in the last 15 years and to use the realistic BE codes for analyzing the ECCS performance, the USNRC approved a revision of 10CFR50.46 and Appendix K in August, 1988 [USNRC, 1988]. The revisions, which lead to the analyses reported here, require that the uncertainties arising from the prediction of ECCS performance and impacting on safety (PCT being the most important parameter for safety), be quantified with a high level of assurance.

1.2 The CSAU Methodology

To provide a technical basis for the revision of the ECCS evaluation methodology, the USNRC, its contractors and consultants developed a general method of quantifying the uncertainty in the code predictions [TPG, 1989]. This method is called Code Scaling, Applicability, and Uncertainty (CSAU) evaluation methodology. It provides a structured, auditable, and traceable method of combining quantitative analysis with expert opinion. The code prediction of the safety parameter (PCT for LBLOCA), along with the uncertainty estimated through the CSAU methodology, are compared with the acceptance criteria to assess the plant's safety margin.

The CSAU evaluation methodology was applied to the LBLOCA analysis of the Westinghouse four-loop Pressurized Water Reactor (PWR), using TRAC-PF1/MOD1, Version 14.3 [TPG, 1989]. The code was used to predict PCT for the accident. The CSAU methodology was used to estimate the uncertainty with a 95% level of confidence for the TRAC code prediction of PCT. The predicted PCT plus its uncertainty must be less than the permissible value of PCT (2200°F). The difference between the permissible value of PCT and the predicted PCT, augmented by its uncertainty, is the safety margin and, thus, an adequacy measure of the ECCS performance.

1.2.1 Contributions to Uncertainty

Computer codes to predict of reactor transients consist of a set of balance equations for two-phase coolant flows, a model for conduction in the neutron fission power and for solids, a set of intrinsic constitutive relationships for material properties of gases, liquids and solids, extrinsic constitutive relationships such as flow regime maps, wall and interfacial heat and momentum transfer coefficients, and numerical procedures. The results depend upon the models in the code, the initial and boundary conditions, the numerical methods and the nodalization scheme used. The uncertainty in the prediction can arise from an inadequate formulation of flow models, inappropriateness of some of the constitutive relationships, insufficient detail in the nodalization, the approximation in the numerical methods, and uncertainty in specifying the boundary conditions and plant parameters.

Among the many relationships in the code, the inappropriate constitutive relationships include correlations which are either based on data from improperly scaled test facilities, or do not cover the range of the flow conditions expected during the reactor transient, or, in some cases, have no verifiable basis. The uncertainty in the reactor's conditions arises from the imprecise knowledge of the reactor's initial conditions, fuel composition and geometry of the plant. Any method for evaluating the uncertainty in the code prediction must account for all the contributors listed here. The CSAU methodology provides a systematic means of quantifying these uncertainties.

1.2.2 Description of CSAU Methodology

The CSAU methodology [TPG, 1989] consists of 14 steps which are organized in three groups (Figure 1.1). The first group (Steps 1-6) is called Requirements and Code Capabilities [Wilson, et al., 1988]; it consists of the specification of the transient (Step 1) and Nuclear Power Plant (NPP) (Step 2), the identification of phenomena and their ranking (Step 3), leading to the Phenomena Identification and Ranking Table (PIRT), and the selection of the code (Step 4) and its documentation (Step 5). The final step in this group is the determination of the code's capability to model the important phenomena identified in Step 3.

The second group, Steps 7 to 10, is called Assessment and Ranging of Parameters [Wulff, et al., 1988]. This part of the methodology consists of selecting a matrix of Separate Effects Tests (SET) and Integral Effect Tests (IET) (Step 7), relevant to the scenario, as well as to the important phenomena and components selected in Step 3. Step 8 requires setting up of the standard nodalization for the nuclear power plant (NPP) representation, thereby accounting for all the important phenomena. Nodalization for the SET and IET calculations must be the same as the nodalization used in the NPP calculation. The identification of the code parameters which model the important phenomena, and the ranging of the parameters on the basis of their uncertainties and stand-alone calculations are performed in Step 9. Finally, in cases where the data base or the separate effects tests used in Step 9 did not cover the fluid conditions expected in the accident nor the full-plant size, the range of the parameter has to be modified to conservatively account for the scale compromises. This modification is performed in Step 10. The IET calculations provide an independent check on the overall uncertainty in the predicted safety parameter (Steps 9 and 10).

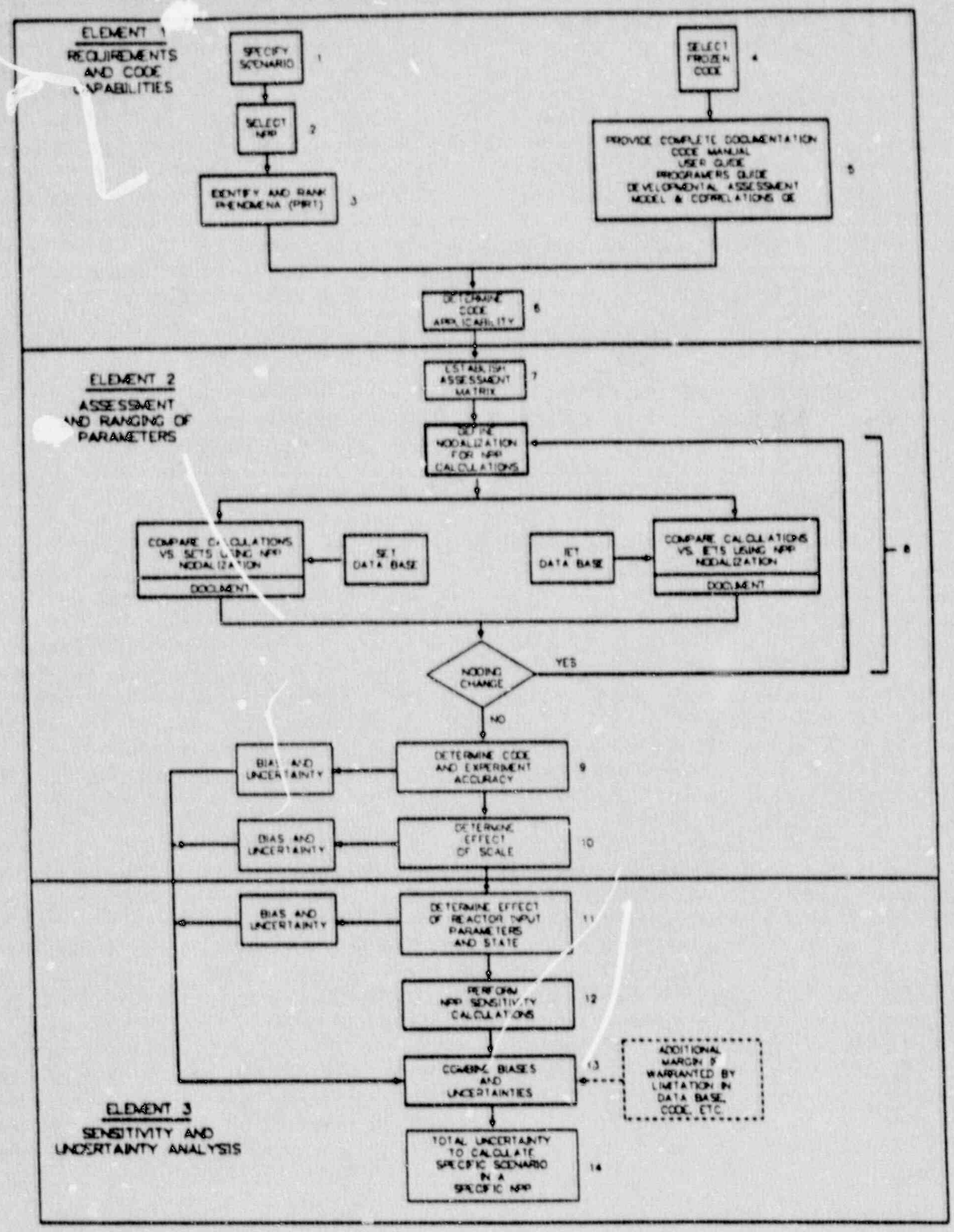

Figure 1.1 Code Scaling, Applicability and Uncertainty Evaluation Methodology

The third group (Steps 11-14) is called Sensitivity and Uncertainty Analysis [Lellouche, et al., 1988]. In Step 11, NPP calculations are performed to predict the sensitivity of the safety parameter to the perturbed value of the modeling parameters. The range of perturbation is determined from the range of the modeling parameter uncertainty (Step 9). A response surface is developed to approximate the relationship between modelling parameters and the safety parameter (PCT). This alleviates the need for expensive code calculation in the statistical analysis, used to compute the uncertainty distribution for the safety parameter (Step 12). When the modelling parameters in the code, governing an important phenomenon, have systematic errors either due to the lack of a data base, or due to artificial constraints, the code is said to have a bias in the prediction of safety parameters. In such cases, a bias is estimated either directly through the code or through a separate calculation. This bias is used to shift the uncertainty probability distribution, and this is accomplished in Step 13. The uncertainty in the safety parameter is documented in the last step.

1.2.3 Application of CSAU Methodology to LBLOCA Prediction

The CSAU methodology [TPG, 1989] described here was applied to the best estimate (BE) analysis of LBLOCA in a Westinghouse four-loop plant using TRAC-PF1/MOD1, Version 14.3. The uncertainty from modeling ECCS phenomena and from omitting the modeling of dissolved nitrogen in the predicted PCT, which is the safety parameter in LBLOCA, is estimated here with this method.

The time span of the transient from the time of the break to the time of the complete clad quenching was divided into three periods, namely Blowdown, Refill, and Reflood Phases. The Blowdown Phase is the period during which the system depressurizes, as it loses coolant through the break. This Blowdown Phase ends when the ECC flow is initiated in the intact loops. The Refill Phase is next, during which the ECC liquid initially bypasses the downcomer, and later, begins to accumulate in the downcomer and lower plenum. The Refill Phase ends when the lower plenum is filled. During the third or Reflood Phase, the core begins to fill up. This phase ends when the cladding is quenched. There are two peaks in the clad temperature history: the first is in the Blowdown Phase and the second in the Reflood Phase.

The Phenomena Identification and Ranking Table (PIRT) [Shaw, et al., 1988; Wilson, et al., 1988] was developed as part of the CSAU demonstration for LBLOCA; it showed that the downcomer is an important component, and the ECC bypass phenomena and the effect of non-condensables during the Refill Phase are important. The uncertainty in modelling the downcomer flows leads to uncertainty in predicting the filling rate of the lower plenum and, consequently, the duration of the Refill Phase. During the Refill Phase, the cladding continues to heat up: heat-up ends when the lower plenum is full and the coolant is entrained into the core. Any uncertainty in the prediction of the duration of the Refill Phase will lead to an uncertainty in the time available for clad heat-up and, therefore, in PCT. There will be contributions to PCT uncertainty by the uncertainty in modelling the bypass phenomena and the effect of any non-condensable. The estimates of these contributions are the subject of this report.

1.2.3.1 Bias in ECC Bypass Phenomena Prediction

The bypass phenomena are modelled in TRAC by seven sets of code parameters; namely, the parameters defining flow regime maps, interfacial area density, interfacial shear coefficients, interfacial heat transfer coefficients, entrainment, wall friction, and wall heat transfer coefficients. The wall friction and wall heat transfer will have lesser influence on the bypass phenomena than the other five sets of parameters.

The correlations for the important five sets of ECCS model parameters in the TRAC code are not based on data relevant to conditions in Nuclear Power Plants (NPP) and have built-in constraints. Therefore, they have systematic errors and cause biases in the code prediction of PCT. Furthermore, because these systematic modeling errors do not have stochastic distributions and cannot be ranged, their contribution to the uncertainty in predicted PCT cannot be included in the probability distribution of PCT uncertainty.

Instead, the bias in PCT due to the systematic modeling errors will be estimated by first computing the bias in the lower plenum filling rate from the simulation of a full-scale Separate Effects Test (Upper Plenum Test Facility) and then by converting the bias in the filling rate into the bias in the duration of the Refill Phase, and finally, into the bias in PCT. This PCT bias is used to shift the PCT uncertainty distribution.

1.2.3.2 Bias Due to Lack of Model for Dissolved N_2 Model

During the Refill Phase, Emergency Core Coolant (ECC) flows from the accumulators into the cold legs. The ECC liquid in the accumulator is saturated with dissolved N_2. The dissolution of N_2 occurs because of depressurization. The N_2 emerging from the ECC liquid affects the filling rate of the lower plenum by displacing liquid from the cold legs to the downcomer, by reducing the condensation rate, and by causing the reduction in ECC flow. The TRAC code does not have a model for such phenomena, and the predicted PCT will have a bias.

This bias in PCT is estimated by a separate calculation first, to determine the bias in ECC flow rate and then in the duration of the Refill Phase. The bias in the Refill Phase duration is converted to a bias in PCT by multiplying the bias in duration by the clad heat-up rate. The resulting PCT bias is used to shift the PCT uncertainty distribution.

1.3 Report Organization

This report describes the procedure for estimating biases due to the modelling of ECC bypass phenomena and due to the lack of a model for dissolved N_2 when the TRAC code is applied to calculate a LBLOCA for a Westinghouse PWR. The report has five chapters and five appendices. Chapter 2 describes the objective of the task, Chapter 3 describes the procedure and its application in estimating the PCT bias due to deficiencies in the ECC bypass model; Chapter 4 describes a procedure and its application of estimating PCT bias due to the lack of a model for dissolved N_2, and, finally, Chapter 5 provides the summary and conclusions. The five appendices describe the Upper Plenum Test Facility (UPTF) and the method of computing lower plenum filling rate (Appendix A), the nodalization used to model UPTF with TRAC (Appendix B), the input deck for UPTF code simulation (Appendix C), the method of obtaining UPTF lower plenum filling rate from TRAC predictions (Appendix D) and, lastly, Appendix E describes the procedure of estimating the dissolution rate of N_2 and its effect on the ECC flow rate.

2. OBJECTIVES

The objectives of the work reported here are the following:

1. To demonstrate a method for assessing the uncertainties in Peak Clad Temperature (PCT) predictions by computer code, caused by stochastic modeling uncertainties and systematic modeling errors, associated with predicting

   (i) ECC bypass hydraulics, and
   (ii) effects from the release of dissolved nitrogen from the ECCS,

2. To apply the above method to the TRAC-PF1/MOD1, Version 14.3 code, as it is used to analyze an LBLOCA for a Westinghouse four-loop PWR.

Specifically, the purpose is to determine the effects from existing modeling uncertainties and scale distortions on Peak Clad Temperature (PCT), as well as to find PCT uncertainties and biases from stochastic and systematic errors in downcomer modeling. Such biases can be added by statistical methods [TPG, 1989] to the PCT uncertainties arising from modeling errors associated with the code prediction of all other phenomena related to LBLOCA.

3. BIAS IN PCT FROM THE MODELLING OF ECC BYPASS PHENOMENA

The ECC bypass phenomena result from the interaction of downcomer flows, cold leg flows and break flows. These flows are governed by the combination of interfacial momentum transfer, interfacial mass transfer (flashing and condensation), entrainment, wall heat and momentum transfer and critical flow. The TRAC code (documented in Step 5, Figure 1.1) has seven sets of parameters to model these interactions, namely: flow regime transitions, interfacial area density, interfacial shear coefficients, interfacial heat transfer coefficients, entrainment, wall friction, and heat transfer coefficients. Some of the correlations used to model these interactions are not based on experiments relevant to NPP and have non-physical constraints [Liles, et al., 1988]. Therefore, they have systematic errors and the parameters in these correlations have no statistical distributions and, can not be treated by statistical analysis. Furthermore, there is a lack of data to determine standard deviations of individual parameters. There is strong coupling between the interfacial and wall interactions. Therefore, it is not possible to isolate uncertainty distributions or biases of parameters, based on downcomer flow tests. Therefore, the effects from the deficiencies in the code models for the bypass phenomena cannot be accounted for in the generation of a response surface and have to be accounted for through a bias.

The next section describes the important processes taking place during the Refill Phase and the division of this phase into four phenomenologically distinct periods.

3.1 The ECC Bypass Phenomena

During LBLOCA, the system depressurizes because of coolant loss through the break(s). Depressurization causes vapor generation by flashing in the core, the lower plenum, and the downcomer. The core empties quickly while the lower plenum and the downcomer continue to produce steam. Figure 3.1 shows a schematic of plant conditions calculated approximately nine seconds after break. The accumulators, which provide the bulk of the ECC fluids, start injecting cold fluid in the cold legs when the system pressure decreases below 40 bar. However, initially, there is sufficient steam being produced in the lower plenum and in the downcomer such that none of the ECC fluid reaches the lower plenum.

Figure 3.2 shows the schematic of the plant conditions in the early part of the Refill Phase. The accumulator flows have begun, but there is no accumulation in the downcomer nor in the lower plenum since the ECC fluid bypasses through the downcomer and out through the break. The lower plenum inventory continues to deplete for a few seconds. As the rate of depressurization decreases the steam production also decreases which allows some of the ECC fluid to reach the lower plenum.

Figures 3.3, 3.4 and 3.5 show the progression of the transient. The lower plenum and the downcomer liquid inventories are still depleting after 20 seconds from the start of the transient. Around 24 seconds, there is some accumulation in the top of the downcomer. Figure 3.5 shows a rapid accumulation of ECC in the downcomer and the lower plenum as the steam flow in the downcomer decreases. The cold ECC fluid mixes with the steam in the downcomer and in the lower plenum, and causes the steam to condense. As the Refill Phase proceeds, the rate of ECC

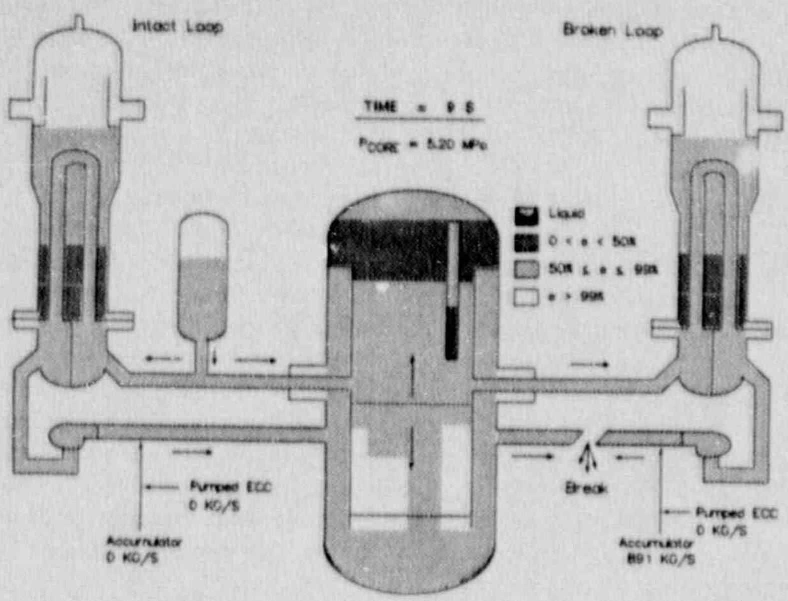

Figure 3.1 Expected Conditions in a PWR System at 9 Seconds After Rupture (Shaw, et. al., 1988) (BNL 1-361-90)

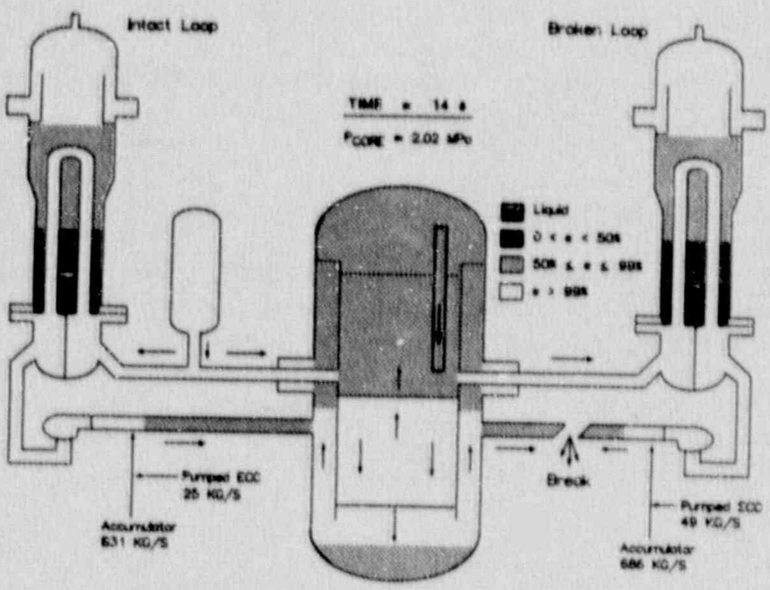

Figure 3.2 Expected Conditions in a PWR System at 14 Seconds After Rupture (Shaw, et. al., 1988) (BNL 3-164-90)

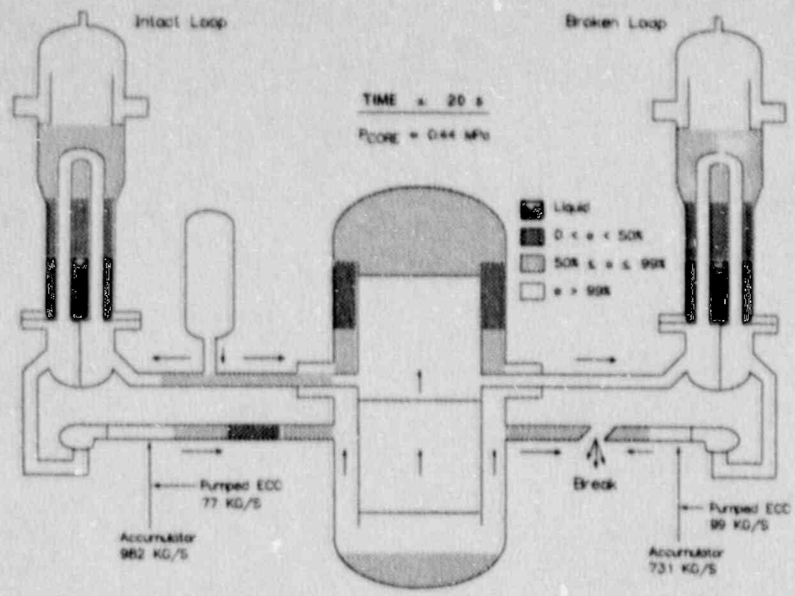

Figure 3.3 Expected Conditions in a PWR System at 20 Seconds After Rupture (Shaw, et. al., 1988) (BNL-1-365-90)

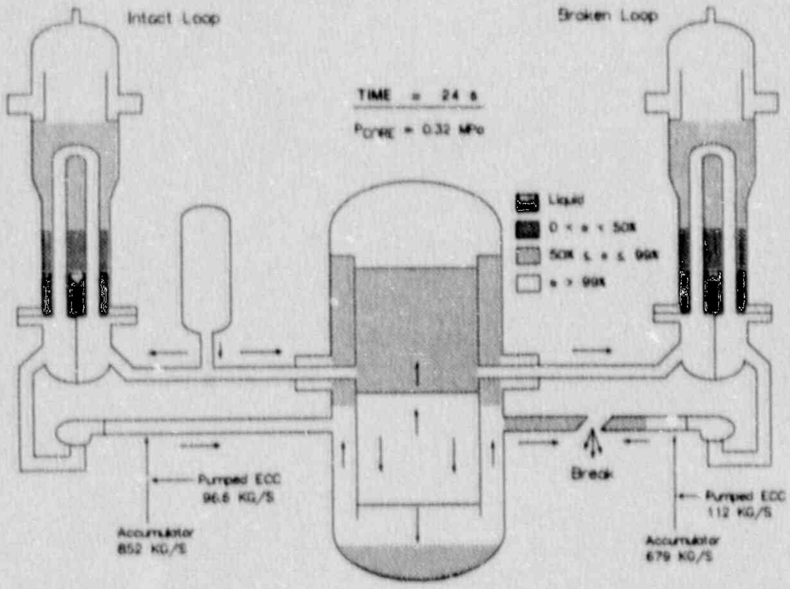

Figure 3.4 Expected Conditions in a PWR System at 24 Seconds After Rupture (Shaw, et al., 1988) (BNL-1-363-90)

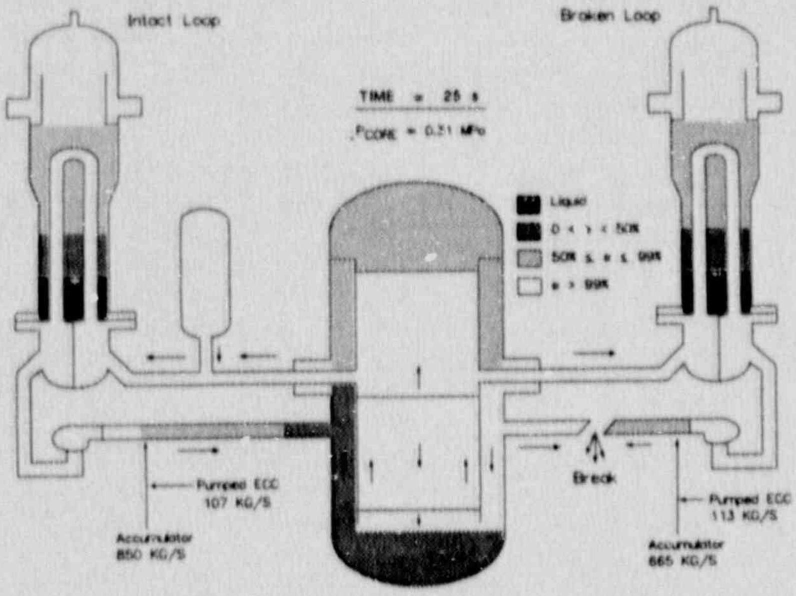

Figure 3.5 Expected Conditions in a PWR System at 25 Seconds After Rupture (Shaw, et al., 1988) (BNL-2-120-90)

delivery increases, eventually becoming equal to the rate of injection, i.e., there is complete delivery.

During this Refill Phase the core is normally empty and the fuel clad is heating up almost adiabatically. However, when the lower plenum is almost full, as shown in Figure 3.6, the liquid enters the core and begins to quench the fuel rods, leading to a peak in the clad temperature history.

3.1.1 Four Periods of the Refill Phase

The LOCA described above is summarized in Figure 3.7 which shows typical time plots of the downcomer inventory, fuel clad temperature, rate of steam flow from the lower plenum to the downcomer, and downcomer inventory during the transient. The Refill Phase of LOCA begins at time t_I, when the accumulator flow starts and ends at time t_B, when the lower plenum is full. The duration of the Refill Phase is t_{IB}. The clad temperature plot (Figure 3.7) shows that during the Refill Phase, the clad heated up almost linearly in time and the temperature turn-around occurred around time t_B.

The Refill Phase is divided into two periods; the Bypass Period and the Filling Period, as shown in Figure 3.7. The Bypass Period begins at time t_I and ends at time t_A, and its duration is t_{IA}. The Filling Period begins at time t_A and ends at time t_B, and its duration is t_{AB}. The Bypass Period is further divided into two subperiods, namely the Period of Complete Bypass and the Delay Period, as shown in Figure 3.7. The Period of Complete Bypass begins at time t_I and ends at time t_D, and it duration is t_{ID}. The Delay Period begins at time t_D and ends at time t_A, and its duration is t_{DA}. The Filling Period is also divided into two subperiods; the Counter Current Flow Period and the No-Bypass Period, as shown in Figure 3.7. The Counter Current Flow Period begins at time t_A and ends at time t_E and its duration is t_{AE}. The No-Bypass Period begins at time t_E and ends at time t_B, and its duration is t_{EB}.

During the Bypass Period, t_{IA}, the steam flow from the lower plenum in the downcomer decreases. This period ends when the lower plenum inventory begins to increase. The boundary between the two subperiods in the Bypass Period is time t_D when the critical steam flow rate (W_{gc}) is reached. The critical steam flow rate is the highest steam flow rate which will permit liquid delivery to the lower plenum, provided the liquid injection is maintained for a long enough time to reach the lower plenum. The critical steam flow rate is estimated from steady state flooding curves for the PWR downcomer. The flooding curves are obtained from either full-scale, or properly scaled, experiments. A schematic of a flooding curve is shown in Figure 3.8. The time t_D corresponding to the critical steam flow rate is obtained from the computed curve for the rate of steam flow from the lower plenum to the downcomer. A schematic of steam flow rate curve is shown in Figure 3.9. During the complete Bypass Period, t_{ID}, the steam flow rate is higher than the critical steam flow rate and, therefore, there is no possibility of liquid delivery to the lower plenum.

During the Delay Period, t_{DA}, the rate of steam flow into the downcomer is low enough to permit liquid delivery to the lower plenum. However, there is a delay in liquid delivery to the lower plenum equal to the time needed by the liquid to flow down through the downcomer. This delay decreases with the decrease in steam flow rate. This subperiod ends at time t_A when the liquid

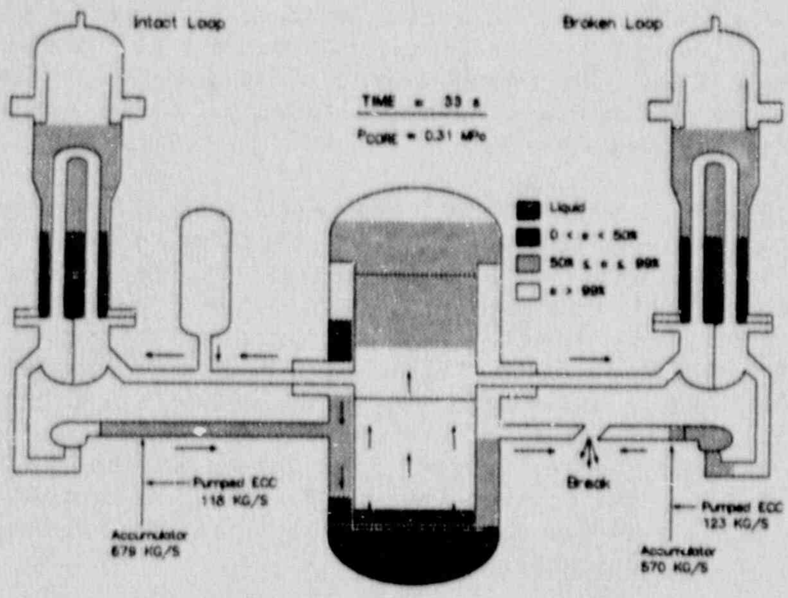

Figure 3.6 Expected Conditions in a PWR System at 33 Seconds after Rupture (Shaw, et al., 1988) (BNL-1-367-90)

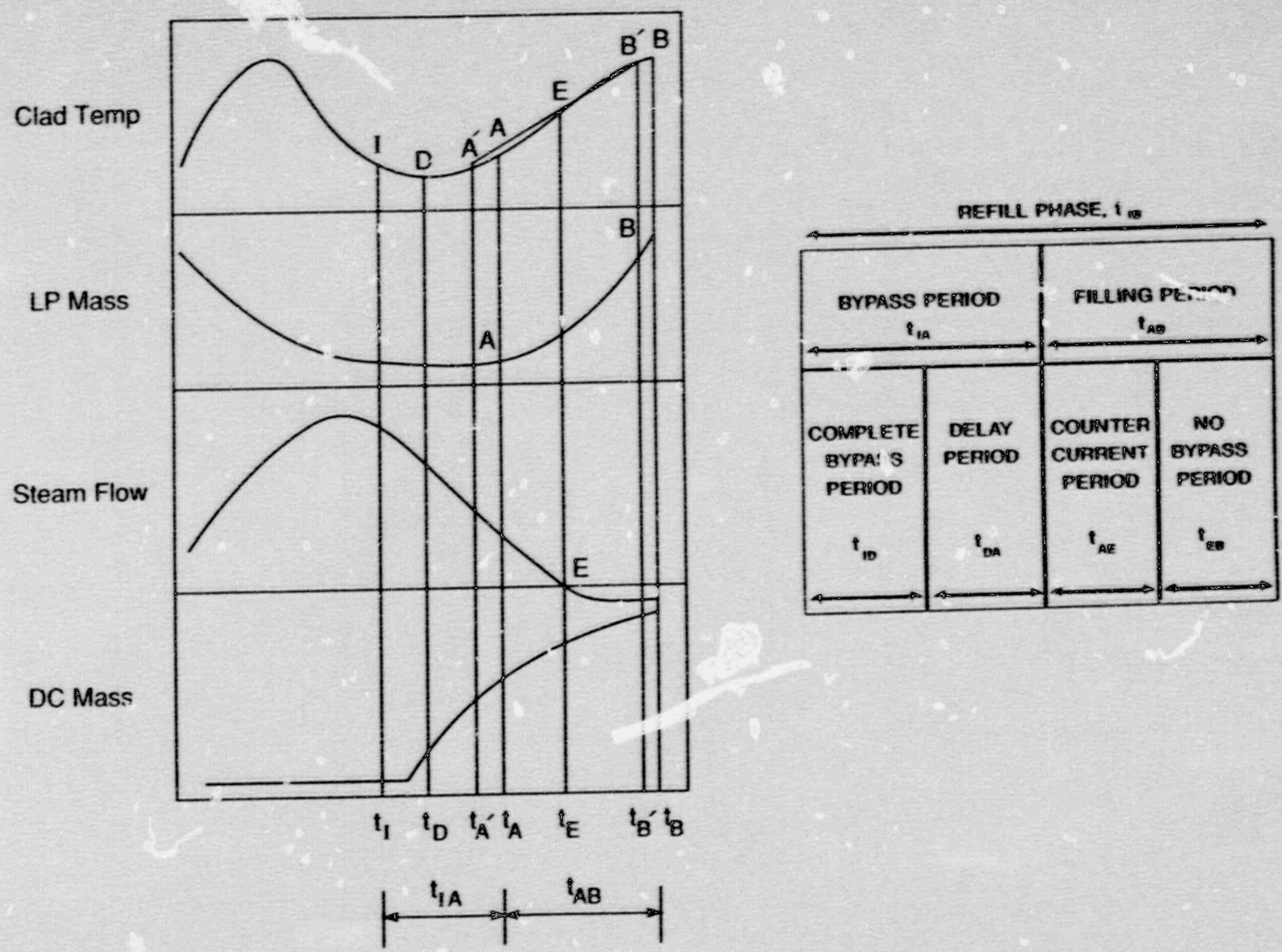

Figure 3.7 Schematic of LBLOCA in NPP

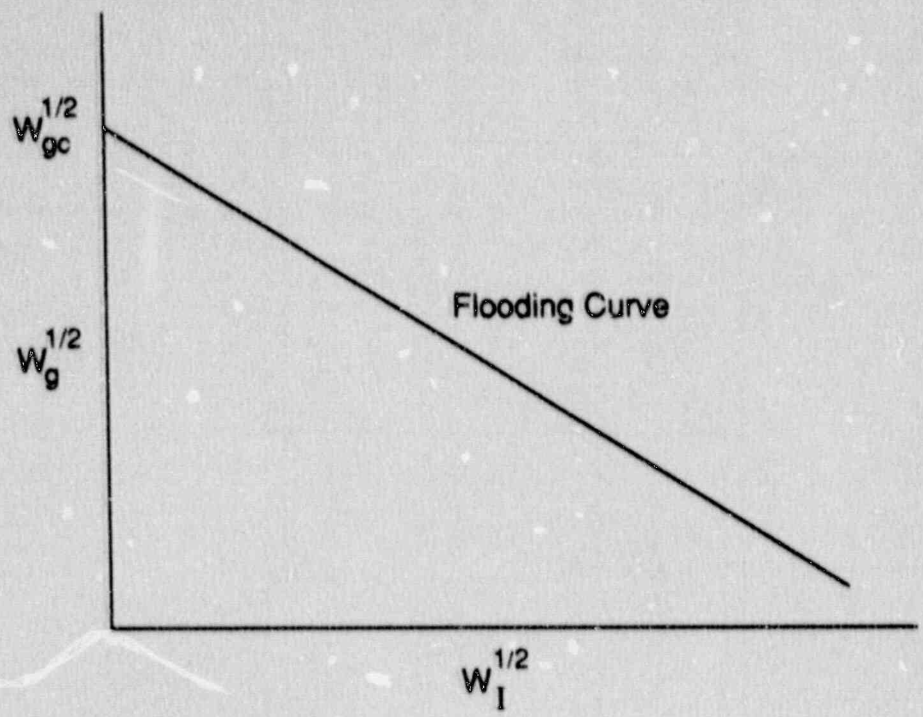

Figure 3.8 Schematic of Flooding Curve and Critical Steam Velocity

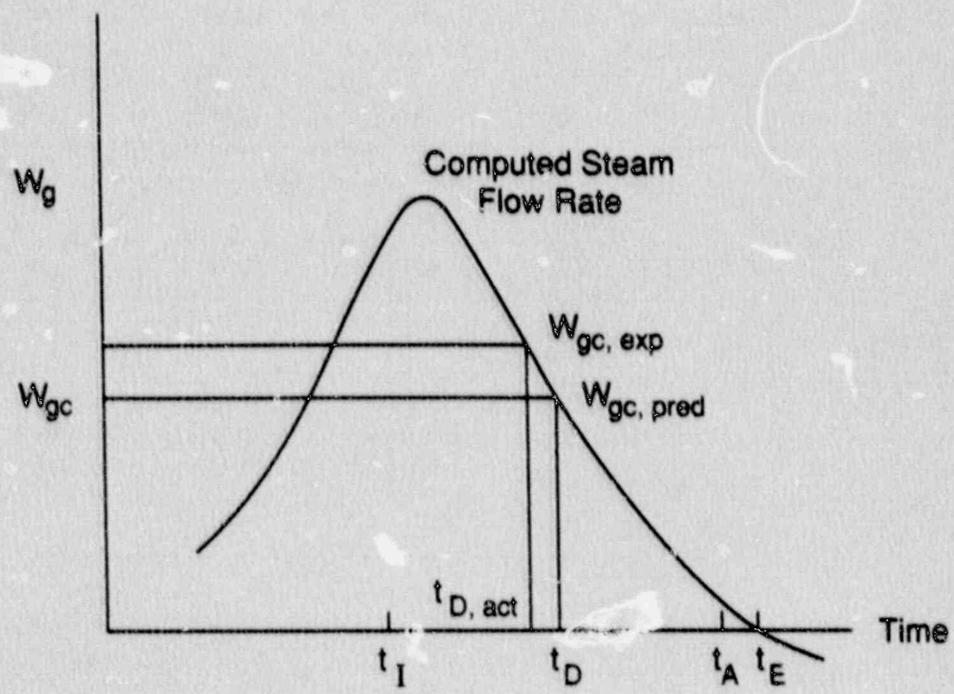

Figure 3.9 Schematic of Steam Flow Rate From the Lower Plenum to the Downcomer in the NPP

delivery to the lower plenum begins. Such a delay was observed in CREARE [Crowley, 1987, 1988] and UPTF [Wolfe, 1988a; Damarell, 1988a] experiments.

The Filling Period, t_{AB}, is the period during which the lower plenum fills up. This period ends at time t_B when the lower plenum is full. The boundary between the two subperiods is the time t_E when there is no steam flow from the lower plenum to the downcomer, as indicated in Figure 3.9. During the first subperiod, i.e. the Counter Current Flow Period, there is liquid down-flow and steam up-flow in the downcomer. During the second or No-Bypass Period, there is no steam flow from the lower plenum to oppose the liquid down-flow and almost all the injected liquid (some may be evaporated due to wall heat transfer) is delivered to the lower plenum.

The next section describes the principles involved in estimating the bias in PCT.

3.2 Principle of Bias Estimate

During the Refill Phase, t_{IB}, the core continues to void and heat transfer from the clad to vapor is small. The clad continues to heat up (almost adiabatically) until the ECC liquid reaches the core as shown in Figure 3.7. Any uncertainty in predicting t_{IB} will result in a bias in the Reflood Phase PCT. The PCT bias δPCT is estimated as follows:

$$\delta PCT = (dT_c/dt) * \delta t_{IB} \tag{3.1}$$

where dT_c/dt and δt_{IB}, are the average rate of clad temperature rise during heatup and the uncertainty in the predicted duration of the Refill Phase, respectively. The average clad temperature rise is obtained from the hot rod clad temperature history predicted by the code for the nominal conditions. The approach is similar to the method suggested by [Damarell, 1988b]. Figure 3.7 also shows the hot rod clad temperature history. The average clad heatup rate during the Refill Phase is computed as follows:

$$dT_c/dt = (T_{B'} - T_{A'}) / (t_{B'} - t_{A'}) \tag{3.2}$$

where $T_{B'}$, $T_{A'}$, $t_{b'}$, and $t_{A'}$ are the clad temperatures and corresponding times as shown in Figure 3.7. The only variable that remains to be determined in Equation 3.1 is δt_{IB}, which is the bias in predicting the Refill Phase duration. Thus, the estimation of PCT bias is reduced to the estimation of bias in the Refill Phase duration.

3.3 Bias in Timing of Refill Phase

The bias in predicting the period of Refill Phase reduces to the biases in predicting the Bypass and Filling Periods as defined in Section 3.1. The Refill Period bias is computed from the biases in the two periods as follows:

$$t_{IB} = t_{IA} + t_{AB} \quad ,$$

$$\delta t_{IB} = \delta t_{IA} + \delta t_{AB} \quad , \qquad (3.3)$$

where δt_{IA} and δt_{AB} are the biases in the prediction of the Bypass Period and the Filling Period, respectively.

3.3.1 Bias in Timing of Bypass Period

The net bias in the Bypass Period is evaluated from the biases in the subperiods, namely "Complete Bypass Period" and "Delay Period," as follows:

$$t_{IA} = t_{ID} + t_{DA} \quad ,$$

$$\delta t_{ID} = \delta t_{ID} + \delta t_{DA} \quad , \qquad (3.4)$$

where δt_{ID} and δt_{D} are the biases in the "Complete Bypass" Period and "Delay Period," respectively.

3.3.1.1 Bias in Timing of Complete Bypass Period

The bias in this period is due to the uncertainty in predicting the critical steam flow rate for the NPP. The evaluation of bias requires the determination of the critical steam flow rate from the data obtained from full-scale, separate effect tests in the Upper Plenum Test Facility (UPTF) under NPP conditions. These separate effects tests are simulated with the code, by using NPP-type nodalization. The predicted critical steam flow rate for this SET will be the critical steam flow rate for the NPP calculation. The measured critical steam flow rate ($W_{gc,exp}$) from the SET will be the actual critical steam flow ($W_{gc,act}$) act for the NPP. Any discrepancy in the predicted and actual critical steam flow rates ($W_{gc,pred}$ and $W_{gc,act}$) will produce a bias in the code prediction of the time, t_D. The times t_D and $t_{D,\ act}$, corresponding to the critical steam flow rates $W_{gc,pred}$ and $W_{gc,act}$, respectively are estimated from the time plot of the rate of steam flow from the lower plenum to the downcomer obtained from a reference NPP calculation.

The bias δt_{ID} is computed as follows:

$$t_D = t(W_{gc,pred}) \quad , \qquad (3.5)$$

$$t_{D,act} = t(W_{gc,act}) \quad , \tag{3.6}$$

$$\delta t_{ID} = t_{D,act} - t_D \quad . \tag{3.7}$$

A schematic of computed steam flow rate curve with critical steam flow rates and corresponding times is shown in Figure 3.9, presented earlier.

3.3.1.2 <u>Bias in Timing of Delay Period</u>

This period spans from the time t_D to time t_A. The time t_A is the time at which the lower plenum inventory is the lowest and begins to increase as shown in Figure 3.10. The time span for this period is estimated from time t_A, read from Figure 3.10 and time t_D obtained from Equation (3.5).

$$t_{DA} = t_A - t_D \tag{3.8}$$

The bias of this period is estimated by modelling with TRAC the full-scale separate effects tests in UPTF with the nodalization corresponding to NPP and simulating the complete transient until steady state is reached for fixed steam and liquid flow rates. Figure 3.11 shows a schematic of the expected lower plenum inventory in the SET and the delay t_{DA}. The measured and predicted delays are compared and the difference between them is the bias in the Delay Period. As it is difficult to simulate the conditions in the NPP during the Delay Period, a ratio, R_t, of predicted $t_{DA,pred}$ to observed $t_{DA,exp}$ for each steam flow rate in the SET is estimated and this ratio is a measure of the deficiency in the code.

$$R_{t,SET} = \left(\frac{t_{DA,pred}}{t_{DA,exp}} \right)_{SET} \tag{3.9}$$

During the Delay Period, t_{DA}, the steam flow rate decreases in the NPP. Therefore, an average of the ratios (R_t) obtained from the many tests for the SET is used for the application to NPP. Since the SET is properly scaled, an average delay ratio $\langle R_t \rangle_{SET}$ estimated for the SET is also applicable to the NPP.

Therefore,

$$\langle R_t \rangle_{NPP} = \langle R_t \rangle_{SET} \tag{3.10}$$

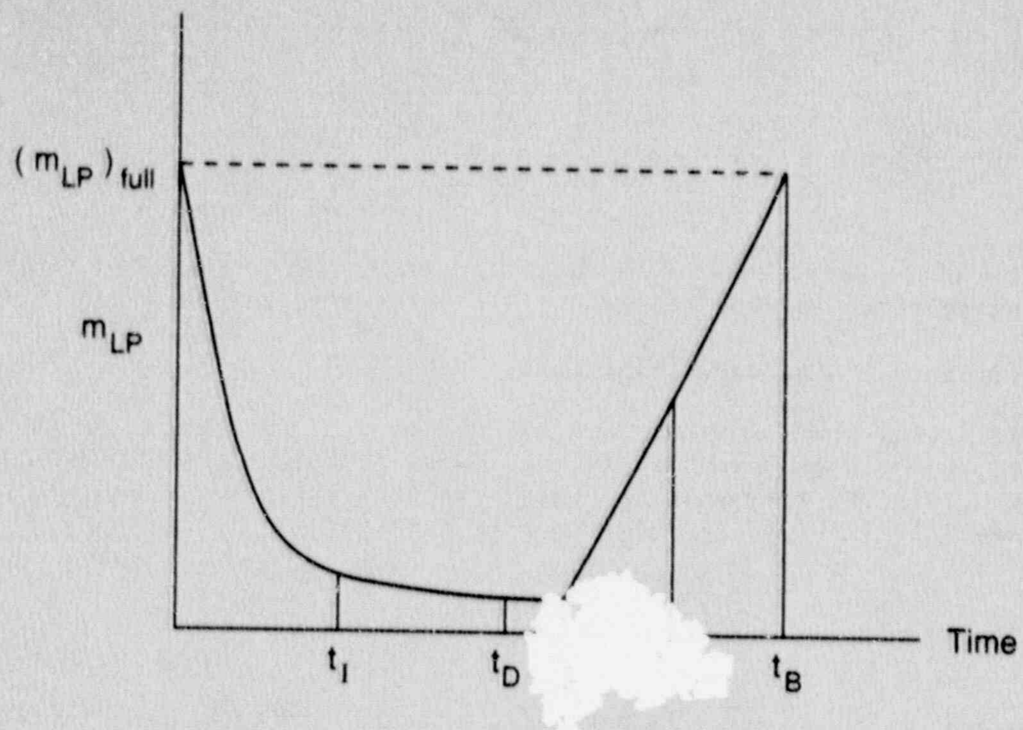

Figure 3.10 Schematic of Lower Plenum Inventory During LBLOCA

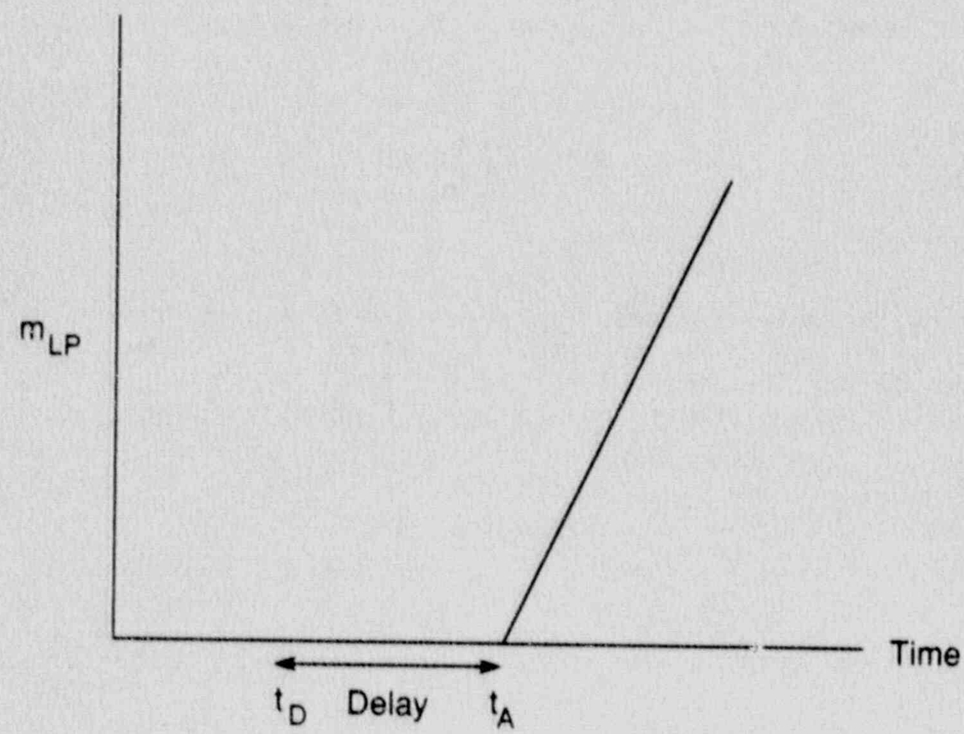

Figure 3.11 Schematic of Lower Plenum Inventory of Separate Effects Tests

The average delay ratio for the NPP is used to estimate the bias in the Delay Period:

By definition for the bias in the Delay Period,

$$\delta t_{DA} = t_{DA,act} - t_{DA,pred} \quad . \tag{3.11}$$

By combining Eqs.(3.9) and (3.10), one finds

$$\langle R_t \rangle_{NPP} = \frac{t_{DA,pred}}{t_{DA,act}} \quad . \tag{3.12}$$

By eliminating $t_{DA,act}$ from Eqs.(3.11) and (3.12), one gets:

$$\delta t_{DA} = t_{DA,pred} \frac{(1 - \langle R_t \rangle_{NPP})}{\langle R_t \rangle_{NPP}} \quad , \tag{3.13}$$

where δt_{DA} is the bias in the Delay Period and $t_{DA,act}$ is the expected actual duration of the Delay Period for the NPP.

3.3.2 Bias in the Timing of the Filling Period

The second part of the Refill Phase is the Filling Period which spans from time t_A to time t_B. During this period, the lower plenum fills up slowly at first and then at the rate of the ECC injection. The time t_A is obtained from Figure 3.11, as explained before in Section 3.3.1.2. The time t_B is reached when the lower plenum is full. The time t_B is read from the lower plenum inventory curve obtained from a reference NPP calculation (cf. Figure 3.10). The time period t_{AB} is obtained as follows:

$$t_{AB} = t_B - t_A \quad . \tag{3.14}$$

The steam flow into the downcomer decreases and completely ceases at time t_E. This time, t_E, divides the Filling Period into two phenomenologically different periods, namely the Counter Current Flow Period and the No-Bypass Period. The bias in the Filling Period, therefore, is the sum of the biases in the prediction of two subperiods.

From:

$$t_{AB} = t_{AE} + t_{EB} \quad ,$$

and component biases, the overall bias is computed as follows: (3.15)

$$\delta t_{AB} = \delta t_{AE} + \delta t_{EB} \quad ,$$

where δt_{AE} and δt_{EB} are the subperiod biases for the Counter-Current Flow and No-Bypass Flow Periods, respectively.

3.3.2.1 <u>Bias in the Timing of the Counter-Current Flow Period</u>

This period spans from time t_A to time t_E. The time t_E is obtained from the predicted steam flow rate curve shown in Figure 3.9. The duration of this period is computed as follows:

$$t_{AE} = t_E - t_A \tag{3.16}$$

The bias in the Counter-Current Flow Period is due to the uncertainty in predicting the amount of the ECC delivered to the lower plenum. The more the ECC fluid accumulates during this period, the shorter will be the Filling Period. The downward ECC flow in the downcomer depends upon the steam flow rate from the lower plenum and the interfacial mass and momentum transfer in the downcomer.

The discrepancy between the predicted and measured lower plenum filling rates, $\delta\dot{m}_{LP}$, is defined via the ratio $\langle R_{\dot{m}LP} \rangle$ of the predicted ($\dot{m}_{LP,pred}$) and actual ($\dot{m}_{LP,act}$) filling rates, as follows:

$$\delta\dot{m}_{LP} = \dot{m}_{LP,act} - \dot{m}_{LP,pred} \tag{3.17}$$

$$\langle R_{\dot{m}LP} \rangle_{NPP,AE} = \dot{m}_{LP,pred} / (\dot{m}_{LP,pred} + \delta\dot{m}_{LP}) \quad . \tag{3.18}$$

From the discrepancy in the filling rate one computes the bias in the predicted duration t_{AE}; Figure 3.10 shows the times and the corresponding lower plenum inventories for this period. The filling rate discrepancy will lead to the bias in the time period for the Counter-Current Flow Period to achieve the same inventory in the lower plenum in both the reference NPP calculation and the NPP.

$$m_{LP,E} - m_{LP,A} = \dot{m}_{LP,pred} * t_{AE} \tag{3.19}$$

$$= (\dot{m}_{LP,pred} + \delta \dot{m}_{LP}) * (t_{AE} + \delta t_{AE}) \tag{3.20}$$

where $m_{LP,A}$ and $m_{LP,E}$ are the liquid inventories in the lower plenum at times t_A and t_E, respectively.

The bias δt_{AE} is obtained from Equations (3.16), (3.17), (3.18), and (3.19) and is shown here:

$$\delta t_{AE} = (\langle R_{\dot{m}LP} \rangle_{NPP,AE} - 1) * t_{AE} \quad . \tag{3.21}$$

The prediction of bias in the Counter Current Flow Period is reduced to the estimation of ratio $\langle R_{\dot{m}LP} \rangle_{NPP,AE}$. This ratio is obtained from the full-scale Separate Effect Test (SET) facilities (UPTF) for the downcomer flows measured under conditions as expected in the NPP during the Counter Current Flow Period. Since there is no scale distortion in UPTF, one gets

$$\langle R_{\dot{m}LP} \rangle_{NPP,AE} = \langle R_{\dot{m}LP} \rangle_{SET} \quad . \tag{3.22}$$

The ratio $\langle R_{\dot{m}LP} \rangle_{SET}$ is obtained by modelling with the code the tests previously conducted in the SET facility (UPTF) and by computing a set of ratios of predicted over measured lower plenum filling rates.

$$R_{\dot{m}LP} = \dot{m}_{LP,pred} / \dot{m}_{LP,meas} \tag{3.23}$$

An average of all the ratios (Equation 3.23) in the set is computed according to Equation (3.22) and this average ratio is applied to compute δt_{AE} according to Equation (3.21).

3.3.2.2 Bias in the Timing of No-Bypass Period

The No-Bypass time Period is the last period (t_{EB}) of the Refill Phase and begins at time t_E at which time the steam flow into the downcomer ceases and ends at time t_B when the lower plenum is full. The time t_B is obtained from Figure 3.10 as the intersection of the TRAC-predicted $m_{LP}(t)$ curve with the horizontal line corresponding to $(m_{LP})_{full}$. The duration of this period is computed as follows:

$$t_{EB} = t_B - t_E \tag{3.24}$$

The bias in this period is due to the bias in predicting the lower plenum filling rate or the error in predicting the distribution of ECC fluid between the lower plenum and the downcomer. The steps to estimate the uncertainty in the duration of this period are the same as in the previous section. A ratio $\langle R_{\dot{m},LP} \rangle$ of the predicted and the actual lower plenum filling rates is computed and it is used to estimate the bias in t_{EB}.

$$\delta t_{EB} = (\langle R_{\dot{m}LP} \rangle_{NPPEB} - 1) * t_{EB} \quad , \qquad (3.25)$$

where the ratio $\langle R_{\dot{m},LP} \rangle_{NPP,EB}$ is obtained from properly scaled or full-scale Separate Effects Tests with conditions similar to the conditions expected in NPP for No-Bypass Period.

$$\langle R_{\dot{m}LP} \rangle_{NPPEB} = \langle R_{\dot{m}LP} \rangle_{SET} \quad . \qquad (3.26)$$

3.3.3 Total Bias in the Refill Phase

The biases estimated in the Sections 3.3.1 and 3.3.2 are added to provide the bias in the Refill Phase.

$$\delta t_{IB} = \delta t_{ID} + \delta t_{DA} + \delta t_{AE} + \delta t_{EB} \quad . \qquad (3.27)$$

The total bias δt_{IB} estimated in Equation (3.27) is used in Equation (3.1) to estimate the bias in PCT.

3.3.4 Required Information for Application

Application of the procedure developed in the previous sections (Sections 3.3.1 to 3.3.3) requires information from the nominal NPP calculation and from SETs for the downcomer flow. The information needed and its source are summarized here:

t_I	Time of ECC Injection	NPP Calculation/Accumulator Flow
t_D (W_{gc})	Time of Critical Steam Flow	NPP Calculation/Steam Flow from LP to DC
t_A	Time of Lowest LP Inventory	NPP Calculation/LP Liquid Inventory
t_E	Time of End of Steam Flow DC	NPP Calculation/Steam Flow from LP to DC
t_B	Time When LP Full	NPP Calculation/LP Liquid Inventory
dTc/dt	Rate of Clad Temp Rise	NPP Calculation/Hot Rod Clad Temperature History
W_{gc}	Critical Steam Flow Rate	Calculation/Stand alone DC with Fixed ECC and Steam Flows
$W_{gc,exp}$	Critical Steam Flow Rate, Exp	SET
$R_{t,SET}$	Ratio of Delays From SET	SET
$R_{\dot{m}LP,SET}$	Ratio of Filling Rates From SET	SET

The information from the SETs is used for evaluating the bias in the timing of the Refill Phase.

3.4 Application

The methodology developed in the previous section is applied to the TRAC-PF1/MOD1, Version 14.3 calculation of a LBLOCA for a four loop Westinghouse plant. This section describes the numerical evaluation of Equations (3.1), (3.2) and (3.27) to obtain the bias in the predicted PCT due to the uncertainty in the code modelling of the Refill Phase.

3.4.1 Experiments for Estimating Bias

The evaluation of the bias in the Refill Phase timing requires a comparison of the code predictions with the data from well-scaled or full-scale test facilities simulating the downcomer flow during the Refill Phase. These tests are identified in Step 8 of the CSAU Methodology (Section 1.2.2).

There are two types of facilities which simulate the downcomer flow during the Refill Phase. They are: Integral Effects Test (IET) and Separate Effects Test (SET). The IETs, such as LOFT, are scaled with power to volume scaling method [Zuber, et al., 1990]. While preserving the time scales and the mass and energy distributions, such scaling distorts the downcomer flows. The downcomer in the IET has narrow gaps and therefore, does not accurately simulate the flow regimes and counter-current flow.

The SETs are designed to overcome the scale distortion in the downcomer in the IET. The downcomer flow phenomena are affected by geometry such as that of the annular gap, the arrangement of cold legs, and by wall heat transfer, by rate of steam flow from the lower plenum to the downcomer, and the temperature and flow rate of the ECC fluid. These conditions are easily controlled in the SETs. The procedure for bias assessment (described in Section 3.3) needs three empirical parameters $W_{gc,exp}$, $R_{t,SET}$ and $R_{\dot{m}LP,SET}$ from the steady state tests with constant steam flow and ECC injection rates. These parameters can only be obtained from SETs and therefore, only SETs will be considered. In the next section, the available SETs for the downcomer flow are described.

3.4.1.1 Available Data

A search through the literature indicated that the data from five sub-scale experiments and one full-scale experiment were available. The dimensions of these faclities are listed in Table 3.1. In this table, the first column lists the type of dimension, the second column indicates the size of a typical PWR, and the remaining six pairs of columns list the actual dimension and the ratio of these dimensions to the corresponding dimensions of PWR, for the six SETs used, i.e., the Upper Plenum Test Facility (UPTF), CREARE (1/5), Battelle Columbus Laboratory (BCL) tests (2/15), BCL (1/15), CREARE (1/15), and CREARE (1/30) respectively. All the facilities had four cold legs. Three of the cold legs had injections, and the fourth cold leg represented the break. The UPTF [Siemens/KWU, 1987; Liebert, 1988] is a full-scale test facility. The subscale test facilities [Crowley, et al., 1977, 1979, 1980, 1981; Cudnik, et al., 1977, 1978] covered variations in the steam or air flow rates, ranging from no liquid delivery or complete bypass to full liquid delivery.

Table 3.1 - Geometrical Parameters for Test Facilities***

	PWR	UPTF		CREARE (1/5)		BCL (2/15)		BCL (1/15)		CREARE (1/15)		CREARE (1/30)	
		ACTUAL	SCALE*	ACTUAL	SCALE	ACTUAL	SCALE	ACTUAL	SCALE	ACTUAL	SCALE	ACTUAL	SCALE
VESSEL DIA	4.4m	4.87	1.1	0.89m	0.2	0.618m	0.14	0.307	0.070	0.292m	0.066	0.152m	0.034
DC,GAP	0.26m	0.25m	0.96	0.038m	0.146	0.031m	0.119	0.015	0.058	0.0126m	0.048	0.0064m	0.025
DC,HEIGHT	5.33m	6.64m	1.25	1.37m	0.257	0.82m	0.153	0.521	0.098	0.46m	0.086	0.229m	0.043
LP,DEPTH	1.94m	2.48m	1.28	1.52m	0.783	1.022m	0.526	0.508**	0.262	0.86m	0.443	0.528m	0.272
LP VOL,m^3	29.6	24.9	0.84	0.94	0.032	0.302	0.010	0.038**	0.0013	0.058	0.0019	0.0096	$3x10^{-4}$
COLD LEG DIA	0.74m	0.75m	1.01	0.152m	0.21	0.102m	0.14	0.053	0.072	0.0476m	0.064	0.076m	0.1
$D_{CL/D}$	0.168	0.154	----	0.168	-----	0.165	-----	0.173	------	0.163	------	------	0.5

* Scale is the ratio of the dimension of the facility and the dimension of PWR.

** Dimensions are taken from sketch (Fig. 1, BMI-1941, November 1975).

*** Data obtained from Crowley, et al. (1980).

The subscale facilities were scaled with the linear scaling method [Zuber, et al., 1990]. The gap size, vessel diameter and cold leg diamter were linearly scaled from the PWR as shown in Table 3.1. However, the downcomer height and the lower plenum depth were oversized. These facilities are not similar and do not model the same flow phenomena. Three flow regimes [Richter, 1977; Liebert, 1988] are possible in the downcomer during the counter-current flow; falling films on the wall, bridging of the films with liquid globules and flow of ECC as column below intact cold legs in the downcomer. These flow regimes are dependent on the physical dimensions of the downcomer. The first two flow regimes have been observed in the subscale facilities, but the third flow regime has only been observed in the UPTF [Appendix A]. Use of subscale test data for bias evaluation will introduce uncertainty in the bias due to scale distortion.

The TRAC code does not have constitutive package to represent the flow regimes expected in the downcomer and it is impossible to estimate the uncertainty due to scale distortion in the bias by using the code. As an illustration of the uncertainty due to scale distortion, four of the SETs [Neymotin et al, 1988] were modelled with the TRAC code and the ratios (R_{mLP}) of lower plenum filling rates are shown in Figure 3.12. The TRAC code overpredicts the LP filling rate for smaller facilities and underpredicts for the larger facilities. The code is conservative for the larger facilities. Therefore, an estimate of bias (Equations 3.21, 3.25, 3.27) in the timing of the Refill Phase on the basis of the above smaller facilities can lead to both a small reduction and an increase in the timing. The uncertainty in the bias in the PCT due to scale distortion of the SET could make the bias conservative. However, a definite conclusion could only be reached on the basis of the full-scale UPTF data.

Fortunately the data from a full-scale facility, such as UPTF, are available and the estimate of bias on the basis of this data will not have uncertainties due to scale distortion. UPTF data are used below in estimating the bias.

3.4.1.2 UPTF Experiments

The procedure described in Section 3.3 requires data from Separate Effects Tests. The full-scale data are available from the Upper Plenum Test Facility (UPTF) and the biases are evaluated on the basis of UPTF data only. However, only five UPTF data points are available which precludes any statistical analysis.

Appendix A describes UPTF Test 6 and the procedure for analyzing the data. These tests were modelled with TRAC-PF1/MOD1, Version 14.3 with the same nodalization as for NPP analyses. The description of the nodalization and the input deck listing are given in Appendices B and C, respectively. The results of the TRAC model of the UPTF Test 6 runs have been analyzed in Appendix D. The results from Appendix A and D for five steam flow rates are summarized in Table 3.2. The first column indicates the run numbers, and the second column provides the steam flow rates. The next four columns (3 to 6) list the lower plenum filling rates, the time of injection, the time at which the lower plenum inventory begins to increase, and the delay in the delivery of ECC to the lower plenum. The next four columns (7 to 10) list the predicted values of the lower plenum filling rates, the time of injection, the time at which the lower plenum inventory begins to increase, and the delay in ECC liquid delivery to the

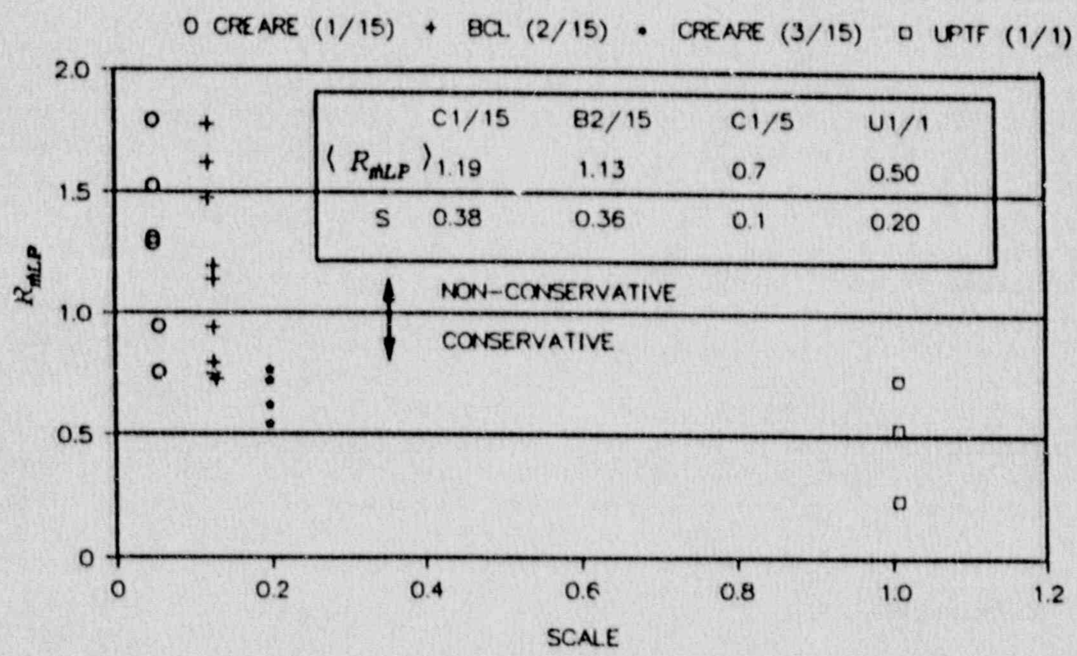

Figure 3.12 Comparison of Ratios of Predicted and Measured Lower Plenum Fill Rates for Three Subscale Facilities and UPTF Test 6

Table 3.2 - Summary of UPTF Results (Test 6)

	EXPERIMENT					TRAC					
Run	W_g kg/s	$\dot{m}_{LP}$ kg/s	t_I s	t_A s	$t_{IA,UPTF}$ s	$\dot{m}_{LP}$ kg/s	t_I s	t_A s	$t_{IA,UPTF}$ s	$R_{\dot{m}LP}$	R_t
131	400	419	43	49(54)	6(11)	0	43	∞	∞	0	∞
132	300	840	43	52	9	199	43	63	20	0.24	2.22
133	200	699	43	50	7	360	43	59	16	0.52	2.29
135	440	> 0	43	------	-----	0	43	∞	∞	----	----
136	100	644	43	45	2	512	43	50	7	0.7	3.50

$\langle R_{\dot{m}LP} \rangle$ = 0.5^2 (Runs 132, 133, 136)

$\langle R_{t,NPP} \rangle$ = 2.67 (Runs 132, 133, 136) lower plenum. The last two columns indicate the ratios of the predicted and the measured lower plenum filling rates and the ratios of the predicted and the measured delay in the delivery of ECC fluid. These ratios will be used to estimate the bias in PCT.

In addition to the experimental data and code predictions for the UPTF tests, one also needs results from the reference NPP calculations, namely accumulator flow rate (Figure 3.13), lower plenum liquid inventory (Figure 3.14), rate of steam flow from the lower plenum to the downcomer (Figure 3.15), and hot rod clad temperature (Figure 3.16). The next section describes the application of the procedure developed in Section 3.3 and the available UPTF data described in this section.

3.4.2 Evaluation of Biases

Figure 3.13 shows the accumulator flows in one of the intact loops from the NPP calculation carried out with TRAC-PF1/MOD1, Version 14.3. The flow begins at 11.5 seconds, which is the beginning of the Refill Phase.

$$t_I = 11.5\ s \tag{3.28}$$

Times t_A and t_B are read from Figure 3.14 which shows the lower plenum inventory from the NPP calculation.

$$t_A = 22.9\ s \tag{3.29}$$

and

$$t_B = 33.5\ s \tag{3.30}$$

The times obtained from the NPP calculation delineate the subperiods in the Refill Phase and will be used to estimate biases in the subperiods.

3.4.2.1 Bias in the Timing of the Complete Bypass Period

The bias in this period is due to the uncertainty in predicting the critical steam flow rate (W_{gc}) and is evaluated from Equation (3.7). Full-scale data are available from UPTF Test 6 as shown in Table 3.2, where Column 2 shows the steam flow rates and the Column 3 lists the lower plenum filling rates. The highest steam flow rate reported is 440 kg/s for Run 135, and there was liquid delivery to the lower plenum for this run. This observation implies that a complete bypass will take place at an even higher steam flow rate. From the available data one can only conclude:

$$W_{gc,UPTF,exp} > 440\ kg/s \tag{3.31}$$

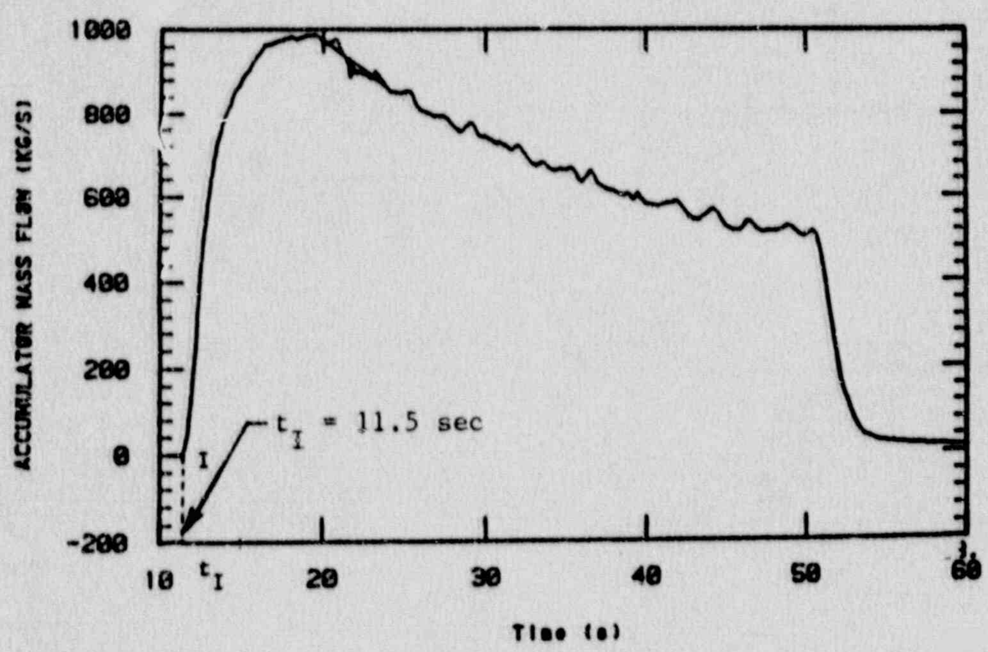

Figure 3.13 Identification of t_I from the Predicted Accumulator Discharge Mass Flow Rate. (Nominal TRAC-PF1/MOD1 Version 14.3 Calculation Performed by INEL in Support of CSAU Methodology Demonstration) (BNL-1-368-90)

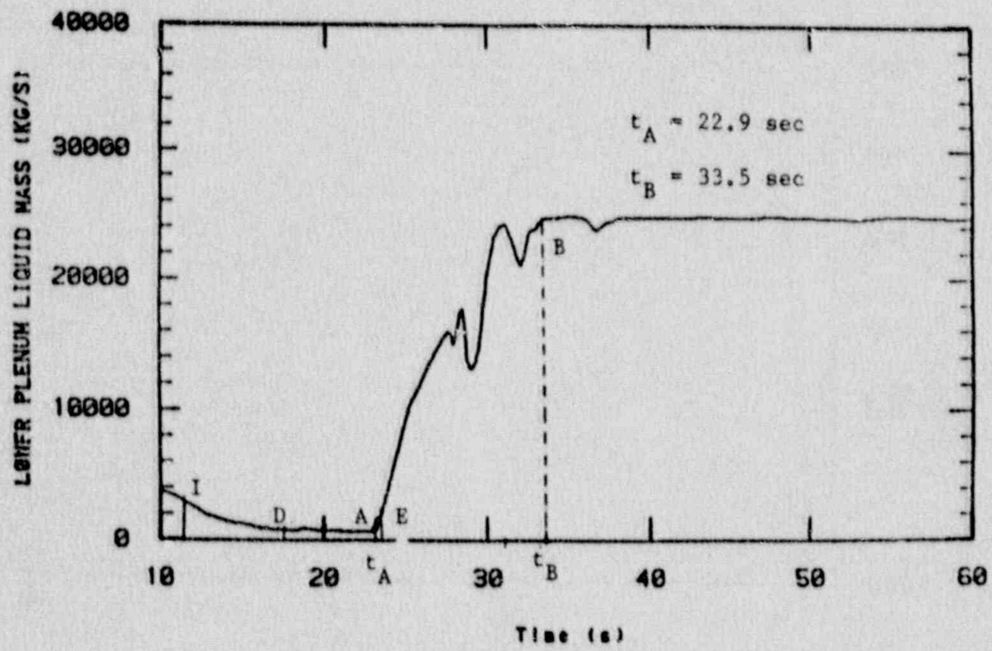

Figure 3.14 Identification of t_A and t_B from the Predicted Lower Plenum Liquid Inventory. (Nominal TRAC-PF1/MOD1 Version 14.3 Calculation Performed by INEL in Support of CSAU Methodology Demonstration) (BNL-1-360-90)

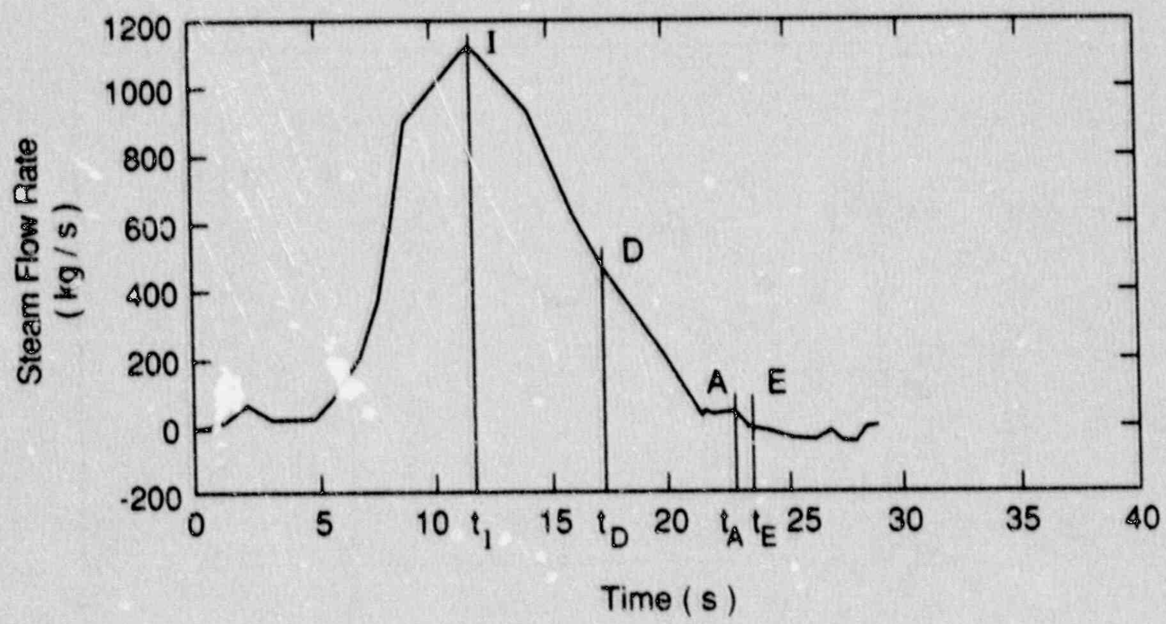

Figure 3.15 Identification of t_D and t_E from the Predicted Steam Flow Rate from the Lower Plenum to the Downcomer. (Nominal TRAC-PF1/MOD1 Version 14.3 Calculation Performed by INEL in Support of CSAU Methodology Demonstration)

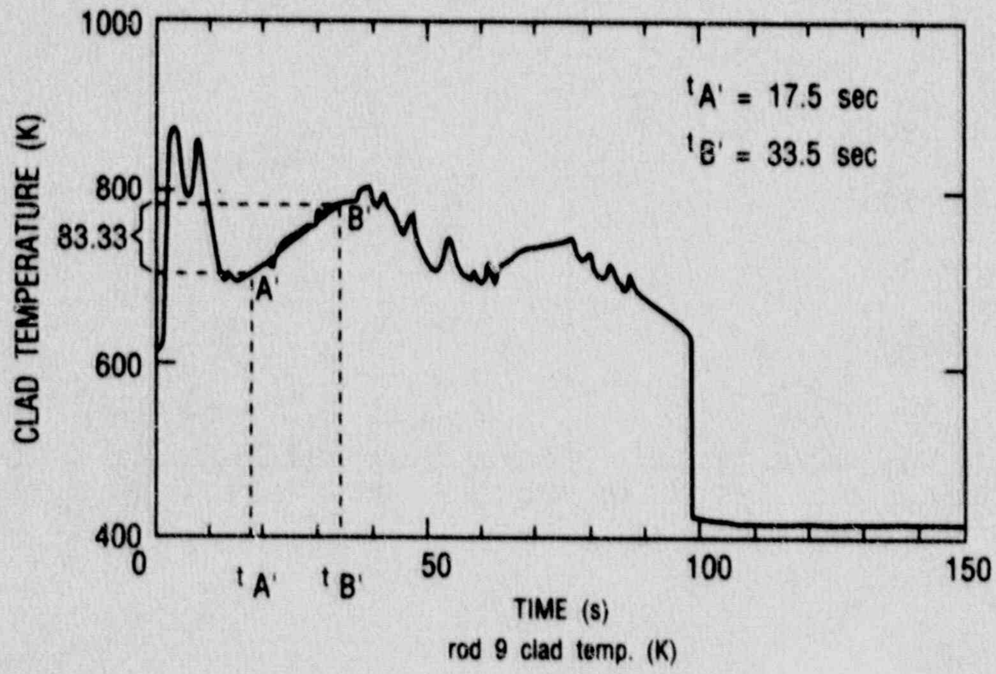

Figure 3.16 Identification of $T_{A'}$, $T_{B'}$, $t_{A'}$, and $t_{B'}$ from the Predicted Rod 9 (Hot Rod) Clad Temperature (Nominal TRAC-PF1/MOD1 Version 14.3 Calculation Performed by INEL in Support of CSAU Methodology Demonstration)

The critical steam flow rate $W_{gc,NPP}$ for the NPP will be larger than for any UPTF run reported in Test 6, because the ECC subcooling and ECC injection rate in UPTF Test 6 were lower than in the NPP prediction as shown in Table 3.3. These differences imply that there is a larger condensation in the NPP, and a larger steam flow rate will be needed for complete bypass in the NPP than in the UPTF Test 6. Therefore,

$$W_{gc,NPP} > W_{gc,UPTF,exp} \tag{3.32}$$

For a conservative estimate of the bias in the PCT, a lower bound for $W_{gc,NPP}$ is chosen from Equations (3.31) and (3.32):

$$W_{gc,NPP} = 440\ kg/s \tag{3.33}$$

The time t_D corresponding to the critical steam flow rate in Equation (3.32) is obtained from Figure 3.15, which shows the steam flow rate from the lower plenum to the downcomer, as obtained from the NPP calculation.

$$t_D = 17.5\ s \tag{3.34}$$

The actual value $W_{gc,NPP,act}$ of the critical steam flow rate will be higher than given in Equation (3.33) and, as shown in Figure 3.14, the steam flow rate from the lower plenum to the downcomer decreases monotonically with time. The time, $t_{D,act}$ corresponding to $W_{gc,NPP,act}$ will occur earlier than t_D, i.e.,

$$W_{gc,NPP,act} > W_{gc,NPP} \quad . \tag{3.35}$$

Therefore,

$$t_{D,act} < t_D \quad . \tag{3.36}$$

The bias in the Bypass Period is obtained from Equation (3.7), which gives

$$\delta t_{ID} = t_{D,act} - t_D < 0.0\ s \quad . \tag{3.37}$$

The bias δt_{ID} is negative because of Equation (3.36) and can only reduce the refill time period t_{IB}, and the PCT. Therefore, a conservative estimate is

Table 3.3 - Comparison Between NPP and UPTF (Full-Scale Facility) Conditions

NO.	CONDITIONS	NPP	UPTF
1	STEAM FLOW LP TO DC	FROM FLASHING IN LP DECREASING WITH TIME	FIXED FLOW RATE
2	SYSTEM PRESSURE	DECREASING	INCREASING
3	BREAK FLOW RATE	DECREASING	INCREASING
4	ECC SUBCOOLING	HIGH (~90°K)	LOW (~50°K)
5	ECC FLOW RATE	HIGH (~2500 kg/s)	LOW (~1500 kg/s)
6	COLD LEGS	OPEN LOOPS	LOOPS CLOSED AT PUMP SIMULATOR
7	NUMBER OF ECC INJECTION	FOUR	THREE, NONE IN BROKEN LOOP

$$\delta t_{ID} = 0.0\ s \quad . \tag{3.38}$$

3.4.2.2 Bias in the Timing of the Delay Period

The duration t_{DA} of the Delay Period is obtained from Equations (3.29) and (3.34)

$$t_{DA} = 22.9\ s - 17.5\ s = 5.4\ s \quad . \tag{3.39}$$

The delay ratio ($\langle R_t \rangle_{NPP}$) is obtained from Table 3.2 by averaging the last three values of R_t in the last column.

$$\langle R_t \rangle_{NPP} = 2.67 \quad . \tag{3.40}$$

The bias for the Delay Period is estimated by substituting Equations (3.39) and (3.40) into Equation (3.13). The result is

$$\delta t_{DA} = -3.4\ s \quad . \tag{3.41}$$

3.4.2.3 Bias in the Timing of the Counter-Current Flow Period

The Counter-Current Flow Period spans from time t_A to time t_E. The time t_A is obtained from Equation (3.29). The time t_E is read from Figure 3.15 and is:

$$t_E = 23.4\ s \quad . \tag{3.42}$$

The duration of this period is

$$t_{AE} = t_E - t_A = 23.4\ s - 22.9\ s = 0.5\ s \quad . \tag{3.43}$$

The filling rate ratio, $\langle R_{\dot{m}LP} \rangle_{NPP,AE}$, for the NPP is obtained from Table 3.2 by averaging the last three values of $R_{\dot{m}LP}$>LP in the eleventh column.

$$\langle R_{\dot{m}LP} \rangle_{NPP,AE} = 0.52 \quad . \tag{3.44}$$

The bias is estimated by substituting Equations (3.43) and (3.44) into Equation (3.21), and the result is

$$\delta t_{AE} = -0.24\ s \quad . \tag{3.45}$$

3.4.2.4 Bias in the Timing of the No-Bypass Period

The No-Bypass Period spans from time t_E to the end of the Refill Phase at time t_B. The times t_E and t_B are obtained from Equations (3.29) and (3.42). The bias in this period is due to the discrepancy in predicting the lower plenum filling rate. There are no data available at low steam flow rate cases and, therefore, an estimate of the bias is made on the basis of UPTF data listed in Table 3.2. The eleventh column shows $R_{\dot{m}, LP}$, the ratio of the predicted to measured lower plenum filling rates. The trend in this column shows that this ratio increases with the decrease in the steam flow rate. The values of the ratio ($R_{\dot{m},LP}$) were extrapolated down to zero steam flow rate and it is assumed that this value is applicable to the NPP. Therefore:

$$\langle R_{\dot{m},LP} \rangle_{NPP,EB} = 0.87 \quad . \tag{3.46}$$

As the extrapolated value of the $\langle R_{\dot{m},LP} \rangle$ is less than 1.0, the code underpredicts the filling rate and therefore, it is conservative. This ratio is substituted into Equation (3.25), and the following estimate of the bias is obtained:

$$\delta t_{EB} < 0.0\ s \quad . \tag{3.47}$$

Therefore, a conservative estimate of the bias for the No-Bypass Period is:

$$\delta t_{EB} = 0.0\ s \quad . \tag{3.48}$$

3.4.2.5 Total Bias in the Refill Phase

The bias in the duration of the Refill Phase (δt_{IB}) is obtained by substituting Equations (3.38), (3.41), (3.45), and (3.48) into Equation (3.27).

$$\delta t_{IB} = -3.64\ s \quad . \tag{3.49}$$

3.4.2.6 Bias in PCT

The Bias in the PCT is obtained from Equation (3.1). The clad heat up rate (dT_C/dt) is estimated from Figure 3.15, which shows the clad temperature history for the hot rod from the reference NPP calculation. The result is as follows:

$$dT_c/dt = (83.3°K)/(33.5\ s - 17.5\ s) = 5.2°K/s \quad . \tag{3.50}$$

The bias in PCT due to the deficiencies in the code in modelling the ECC bypass phenomena is estimated by substituting Equations (3.49) and (3.50) into Equation (3.1). The final result is

$$\delta PCT = -19°K(-34°F) \quad . \tag{3.51}$$

3.5 Conclusions

A procedure has been developed to estimate the bias in the PCT due to the deficiencies in the code modelling of the important processes, numerics and nodalization affecting the bypass flow phenomena in the Refill Phase of the LBLOCA. The estimated bias in PCT is -19°K which implies that the code overpredicts the PCT and is conservative with respect to the bypass phenomena.

The Refill Phase was divided into four phenomenologically different periods. The largest contribution to the bias is from the Delay Period (-17.?°K) during which the ECC is accumulating in the cold legs and the downcomer region of the reactor. The Counter Current Flow Period was surprisingly small (0.5 s) and contributed only -1.3°K to the total bias in PCT. The most important parameter during the Delay Period is the critical steam flow rate. Since the available data for determining this critical steam flow rate is sparse, more data is needed, particularly at the high and low ends of the steam flow rate range. Furthermore, additional test data are needed to provide a meaningful statistical analysis.

4. LACK OF MODEL FOR DISSOLVED N_2 AND RESULTING PCT BIAS

N_2 is a non-condensable gas which is present in the accumulators in the form of a free gas above the ECC liquid and dissolved in the liquid. During an LBLOCA, as the coolant flows from the accumulators to the low pressure regions of the cold legs and the downcomer, the dissolved N_2 emerges from the solution. This dissolution of the N_2 will affect the hydraulics of the coolant through influences on system pressure, break flow and condensation processes during the Refill Phase and, thus, also influence the reflood PCT. The TRAC-PF1/MOD1, Version 14.3 code, which is being used here to simulate LBLOCA, does not have a model for dissolved N_2 and, therefore, cannot account for its effect on the PCT. The lack of a model for an important phenomenon is a systematic error or deficiency in the code and will bias the code prediction. The bias in the predicted PCT is estimated here through a separate calculation.

The next five sections describe the effect of the emerging N_2 on the thermal hydraulic behavior of the Refill Phase and a procedure for estimating the bias due to the lack of a dissolved N_2 model in the code.

4.1 Effect of N_2 on the Refill Phase

The accumulators have ECC liquid in equilibrium with N_2 in the gas space at a pressure of 40 bar. Therefore, there is dissolved N_2 in the liquid of the accumulators. During an LBLOCA, the system pressure decreases rapidly. When the primary system pressure drops below 40 bar, the ECC liquid begins to flow from the accumulators to the cold legs and eventually to the downcomer and the lower plenum. As the cold leg pressure is lower than the pressure in the accumulators, the solubility of the N_2 in the coolant is lower in the cold leg than in the accumulators. This drop in the solubility will cause some of the N_2 to emerge in the cold legs and in the downcomer. However, the amount of N_2 emerging in the cold legs will decrease as the N_2 solubility in the accumulator decreases during depressurization of the accumulators. The N_2 escaping from the ECC in the accumulators collects above the ECC level in the accumulators.

The presence of the emerging N_2 in the primary system will lower the system depressurization rate by reducing the condensation rate through a decrease in the interfacial heat transfer rate, and by increasing the gas volume. This reduction in the system depressurization rate extends the time the system remains at high pressure and, therefore causes a higher break flow rate, a lower rate of safety injection and lower accumulator flows than in the situation without N_2. The additional volume of N_2 will also cause coolant from the cold legs and upper downcomer to become displaced to the lower downcomer and finally to the lower plenum. There are two competing effects. The reduction of ECC flow and the displacement of the ECC liquid from the cold leg and the downcomer to the lower plenum, and the influence of the N_2 on the PCT will depend on the relative strengths of these two effects. The analysis for predicting the expected amount of N_2 and its effects on condensation and ECC flow rates in the NPP is described in Appendix E.

The remaining four subsections describe the procedure for using the information generated in Appendix E to estimate the bias in PCT.

4.2 Principle of Uncertainty Estimation

The principle here is the same as that described in Section 3.2. The bias in PCT due to the omission of modelling dissolved N_2 effects is estimated by first computing the bias in the predicted duration t_{IB} of the Refill Phase due to dissolved N_2. Next, the bias in the time period is converted into a bias in PCT, by multiplying the time bias with the average time rate of temperature rise of the hot rod clad during the Refill Phase (Equation 3.1). The refill duration t_{IB} is computed from the time at which the ECC begins to the time at which the lower plenum is full as shown in the Figure 3.7. The clad heatup rate is obtained from the code-predicted clad temperature history:

The PCT bias arising from the omission in TRAC-PF1 of the modeling for N_2 effects is, therefore:

$$\delta PCT_{N_2} = \frac{dT_c}{dt} \delta t_{IB,N_2} , \tag{4.1}$$

where $\delta t_{IB,N_2}$ and dT_c/dt are the bias in the Refill Phase duration and the clad heatup rate, respectively.

The approach taken here consists of the following four steps, using the nominal NPP calculation:

1. Estimate the amount of N_2 which would have emerged if the code had a model for dissolved N_2.

2. Estimate the effect of the N_2 on the condensation process.

3. Set up a separate model for the reactor (vessel, steam generators, pumps and pipes), and the broken and intact loop accumulators to estimate the system pressure and the new ECC flows (accumulator flows and safety injection rates) during the Refill Phase in the presence of N_2.

4. Compute the effect of new ECC flows on the timing of the Refill Phase.

The bias in the Refill Phase duration is computed via the timings estimated from a separate calculation and obtained from the nominal NPP calculation.

4.3 Estimation of N_2 Modeling Bias in Refill Phase

The procedure is that used in Section 3.3. The Refill Phase is divided into two periods, shown in Figure 3.7. The first period, t_{IA}, is the Bypass Period, and the second period, t_{AB}, is the Filling Period. The effects of N_2 on these periods are summed to yield the bias in the Refill Phase.

$$\delta t_{IB,N_2} = \delta t_{IA,N_2} + \delta t_{AB,N_2} \quad . \tag{4.2}$$

4.3.1 Bias in the Timing of the Bypass Period

This period consists of two distinct sub-periods, namely, the Complete Bypass Period and the Delay Period, as described in Section 3.1.

The bias in this period t_{IA} is computed from the estimates of the biases in the sub-periods t_{ID} and t_{DA}.

$$\delta t_{IA,N_2} = \delta t_{ID,N_2} + \delta t_{DA,N_2} \tag{4.3}$$

4.3.1.1 Bias in the Timing of the Period of Complete Bypass

The time (t_I) of the initiation of the accumulator flow is not affected by N_2 dissolved in the ECC. The critical steam flow rate, which is the maximum steam flow rate at which there is ECC delivery to the lower plenum if sufficient time is available, changes in the presence of the N_2 and this affects the time (t_{D,N_2}) at which the Period of Complete Bypass ends.

The time t_{D,N_2} is estimated from the steam flow rate curve obtained from the nominal NPP calculation. This curve is shown in Figure 3.15.

$$t_{D,N_2} = t(W_{gc,N_2}) \tag{4.4}$$

$$t_D = t(W_{gc}) \tag{4.5}$$

where W_{gc} and $W_{gc,N2}$ are critical steam flow rates without and with N_2 present. The duration of this period with and without the presence of N_2 and the bias are estimated as follows:

$$t_{ID,N_2} = t_{D,N_2} - t_I \quad , \tag{4.6}$$

$$t_{ID} = t_D - t_I \tag{4.7}$$

and

$$\delta t_{ID,N_2} = t_{ID,N_2} - t_{ID} \quad , \tag{4.8}$$

where $\delta t_{ID,N_2}$ is the bias in the Complete Bypass Period due to the dissolved N_2 effect.

4.3.1.2 Bias in the Timing of the Delay Period

During the Delay Period, t_{DA}, the steam flow rate is less than the critical steam flow rate and there is accumulation of the ECC in the downcomer and the cold legs. There are two opposing effects of N_2 on this period. The emerging N_2 will displace the liquid and will push liquid into the downcomer and also into the lower plenum. This effect will tend to reduce the time span of the Delay Period and therefore, the duration of the Refill Phase and the PCT. The second effect of the N_2 is to slow down the depressurization rate and therefore, reduce the ECC flow rate (accumulator flows and safety injection). A reduction in ECC flow rate will cause an increase in the durations of the Delay Period and Refill Phase, and in PCT. The bias in t_{DA} is the sum of the biases due to these two effects.

$$\delta t_{DA,N_2} = \delta t_{DA,1,N_2} + \delta t_{DA,2,N_2} \quad . \tag{4.9}$$

The first of the two biases of the right hand side of Equation (4.9), $\delta t_{DA,1,N_2}$ is due to the effect of N_2 on the accumulation of the ECC in the downcomer for the same ECC flow rates. This bias is estimated from a ratio $<R_{t,th}>$ of the code prediction of this time period, with and without the presence of N_2, for same ECC flow rate and NPP conditions. The ratio is called the delay ratio.

$$\langle R_{t,th} \rangle = \frac{t_{DA,1,N_2}}{t_{DA}} \quad . \tag{4.10}$$

The bias, $\delta t_{DA,1,N_2}$ is related to the delay ratio in Equation (4.10) as follows.

$$\delta t_{DA,1,N_2} = t_{DA,1,N_2} - t_{DA} \tag{4.11}$$

$$= t_{DA} * [(R_{1,th}) - 1] \quad . \tag{4.12}$$

The second bias $\delta t_{DA,2,N_2}$ of Equation (4.9) is estimated from the ratio R_{ECC} of the ECC flow rates in the NPP calculations with and without N_2. It is assumed that the ratio of the rates of the ECC accumulation in the cold legs and the downcomer with and without N_2 is equal to the ratio of the rates of ECC flow rates with and without N_2.

$$R_{ECC} = \frac{\dot{m}_{ECC}}{\dot{m}_{ECC,N_2}} \tag{4.13}$$

$$= \frac{\dot{m}_{(DC+CL)}}{\dot{m}_{(DC+CL),N_2}} \quad . \tag{4.14}$$

where $\dot{m}_{ECC,N_2}$ and $\dot{m}_{ECC}$ are the ECC injection rates with and without N_2, and $\dot{m}_{(DC+CL),N2}$ and $\dot{m}_{(DC+CL)}$ are the rate of ECC accumulation in the cold leg and the downcomer with and without N_2.

The second bias is then computed by assuming that the amount of accumulation required in the downcomer and the cold legs, which will lead to the delivery of the ECC to the lower plenum, is the same with or without N_2. Therefore,

$$\delta t_{DA,2,N_2} = t_{DA} * (R_{ECC} - 1) \quad . \tag{4.15}$$

The bias for the Delay Period duration is obtained by adding the biases from Equations 4.12 and 4.15.

4.3.2 Bias in the Timing for the Filling Period

This period begins with the initiation of the recovery of the lower plenum inventory at time t_A and ends at time t_B when the lower plenum is full as shown in Figure 3.7.

The major effect of the N_2 is to slow the depressurization rate and to decrease the rate of ECC flow. Any decrease in the ECC flow rate will extend the duration of the Filling Period. Therefore, the bias in the Filling Period due to the absence of a model for dissolved N_2 will be positive. This bias is estimated from the ratio of the predicted ECC flow rates with and without N_2. The assumption here is that the ratio of the lower plenum filling rates, with and without N_2, is equal to the ratio R_{ECC} of the ECC flow rates. The bias in this period is computed from

$$\delta t_{AB,N_2} = t_{AB,N_2} - t_{AB} \quad , \tag{4.16}$$

where

$$t_{AB} = \frac{m_{LP,B} - m_{LP,A}}{\dot{m}_{LP}} \quad , \tag{4.17}$$

$$t_{AB,N_2} = \frac{m_{LP,B} - m_{LP,A}}{\dot{m}_{LP,N_2}} \quad , \tag{4.18}$$

and where $m_{LP,A}$ and $m_{LP,B}$ are the lower plenum inventories at times t_A and t_B, and $\dot{m}_{LP,N_2}$ and $\dot{m}_{LP}$ are the average lower plenum Filling Rates during the Filling Period with and without the presence of N_2, respectively. The lower plenum filling rates are estimated from the ECC flows as follows:

$$R_{ECC} = \frac{\dot{m}_{ECC}}{\dot{m}_{ECC,N_2}} \quad . \tag{4.13}$$

$$= \frac{\dot{m}_{LP}}{\dot{m}_{LP,N_2}} \tag{4.19}$$

The bias in the Filling Period is computed from the ECC flow rate ratio R_{ECC} and the duration of the Filling Period t_{AB} obtained from the NPP calculation. An expression for this bias is obtained from the manipulation of Equations (4.16) to (4.19) and is

$$\delta t_{AB,N_2} = t_{AB} * (R_{ECC} - 1) \quad . \tag{4.20}$$

4.3.3 Total Bias in the Timing of the Refill Phase

The total bias in the period of the Refill Phase is obtained by substituting the biases for the three periods as given by Equations (4.8), (4.9), and (4.21) into Equations (4.3) and (4.2). The bias in the PCT due to the lack of N_2 modelling in the code is obtained from Equation (4.1).

4.4 Application

The procedure developed in the previous section is applied to the TRAC-PF1/MOD1, Version 14.3 prediction of PCT for a LBLOCA in Westinghouse four loop plant.

The procedure requires nominal NPP calculation results for accumular flow rate, lower plenum inventory, rate of steam flow from the lower plenum to the downcomer and the hot rod clad temperture history. These results are shown in Figures 3.13, 3.14, 3.15, and 3.16 Beside the nominal NPP calculation the procedure also needs values of critical steam velocity (W_{gc,N_2}) in the presence of N_2, of the delay ratio $<R_{t,th}>$, and the ECC flow ratio, R_{ECC}. The next section describes the analysis performed to obtain these parameters.

4.4.1 Supporting Analysis

A separate model for the NPP was developed. The model consisted of a single volume representation for the primary side of the reactor excluding the accumulators, two volumes representing the intact loop accumulators and one volume for the broken loop accumulator. The model used the results of the nominal NPP calculation. The details of this model and its results are described in Appendix E.

Figure 4.1 shows the total ECC expected into the NPP from the nominal NPP calculation and from the separate model. The average ECC flow rate prediction with N_2 effects accounted for is lower than the average ECC flow rate predicted in the NPP calculation without accounting for N_2. Table 4.1 summarizes the integrated ECC flow during the Refill Phase as predicted by the separate calculation and in the reference NPP calculation. In this table, the first column is the time of the transient, the second and third columns show the integrated ECC mass flows from the NPP calculation and from the separate calculation. The ratio of average ECC flows, $<R_{ECC}>$, is 1.14.

In addition to developing a separate model, accounting for the N_2-effect on the NPP response, the UPTF Test 6 was also modelled with the TRAC code, but without N_2 injection. The actual tests had a separate N_2 injection of 1 kg/s, to simulate effects from dissolved N_2. However, 1 kg/s is only an estimate of the emergence rate of N_2 in the PWR during the Refill Phase. The calculations for UPTF Test 6 with and without N_2 provide information about the effect of N_2 on the critical steam flow rate, the delay in the ECC delivery and the lower plenum filling rate. The results for UPTF Test 6 are summarized in Table 4.2. The first column indicates the run numbers, the second column shows the steam flow rates, and the next two columns indicate the lower plenum filling rates, as obtained from TRAC calculations, with and without the N_2 injection. The last two columns list the time spans of the Delay Period, as predicted from TRAC calculation, with and without N_2 injection.

The next section describes the actual calculation of the bias due to the dissolved N_2. Results are used as obtained from the nominal NPP calculation and shown in Figures 3.13, 3.14, 3.15, and 3.16, and the results from a calculation with a separate model for the NPP and UPTF Test 6 calculations.

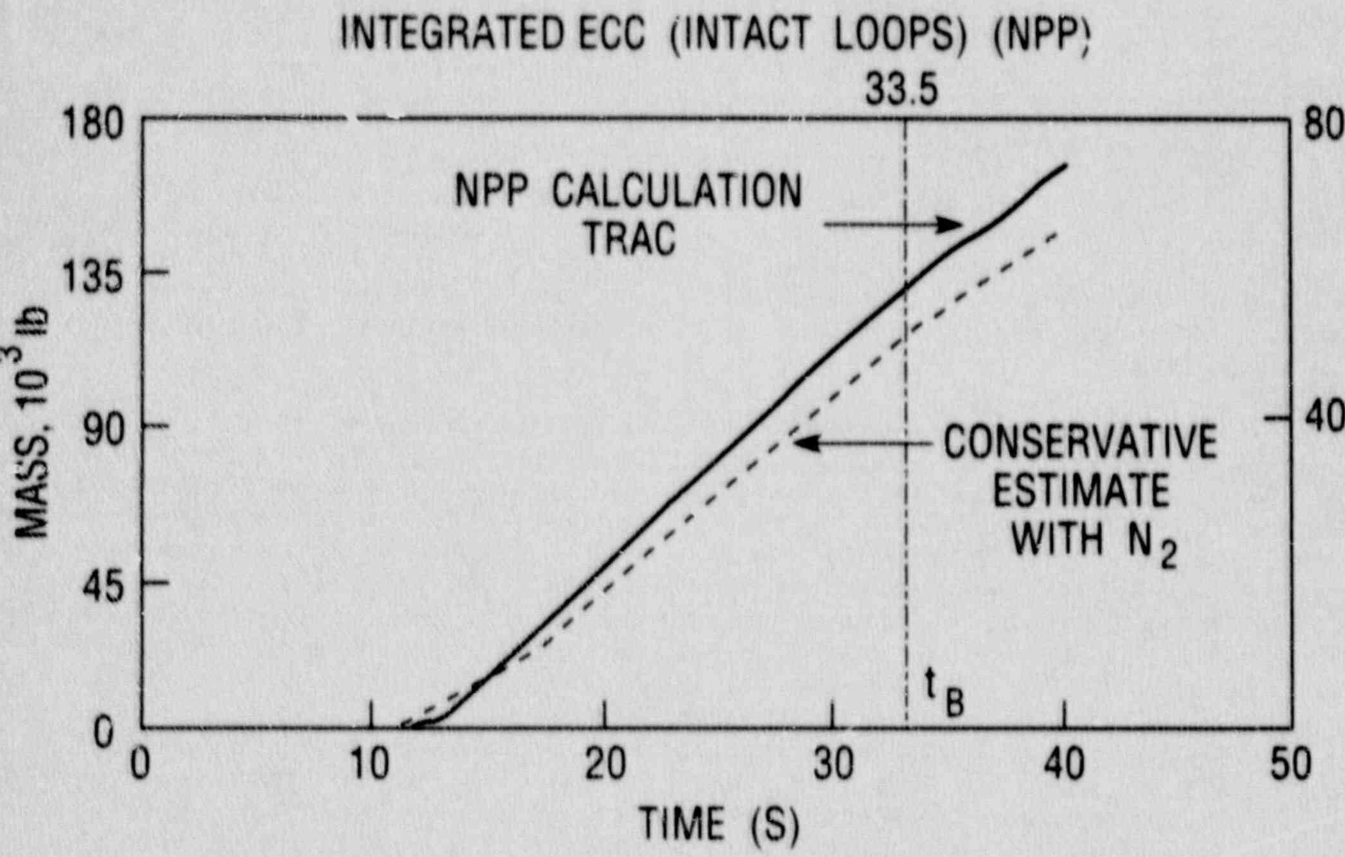

Figure 4.1 Prediction of Integrated ECC Injection

TABLE 4.1 - Integrated ECC Mass With and Without N_2

TIME sec	Δm_{ECC} NPP CALC kg	$\Delta m_{ECC,N_2}$ BOUNDING CALC kg
11.5	0.0	0.0
12.1	860	860
18.1	15,900	12,145
22.9	30,670	23,843
23.8	33,490	26,045
26.1	39,940	31,773
29.5	49,070	40,100
33.5	58,800	58,160

$$\Delta m_{ECC} = \int_{11.5}^{t} \dot{m}_{ECC}\, dt$$

$$\Delta m_{ECC',N_2} = \int_{11.5}^{t} \dot{m}_{ECC',N_2}\, dt$$

$$t_D = 20\ s$$

$$R_{ECC} = \frac{58,800\ kg - 21,746\ kg}{58,160\ kg - 16,776\ kg} = 1.14\ .$$

Table 4.2 - TRAC Simulation of UPTF Test 6

RUN	W_g kg/s	PRED. FILLING RATE		PRED. DELAYS	
		$\dot{m}_{LP,N_2}$ kg/s	$\dot{m}_{LP}$ kg/s	$t_{DA,1,N_2}$ S	t_{DA} S
131	400	0	--	∞	∞
132	300	199	0	20	∞
1[illegible]	250	360	604.6	16	20.6
136	100	512	359.6	7	21.8

$\dot{m}_{LP}$ Lower Plenum Filling rate without N2

$\dot{m}_{LP,N_2}$ Lower Plenum Filling rate with N_2

t_{DA} Delay without N_2

$t_{DA,1,N_2}$ Delay with N_2 and fixed ECC injection rate

W_g Steam flow rate

4.4.2 Evaluation of the Biases

In this section, the actual calculations of the biases for the sub-periods defined in the Section 4.3 are performed, using the procedure described in Section 4.3 and the information described in Section 4.4.

4.4.2.1 Bias in Timing of the Complete Bypass Period

This period begins at the time t_I of initiation of the accumulator flows in the intact loops and ends at time t_D, when the steam flow rate decreases to the critical flow rate. The period is obtained from Equation 3.28.

The critical steam flow rate is obtained from UPTF Test 6 calculations. Since the facility is full-scale, the results can be used directly for the NPP. Table 4.2 shows the TRAC prediction for the lower plenum filling rates, with and without accounting for the N_2 injection. There are no deliveries of ECC fluid to the lower plenum at a steam flow rate of 400 kg/s, for the case with N_2 injection, and at a steam flow rate of 300 kg/s for the case with no N_2 injection. The following conclusion is made about the critical steam flow rate,

if N_2 is injected:

$$300 kg/s < W_{gc,TRAC,N_2,UPTF} < 400 kg/s \quad , \tag{4.21}$$

if no N_2 is injected:

$$200 kg/s < W_{gc,TRAC,UPTF} < 300\ kg/s \quad . \tag{4.22}$$

Therefore, the critical steam flow rate with N_2 will be higher than the critical steam flow rate without N_2.

$$W_{gc,TRAC,N_2,UPTF} > W_{gc,TRAC,UPTF} \quad . \tag{4.23}$$

Since UPTF is a full-scale facility the conclusion in Equation (4.23) is applied to the NPP.

$$W_{gc,TRAC,N_2,NPP} > W_{gc,TRAC,NPP} \quad . \tag{4.24}$$

Since the steam flow rate from the lower plenum to the downcomer is decreasing during the Refill Phase, the higher steam flow rate will occur earlier as shown in Figure 3.15, and it is concluded that,

$$t_D > t_{D,N_2} \quad . \tag{4.25}$$

Therefore,

$$t_{ID} > t_{ID,N_2} \quad . \tag{4.26}$$

The bias $\delta t_{ID,N_2}$ is estimated by substituting Equation (4.26) into Equation (4.4).

$$\delta t_{ID,N_2} < 0.0 \quad . \tag{4.27}$$

Therefore, a conservative estimate of $\delta t_{ID,N_2}$ is:

$$\delta t_{ID,N_2} = 0.0 \quad . \tag{4.28}$$

Furthermore, a conservative limit of the critical steam flow rate for a facility is the lower limit, since the steam flow rate would have to decrease below that limit before any liquid can reach the lower plenum. Therefore, the lower limit is selected from Equation (4.22) for the critical steam flow, which is

$$W_{gc,TRAC,NPP} = 200\ kg/s \quad . \tag{4.29}$$

The time t_2 corresponding to this steam flow rate is obtained from Figure 3.15, and is

$$t_D = 20.0\ s \quad . \tag{4.30}$$

It should be noted that the critical steam flow rate and corresponding time are different from the ones selected in Section 3.4.2.1 (Equations (3.33) and (3.34)). The difference in two critical steam flow rates is due to their application. In Section 3.4.2.1 the bias due to all the model deficiencies in the code, except for the lack of a dissolved-N_2 model, was being estimated. The critical steam flow was obtained from the UPTF data which had N_2 injection to account for dissolved N_2 effect. A lowest possible value of the steam flow rate was selected for the critical flow from the UPTF data. In the current application, the purpose is to estimate the bias due to the lack of a dissolved N_2 model in the code. So, the critical steam flow rate for the NPP with no dissolved N_2 is estimated from a calculation for the UPTF facility with no N_2 injection. A comparison of the results of the two calculations shows the effect of the dissolved N_2, since the code and the test conditions were the same. The effect of the N_2 is to increase the critical steam flow rate and therefore, the critical steam flow rate in Equation (3.33) is higher than in Equation (4.29).

4.4.2.2 Bias in the Timing of the Delay Period

The Delay Period begins at time t_D (Equation (4.30)) and ends at time t_A as obtained from Equation (3.29). Therefore, the duration of this period is:

$$t_{DA} = t_A - t_D = 22.9s - 20.0\,s = 2.9\,s \quad . \tag{4.31}$$

During this period, the N_2 affects the duration of the Delay Period in two ways, each of which contributes to the bias as described in Section 4.3.1.2, and their contributions are estimated using the method described in that section. The computation of the first bias, $\delta t_{DA,1,N_2}$, requires a ratio of delays from the simulation of separate effects tests with and without N_2. Table 4.2 shows the calculations for UPTF Test 6 with and without the consideration of the N_2 injection. The results in this table indicate that delays are smaller when N_2 injection is considered. This conclusion is applied to Equation (4.10) and the result is,

$$\langle R_{t,th} \rangle < 1.0 \quad . \tag{4.32}$$

The first bias for the delay period is computed by substituting Equation (4.32) into Equation (4.12). It follows that

$$\delta t_{DA,1,N_2} < 0.0 \quad . \tag{4.33}$$

A conservative estimate of this bias is

$$\delta t_{DA,1,N_2} = 0.0 \quad . \tag{4.34}$$

The second bias $\delta t_{DA,2,N_2}$ for this period is due to the decrease in the ECC flow rate. The integrated ECC flow is shown in Table 4.1 from the nominal NPP calculation and from the separate model calculation. The results in this table indicate that there is less ECC flow in the presence of N_2 and a ratio of the average ECC flow rates for the Refill Phase during the time period between t_D and t_B is estimated from this table as defined in Section 4.3.1.2.

$$R_{ECC} = 1.14 \quad . \qquad (4.35)$$

The second bias for this period is computed by substituting Equations (4.31) and (4.35) into Equation (4.15).

$$\delta t_{DA,2,N_2} = 0.41\ s \quad . \qquad (4.36)$$

The total bias for the Delay Period is the sum of the two biases obtained from Equations (4.34) and (4.36).

$$\delta t_{DA,N_2} = 0.41\ s \quad . \qquad (4.37)$$

4.4.2.3 Bias in the Timing of the Fillin^ Period

This period begins at time t_A (Equation (3.29)) and ends at time t_B (Equation (3.30)) when the lowe^ plenum is full. The duration of this period is computed from these times.

$$t_{AB} = (33.5s - 22.9s) = 10.6\ s \quad . \qquad (4.38)$$

The bias in this period is estimated by substituting Equations (4.35) and (4.38) into Equation (4.20) and the result is,

$$\delta t_{AB,N_2} = 10.6s(1.14 - 1) = 1.48\ s \quad . \qquad (4.39)$$

(.\.2.4 Total ..as in the Refill Phase

The total bias $\delta t_{IB,N_2}$ in the Refill Phase is obtained by adding the biases from the Equations (4.28), (4.37) and (4.39).

$$\delta t_{IB,N_2} = (0 + 0.41 + 1.48)s = 1.88\ s \ . \tag{4.40}$$

4.4.2.5 Bias in Predicted PCT due to the Omission of Dissolved N_2 Model

The bias in the PCT due to the lack of a dissolved N_2 model in the code is estimated from Equation (4.1) using the information from Equations (3.50) and (4.40).

$$\delta PCT_{N_2} = 9.9°K \ \ (17.8°F) \ . \tag{4.41}$$

4.5 Conclusions

The bias in the predicted PCT due to the omission of a model for dissolved N_2 in the code is 9.9°K. As this bias is positive, it implies that the inclusion of a model for dissolved N_2 in the code will result in a higher predicted PCT.

The bias in this section was estimated from three independent calculations; a bounding calculation of the NPP during the Refill Phase, the nominal NPP calculation with the TRAC code, and the simulation of UPTF Test 6 with the TRAC code. Since for the bounding calculation it was assumed that no N_2 is dissolved in the cold legs and that N_2 completely terminates the condensation process, and since all the beneficial effects from the dissolved N_2 were neglected, the bias in PCT predictions presented in this section, is conservative.

It is recommended that a model of dissolved N_2 based on the variation in the solubility of the noncondensible gas (i.e., Henry's model) be included in the code. The code has a model of noncondensible gas, but it does not allow for any dissolution of gas. In the absence of such a model, the NPP calculation could be repeated with N_2 injection in the intact loops, such as was done in the UPTF Test 6. The results of the NPP calculations with and without N_2 can estimate the PCT bias. The uncertainty in this approach is in the N_2 injection rate and in the location of the N_2 injection. However, a conservative estimate of the rate of N_2 dissolution, based on equilibrium assump-tions, can be made and used to simulate N_2 injection close to the accumulator junction.

5. SUMMARY OF CONCLUSIONS

The peak clad temperature (PCT) predicted by TRAC-PF1/MOD1, Version 14.3 for large break loss of coolant accidents (LBLOCA) has uncertainties arising from (1) ECCS thermohydraulics modelling deficiencies, and (2) lack of a model for dissolved N2. These uncertainties in PCT are quantified here numerically in terms of biases.

The evaluation of the bias due to modelling deficiencies requires comparisons to data, either from full-scale tests or properly scaled separate effects tests (SETs). A review of available SETs indicated that small-size facilities did not model the flow regimes expected in a nuclear power plant during the Refill Phase of an LBLOCA. Therefore, it was concluded that only full-scale test data, from the Upper Plenum Test Facility (UPTF), could be used for the estimation of this bias. Any bias based on the small scale facilities would be conservative, since the ratio of measured to predicted lower plenum filling rate decreases with size.

The total bias in PCT predicted by the TRAC computer code due to modelling deficiencies is -19°K (-34°F). The negative bias implies that these systematic errors in the code over-predict the PCT. Detailed analysis of the contributions to the total bias indicated that the Counter Current Flow Period (which lasts for 0.5 seconds) leads to only -1.3°K of the bias. The largest contribution (-17.7°K) to the bias results from the prediction of the Delay Period. It is recommended that higher priority be placed on the generation of data at steam flow rate corresponding to the complete bypass region.

The second source of uncertainty (i.e., the lack of a model for dissolved N_2) leads to a bias in PCT of 9.9°K (17.8°F). The positive bias indicates that this systematic error leads to an under-prediction of PCT. Thus, the lack of a model for dissolved N_2 makes the code prediction less conservative. Although the TRAC code has a model for the mass balance of non-condensible gasses, it does not account for mass transfer between the liquid and the gas. It is recommended that a model of mass transfer, based on Henry's model of the solubility of the gasses in the liquid, be included in the code.

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APPENDIX A. UPPER PLENUM TEST FACILITY (UPTF) EXPERIMENTS

UPTF [Liebert, 1988] simulates a German four-loop PWR similar to a Westinghouse PWR (Fig. A.1). The facility has a full size vessel, hot and cold legs, ECC injection into the cold legs and the downcomer. The facility also has injection of 1 kg/sec of N_2 in the cold legs to simulate the dissolution of N_2 in the PWR. The main recirculation pumps are simulated by adjustable flow resistances, and the steam generators are represented by four steam/water separators. The core region is simulated by 193 nozzles injecting steam to the lower plenum. The facility's upper plenum internals replicate the actual vessel geometry. The downcomer separate effects tests--ECC bypass in the downcomer--were one of the series of the experiments conducted at the facility.

The clear advantage of using the full-scale facility (UPTF) data is the elimination of the need to extrapolate the results. Also, the question of the flow regimes and their effect on the major parameter of concern, the lower plenum delivery rate, would not arise.

Unfortunately, only 5 runs for UPTF test 6 are available for the investigation which is not a sufficient data base for the statistical analysis.

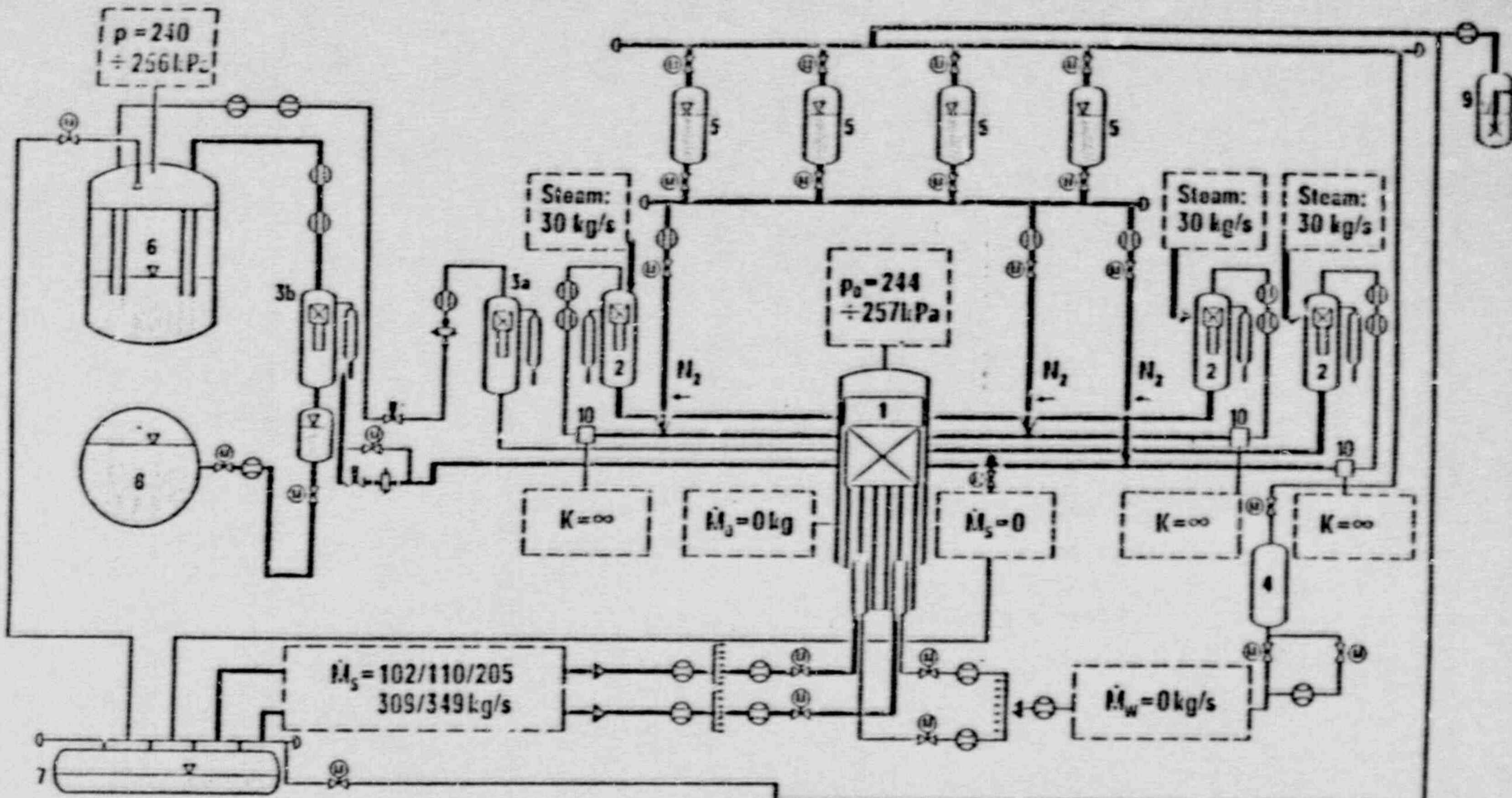
It is important to note that some of the clearly three-dimensional patterns of the flow ("alternate channeling", for example) developing in the downcomer are considerably different from the classical counter-current flow patterns. The channeling can be observed in the pictures showing the measured liquid temperature in the downcomer region (Figs. A.2 and A.3) [Liebert, 1988].

The runs were performed in two stages. In the first stage the steam was injected in the core and a steady state was achieved. The first stage lasted for 43 seconds. In the second stage, the ECC was injected. The ECC did not immediately reach the lower plenum and there was a delay. The tests were run for 30 seconds after the ECC injection. The lower plenum inventory was estimated from pressure drop measurements.

The next section describes the procedure of evaluating lower plenum filling rates from the UPTF test 6 data.

Lower Plenum Filling Rate in UPTF Tests

The lower plenum and downcomer inventories in five-Runs (131, 132, 133, 135 and 136) of test-6 were available [Wolfe, 1988a, 1988b; Damarell, 1988a, 1988c]. The data for Runs 131, 132, 133 and 136 are summarized in Tables A.1 to A.4. In these tables, the first column indicates the time and, the second and third columns show the lower plenum and the downcomer inventories. The lower plenum inventory data for Run 135 were available in the form of lower plenum inventory plot [Damarell, 1988c] which indicated that there was lower plenum filling at 440 kg/S of steam flow. Actual lower plenum filling rate was not needed for current application as TRAC predicted (Appendix D) no ECC delivery for this steam flow rate.



1 Test Vessel
2 Steam Generator Simulator
3a Steam Generator Simulator
3b Water Separator (CL)
4 Hot Water Storage Tank
5 Accumulator
6 Containment Simulator
7 Steam Storage Tank
8 Water Collecting Tank
9 Steam Cooler
10 Pump Simulator
⇒ Flow Path

ECC [kg/s]	Loops 1	2	3	Broken
Hot Side	–	–	–	–
Cold Side	487	486	486	–
T_{ECC} [°C]	117	117	117	–
N_2 [kg/s]	0.33	0.33	0.33	–

Remarks:

RUN 136: No SG-Simulator Steam Injection

RUN 135: T_{ECC} = 130 °C
p, p_0 = 340 kPa

Figure A.1 System Configuration of Test No. 6 (Siemens, 1987)

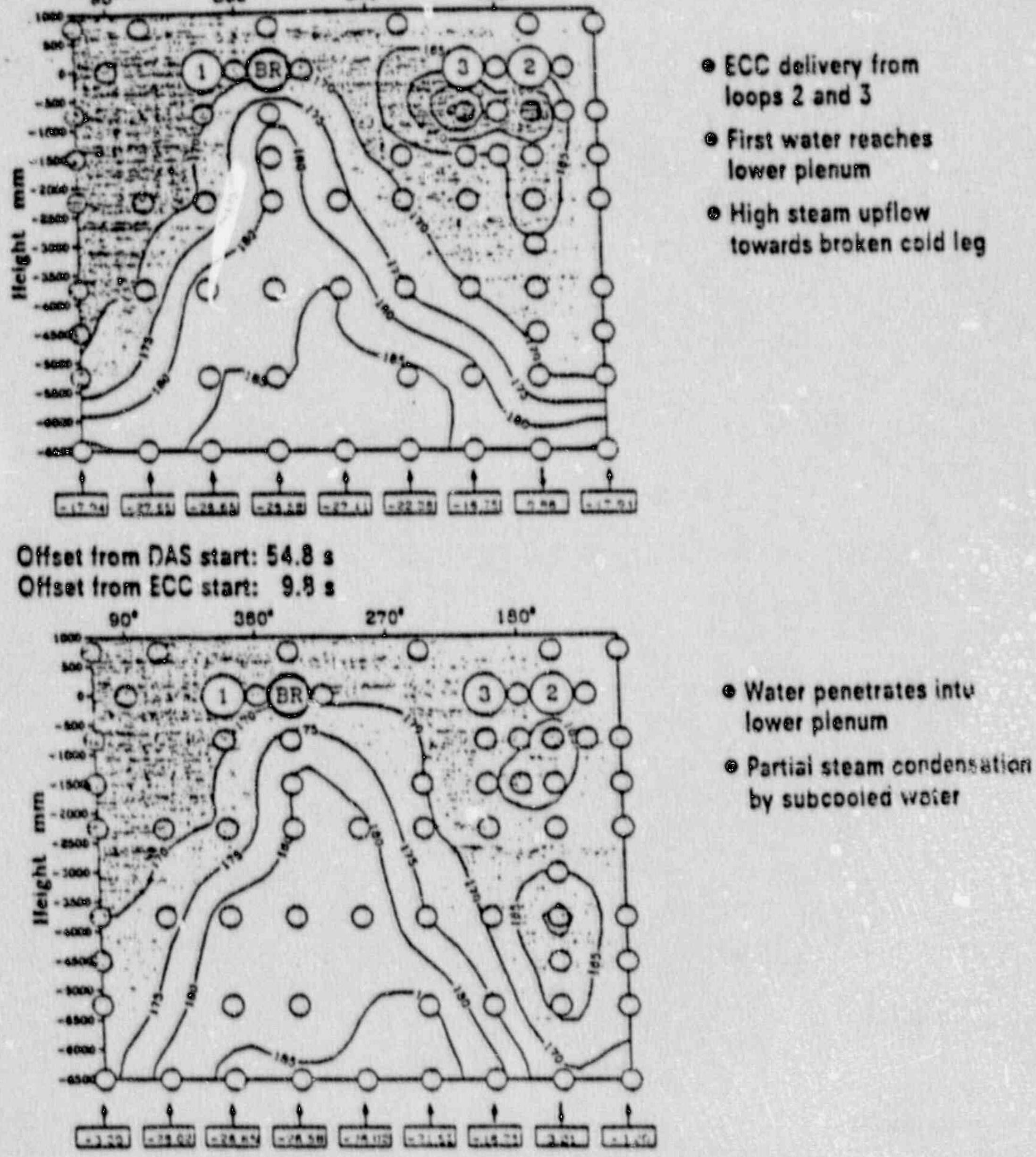


Figure A.2 Contour Plots of Fluid Temperature Distribution in Downcomer (Siemens, 1987)

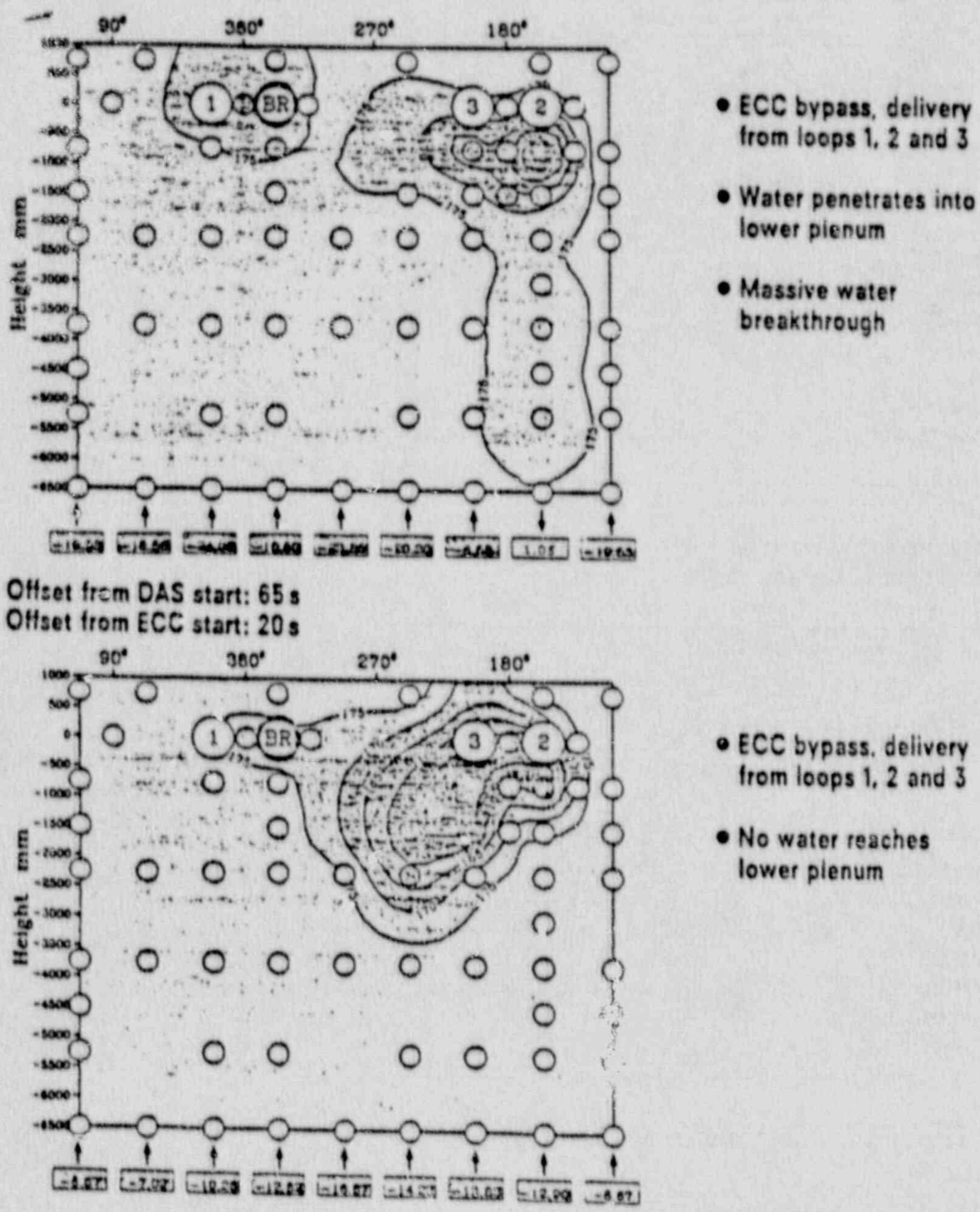


Figure A.3 Contour Plots of Fluid Temperature Distribution in Downcomer (Siemens, 1987)

Table A.1 - UPTF Test 6, Run 131* (Steam Flow 400 kg/S)

Time s	Lower Plenum Inventory kg	Downcomer Inventory kg
49	0	0
55	(1400)	0
60	2500	(200)
63	(4700)	300
69	9000	(2600)
71	(9700)	3300
72	(10100)	0
80	13000	700

* [Wolfe, 1988a]
( ) Interpolated Values

Table A.2 - UPTF Test 6, Run 132* (Steam Flow 300 kg/s)

Time s	Lower Plenum Inventory kg	Downcomer Inventory kg
52	0	-----
56	(2800)	0
58	4200	(0)
59	(5100)	0
66	(11700)	0
67	12600	(200)
78	13700	2000

* [Wolfe, 1988a]
( ) Interpolated Values

Table A.3 - UPTF Test 6, Run 133* (Steam Flow 200 kg/s)

Time s	Lower Plenum Inventory kg	Downcomer Inventory kg
50	0	0
52	1820	0
63	10870	0
70	13980	470
76	14330	3360
80	14670	4090

* [Damarell, 1988a]

Table A.4 - UPTF Test 6, Run 136* (Steam Flow 100 kg/s)

Time s	Lower Plenum Inventory kg	Downcomer Inventory kg
45	0	0
50	1800	0
60	9820	0
70	16110	1410
80	18190	5010

* [Wolfe, 1998b]

The lower plenum filling rates for four runs were obtained from the inventory data by plotting the data and selecting a window. The windows for Runs 131, 132, 133 and 136 were 49 sec to 80 sec, 52 sec to 67 sec, 50 sec to 70 sec, and 45 sec to 70 sec respectively. As an illustration, the lower plenum inventory for Run 136 is shown in Figure A.4 and steps to calculate filling rate are shown here.

$$\dot{m}_{LP} = \frac{m_2 - m_1}{t_2 - t_1} \tag{A.1}$$

$$\dot{m}_{LP} = \frac{(16110 - 0)\,kg}{(70 - 45)\,s} = 644\,kg/ \tag{A.2}$$

The lower plenum filling rates and the delays in the initiation of lower plenum filling are summarized in Table A.5. In this table, the first column lists the Run number, the second column lists the steam flow rates, the third column shows the lower plenum filling rates, the fourth column lists the time of ECC injection and the last two columns list the time at which the lower plenum begins to fill up and the delay in the initiation of lower plenum filling.

Table A.5 - Summary of UPTF Results (Test 6)

		EXPERIMENT			
Run	W_g kg/s	$\dot{m}_{LP}$ kg/s	t_I s	t_A s	$t_{IA,UPTF}$ s
131	400	419	43	49(54)	6(11)
132	300	840	43	52	9
133	200	699	43	50	7
135	440	> 0	43	-----	-----
136	100	644	43	45	2

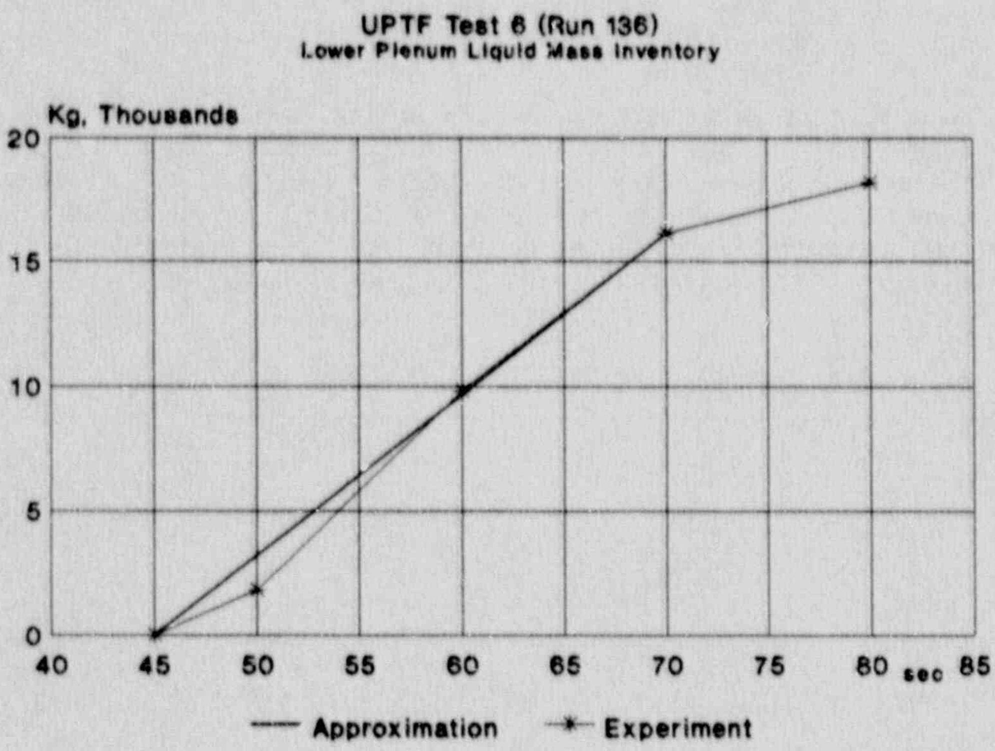


Figure A.4 Lower Plenum Liquid Mass Inventory, UPTF Test 6 (Run 136)

APPENDIX B: NODALIZATION FOR SEPARATE EFFECT TESTS, UPTF

All calculations were performed using same nodalization for the VESSEL component. Figure B.1 shows the schematic of the nodalization for the VESSEL component. The geometrical data for UPTF are provided in Table 3.1. The downcomer was modelled as a two-dimensional region using ten cells in the vertical direction and four cells in the azimuthal direction. The cold and hot leg connections were made at level 11 of the VESSEL. The lower plenum was modelled with two axial levels, and the "core" and upper plenum regions were combined into a cylindrical region represented by eleven axial, two radial, and four azimuthal cells. Steam to the downcomer was supplied through the core region.

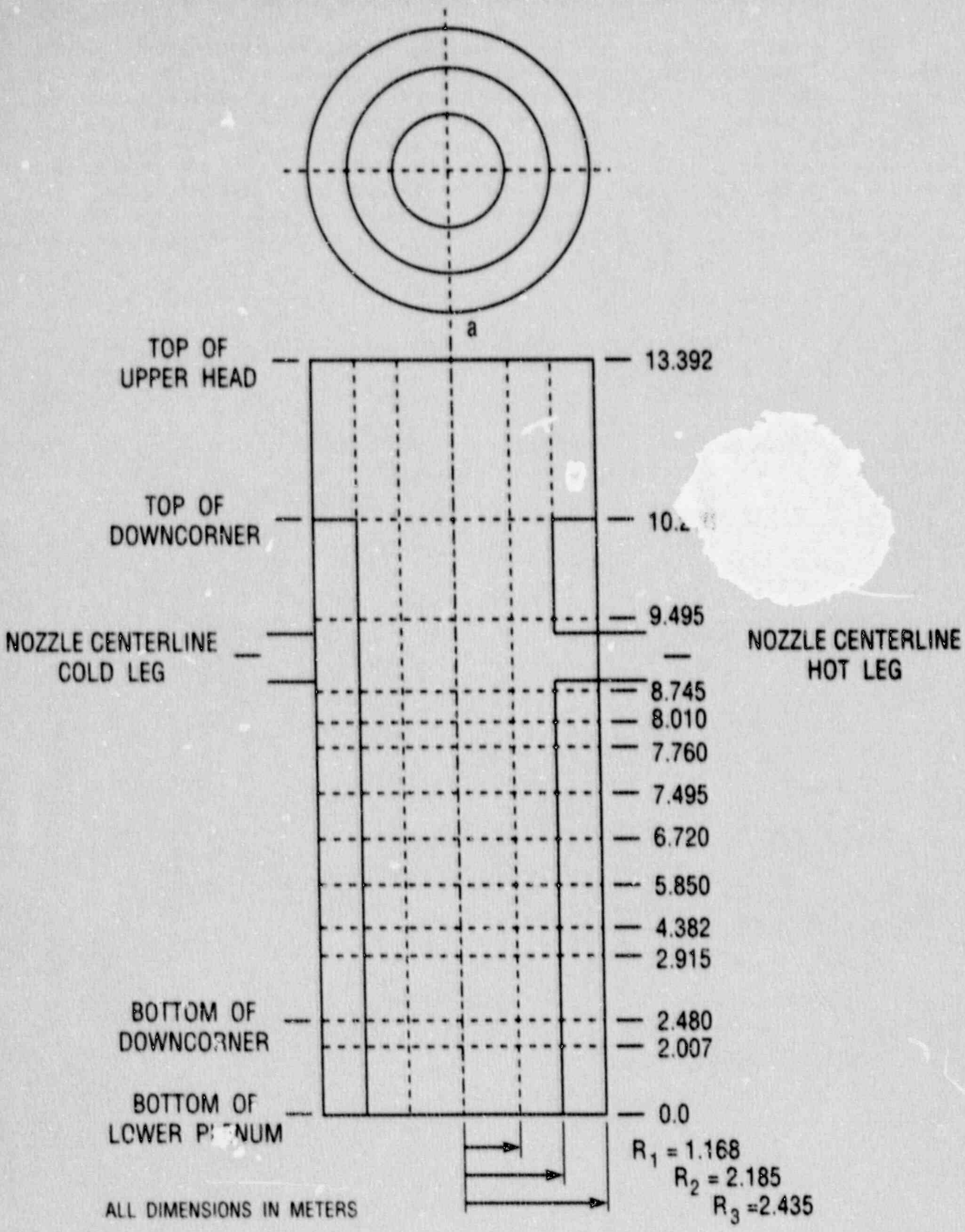


Figure B.1 Schematic of the VESSEL Nodalization

APPENDIX C: TRAC-PF1 INPUT DECK FOR UPTF

This Appendix contains the listing of the input deck used for the UPTF, Test 6 calculations.

```
FREE
1        0        1        0
BASE CASE: 104 KG/S (U136)
$INOPTS ICFLOW=2,NFRC1=2,NFRC3=1,IADDED=10,NCRG=1,NLT=14,NOAIR=0
$END
         0         0.0         0
*
**                                                      **
**              1. MAIN CONTROL DATA                    **        **
**                                                      **
*
*      STDYST      TRANSI      NCOMP      NJUN       IPAK
          0          1          78         86         1
*      EPS0        EPSI        EPSS       EPSP
        .001       .00001      .0001      .001
*      OITMAX      IITMAX      SITMAX     ISOLUT
         10          50          10         0
*      NTSV        NTCB        NTCF       NTRP       NTCP
         22          39          252        31         0
*
* COMPONENT LIST CARDS
*
********** VESSEL AND VESSEL DRAINS
          1          101         102        103        107
********** CORE SIMULATOR INJECTION TEES
*
         501         502         503        504        505 S
         506         507         508 S
***************** CORE SIMULATOR BASE FILLS
         601         602         603        604        605 S
         606         607         608 S
************* CORE SIMULATOR FEEDBACKFILLS
         701         702         703        704        705 S
         706         707         708 S
**************** LOOP1
         10          11          12         13         14 S
         15          16          18         19         115 S
         119 S
****************** LOOP2
         20          21          22         23         24 S
         25          26          27         28         29 S
         228         [illegible]28         229 S
****************** LOOP3
         30          31          32         33         34 S
         35          36          38         39         333 S
         339 S
****************** LOOP4
         40          41          42         45         46 S
                                 449                   91 S
         90                                            S
****************** NITROGEN INJECTION SYSTEM
         160         161         260        261        360 S
         361  E
*
* CONTROL-PARAMETER DATA *
*
* SIGNAL VARIABLES
*        IDSV        ISVN        ILCN       ICN1       ICN2
         100         0           0          0          0
         107         27          101        1          0
         601         21          1          1010       0
         480         21          91         1          0
         99          21          24         21         0
*
* SIGNAL VARIABLES FOR THE CORE FEEDBACK SYSTEM
*
         701         32          1          1007       0
         501         29          501        4          0
         702         32          1          2007       0
         502         29          502        4          0
         703         32          1          3007       0
         503         29          503        4          0
         704         32          1          4007       0
         504         29          504        4          0
*
* SIGNAL VARIABLES IN LOOP 1
*
         105         32          10         6          0
         119         27          12         9          0
*
* SIGNAL VARIABLES IN LOOP 2
*
         205         32          20         6          0
         229         27          22         9          0
*
* SIGNAL VARIABLES IN LOOP 3
*
         305         32          30         6          0
         339         27          32         9          0
         449         27          41         16         0
         [illegible] 27          18         1          0
         479         27          47         1          0
*
* CONTROL BLOCKS
*        IDCB        ICBN        ICB1       ICB2       ICB3
* CONTROL BLOCKS FOR THE CORE FEEDBACK SYSTEM
```

```
*
* TIME DELAY  CELL 1
      -8001         100        -7001        10          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   1.0000E+00    0.0000E+00
* Z = S X Z  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -7001          39        -6001        -5001          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   0.0000E+00    0.0000E+00
* Z TABLE  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -5001          101         701          4            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   0.0000E+00    0.0000E+00
*
* FUNCTION FOR MFRL (KG/S) VS. MFRV (KG/S)
* CBFTB *     -9.6500E+02   1.0084E+02   -7.2375E+02   9.1675E+01   -4.8250E+02
* CBFTB *      6.7550E+01  -2.4125E+02    0.0000E+00E
*
* S TABLE  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -6001          101        -4001          4            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+00   0.0000E+00    0.0000E+00
*
* CBFTB * R02 0.0000E+00    1.2700E+08   6.1000E-01   2.5000E+08   8.2000E-01
* CBFTB *      6.3400E+08   1.0000E+00E
*
* A - E  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -4001          54         -3001        -1001          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+09   0.0000E+00    0.0000E+00
* A = E0 + ED  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -3001          56         -2001          0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+09   6.3400E+08    0.0000E+00
* ED = C2 X T  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -2001          56          100           0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   0.0000E+00    0.0000E+00   1.0000E+09   0.0000E+00    0.0000E+00
* E = C1 I WS DT  CELL 1
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -1001          33          501           0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
***2.3000E+06    0.0000E+00   1.0000E+09   1.0000E+00    0.0000E+00
*
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -8002          100        -7002         10            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   1.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -7002          39         -6002        -5002          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   0.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -5002          101         702           4            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   0.0000E+00    0.0000E+00
*
* CBFTB *     -9.6500E+02   1.0084E+02   -7.2375E+02   9.1675E+01   -4.8250E+02
* CBFTB *      6.7550E+01  -2.4125E+02    0.0000E+00E
*
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -6002          101        -4002          4            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+00   0.0000E+00    0.0000E+00
*
* CBFTB * R02 0.0000E+00    1.2700E+08   6.1000E-01   2.5000E+08   8.2000E-01
* CBFTB *      6.3400E+08   1.0000E+00E
*
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -4002          54         -3002        -1002          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+09   0.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -3002          56         -2002          0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+09   6.3400E+08    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
       2002          56          100           0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   0.0000E+00    0.0000E+00   1.0000E+09   0.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -1002          23          502           0            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   2.3000E+06    0.0000E+00   1.0000E+09   1.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -8003          100        -7003         10            0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   1.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
      -7003          39         -6003        -5003          0
*     CBGAIN        CBXMIN       CBXMAX        CBCON1        CBCON2
   1.0000E+00    0.0000E+00   1.0000E+02   0.0000E+00    0.0000E+00
*      IDCB          ICBN         ICB1         ICB2         ICB3
```

```
     -5002          101          703           4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+02    0.0000E+00    0.0000E+00
*
* CBFTB *    -9.6500E+02    1.0084E+02   -7.2375E+02    9.1675E+01   -4.8250E+02
* CBFTB *     6.7550E+01   -2.4125E+02    0.0000E+00E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -6003          101         -4003           4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+00    0.0000E+00    0.0000E+00
*
* CBFTB * R02 0.0000E+00    1.2700E+08    6.1000E-01    2.5000E+08    8.2000E-01
* CBFTB *     6.3400E+08    1.0000E+00E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -4003          54          -3003         -1003          0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+09    0.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -3003          56          -2003           0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+09    6.3400E+08    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -2003          56           100            0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   0.0000E+00    0.0000E+00    1.0000E+09    0.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -1003          23           503            0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   2.3000E+06    0.0000E+00    1.0000E+09    1.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -8004          100         -7004          10            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+02    1.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -7004          39          -6004         -5004          0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+02    0.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -5004          101          704            4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+02    0.0000E+00    0.0000E+00
*
* CBFTB *    -9.6500E+02    1.0084E+02   -7.2375E+02    9.1675E+01   -4.8250E+02
* CBFTB *     6.7550E+01   -2.4125E+02    0.0000E+00E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -6004          101         -4004           4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+00    0.0000E+00    0.0000E+00
*
* CBFTB * R02 0.0000E+00    1.2700E+08    6.1000E-01    2.5000E+08    8.2000E-01
* CBFTB *     6.3400E+08    1.0000E+00E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -4004          54          -3004         -1004          0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+09    0.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -3004          56          -2004           0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    1.0000E+09    6.3400E+08    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -2004          56           100            0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   0.0000E+00    0.0000E+00    1.0000E+09    0.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -1004          23           504            0            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   2.3000E+06    0.0000E+00    1.0000E+09    1.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -801           101          105            4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   0.0000E+00    0.0000E+00    3.0000E+01    0.0000E+00    0.0000E+00
*
* CBFTB *    -1.0000E+04R03 0.0000E+00    5.0000E+02    2.0000E+01    1.0000E+04
* CBFTB *     2.0000E+01E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -901           100          -801           10            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    3.0000E+01    1.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -802           101          205            4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   0.0000E+00    0.0000E+00    3.0000E+01    0.0000E+00    0.0000E+00
*
* CBFTB *    -1.0000E+04R03 0.0000E+00    5.0000E+02    2.0000E+01    1.0000E+04
* CBFTB *     2.0000E+01E
*
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -902           100          -802           10            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   1.0000E+00    0.0000E+00    3.0000E+01    1.0000E+00    0.0000E+00
*      IDCB          ICBN          ICB1          ICB2          ICB3
     -803           101          305            4            0
*     CBGAIN         CBXMIN         CBXMAX         CBCON1         CBCON2
   0.0000E+00    0.0000E+00    3.0000E+01    0.0000E+00    0.0000E+00
```

```
*
* CBFTB *   -1.0000E+04R03 0.0000E+00   5.0000E+02   2.0000E+01   1.0000E+04
* CBFTB *    2.0000E+01E
*
*     IDCB       ICBN       ICB1       ICB2       ICB3
      -903        100       -803         10          0
*    CBGAIN     CBXMIN     CBXMAX     CBCON1     CBCON2
  1.0000E+00 0.0000E+00 3.0000E+01 1.0000E+00 0.0000E+00
*     IDCB       ICBN       ICB1       ICB2       ICB3
      -601         44        601        480          0
*    CBGAIN     CBXMIN     CBXMAX     CBCON1     CBCON2
  1.0000E+00 1.0000E+00 1.0000E+30 1.0000E+00 1.0000E+00
*
*                                                     **
* TRIP-DIMENSION VARIABLES CARDS
*
*     NTSE       NTCT       NTSF       NTDP       NTSD
         0          7          0          1          0
*     IDTP       ISRT       ISET       ITST       IDSG
       701          4          0          1        100
*    SETP(1)    SETP(2)    SETP(3)    SETP(4)
  1.0000E+29 1.0000E+29 1.0000E+30 1.0000E+30
*    DTSP(1)    DTSP(2)    DTSP(3)    DTSP(4)
  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)    IFSP(3)    IFSP(4)
         0          0          0          0
*     IDTP       ISET       ISET       ITST       IDSG
       702          4          0          1        100
*    SETP(1)    SETP(2)    SETP(3)    SETP(4)
  1.0000E+29 1.0000E+29 1.0000E+30 1.0000E+30
*    DTSP(1)    DTSP(2)    DTSP(3)    DTSP(4)
  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)    IFSP(3)    IFSP(4)
         0          0          0          0
*     IDTP       ISRT       ISET       ITST       IDSG
       703          4          0          1        100
*    SETP(1)    SETP(2)    SETP(3)    SETP(4)
  1.0000E+29 1.0000E+29 1.0000E+30 1.0000E+29
*    DTSP(1)    DTSP(2)    DTSP(3)    DTSP(4)
  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)    IFSP(3)    IFSP(4)
         0          0          0          0
*     IDTP       ISRT       ISET       ITST       IDSG
       704          4          0          1        100
*    SETP(1)    SETP(2)    SETP(3)    SETP(4)
  1.0000E+29 1.0000E+29 1.0000E+30 1.0000E+30
*    DTSP(1)    DTSP(2)    DTSP(3)    DTSP(4)
  0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)    IFSP(3)    IFSP(4)
         0          0          0          0
*
* TRIP 600, BASE STEAM
*
*     IDTP       ISRT       ISET       ITST       IDSG
       600          2          0          1        100
*    SETP(1)    SETP(2)
       0.0        0.0
*    DTSP(1)    DTSP(2)
  0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)
         0          0
*
* TRIP 90, BCL CONTAINMENT BREAK
*
*     IDTP       ISRT       ISET       ITST       IDSG
        90          2          0          1        100
*    SETP(1)    SETP(2)
       0.0        0.0
*    DTSP(1)    DTSP(2)
  0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)
         0          0
*
* TRIP 91, BHL CONTAINMENT BREAK, NOT USED (INACTIVE)
*
*     IDTP       ISRT       ISET       ITST       IDSG
        91          2          0          1        100
*    SETP(1)    SETP(2)
  0.0000E+00 0.0000E+00
*    DTSP(1)    DTSP(2)
  0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)
         0          0
*
* TRIP 106, VESSEL DRAIN FILL 107, NOT USED (INACTIVE)
*
*     IDTP       ISRT       ISET       ITST       IDSG
       106          1          0                 107
*    SETP(1)    SETP(2)
  2.0000E-01 8.0000E-01
*    DTSP(1)    DTSP(2)
  0.0000E+00 0.0000E+00
*    IFSP(1)    IFSP(2)
         0          0
*     IDTP       ISRT       ISET       ITST       IDSG
       105          2          0          1        100
*    SETP(1)    SETP(2)
  1.0000E+30 1.0000E+30
*    DTSP(1)    DTSP(2)
```

```
*   0.0000E+00    0.0000E+00
      IFSP(1)       IFSP(2)
         0             0
*      IDTP          ISRT         ISET         ITST        IDSG
        107            2         0         3        -107
*    SETP(1)       SETP(2)
    5.0000E-01    5.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* TRIP 220, PRESSURIZER FILL, NOT USED (INACTIVE)
*      IDTP          ISRT         ISET         ITST        IDSG
        220            2         0         1         100
*    SETP(1)       SETP(2)
    1.0000E+30    1.0000E+30
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* HOT LEG ECC, LOOP 1, 2, 3, 4, NOT USED (INACTIVE)
*      IDTP          ISRT         ISET         ITST        IDSG
        115            2         0         1         100
*    SETP(1)       SETP(2)
    1.0000E+30    1.0000E+30
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* COLD LEG ECC,LOOP 1, 2, 3 (COMP 16, 26, 36)
*      IDTP          ISRT         ISET         ITST        IDSG
        116            2         0         1         100
*    SETP(1)       SETP(2)
    30.4          30.4
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* SEPARATOR DRAIN OF LOOP 1 (COMP 119), NOT USED (INACTIVE)
*      IDTP          ISRT         ISET         ITST        IDSG
        118            1         0         1         119
*    SETP(1)       SETP(2)
    2.0000E-01    8.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*      IDTP          ISRT         ISET         ITST        IDSG
        117            2         0         1         100
*    SETP(1)       SETP(2)
    1.0000E+30    1.0000E+30
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*      IDTP          ISRT         ISET         ITST        IDSG
        119            2         0         3        -199
*    SETP(1)       SETP(2)
    5.0000E-01    5.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* SEPARATOR DRAIN OF LOOP 2 (COMP 229), NOT USED (INACTIVE)
*      IDTP          ISRT         ISET         ITST        IDSG
        228            1         0         1         229
*    SETP(1)       SETP(2)
    2.0000E-01    8.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*      IDTP          ISRT         ISET         ITST        IDSG
        229            2         0         3        -299
*    SETP(1)       SETP(2)
    5.0000E-01    5.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
*    IFSP(1)       IFSP(2)
        0             0
*
* SEPARATOR DRAIN OF LOOP 3 (COMP 339), NOT USED (INACTIVE)
*      IDTP          ISRT         ISET         ITST        IDSG
        338            1         0         1         339
*    SETP(1)       SETP(2)
    2.0000E-01    8.0000E-01
*    DTSP(1)       DTSP(2)
    0.0000E+00    0.0000E+00
```

```
*    IFSP(1)     IFSP(2)
        0           0
*     IDTP        ISRT        ISET        ITST        IDSG
       339          2           0           3        -399
*    SETP(1)     SETP(2)
   5.0000E-01  5.0000E-01
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* TRIP 666, TIME TRIP FOR INACTIVE COMPONENTS
*     IDTP        ISRT        ISET        ITST        IDSG
       666          2           0           1         100
*    SETP(1)     SETP(2)
   9.9900E+10  9.9900E+10
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* TRIP 999, END PROBLEM
*     IDTP        ISRT        ISET        ITST        IDSG
       999          1           0           1         100
*    SETP(1)     SETP(2)
   1.0000E+30  1.0000E+30
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* TRIP 449, BHL S/W SEPARATOR DRAIN FILL, NOT USED
*     IDTP        ISRT        ISET        ITST        IDSG
       449          1           0           1         100
*    SETP(1)     SETP(2)
   1.0000E+30  1.0000E+30
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* BHL BREAK VALVE (COMP 42), NOT USED (CLOSED DURING EXP.)
*     IDTP        ISRT        ISET        ITST        IDSG
       442          2           0                     100
*    SETP(1)     SETP(2)
   1.0000E+30  1.0000E+30
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* BCL SEPARATOR DRAIN FILL (COMP 49)
*     IDTP        ISRT        ISET        ITST        IDSG
        49          2           0           1         100
*    SETP(1)     SETP(2)
   0.0         0.0
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*     IDTP        ISRT        ISET        ITST        IDSG
       498          2           0           3        -498
*    SETP(1)     SETP(2)
   5.0000E-01  5.0000E-01
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* BCL BREAK VALVE (COMP 46)
*     IDTP        ISRT        ISET        ITST        IDSG
       446          2           0           1         100
*    SETP(1)     SETP(2)
   0.0         0.0
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
*
* TRIP 497, TRIP CONTROLLED TRIP, BHL SEPARATOR DRAIN (COMP 449), NOT USED
*     IDTP        ISRT        ISET        ITST        IDSG
       497          2           0           3        -497
*    SETP(1)     SETP(2)
   5.0000E-01  5.0000E-01
*    DTSP(1)     DTSP(2)
   0.0000E+00  0.0000E+00
*    IFSP(1)     IFSP(2)
        0           0
* TRIP 479, TRIP CONTROLLED TRIP, BCL KTA DRAIN (COMP 479)
*     IDTP        ISRT        ISET        ITST        IDSG
       479          2           0           1         100
*    SETP(1)     SETP(2)
```

```
*  0.0        0.0
*    DTSP(1)      DTSP(2)
*  0.0000E+00   0.0000E+00
*    IFSP(1)      IFSP(2)
*      0            0
*      IDTP         ISRT        ISET        ITST        IDSG
*      601          1           0           1           100
*    SETP(1)      SETP(2)
*  2.0000E+05   2.0000E+05
*    DTSP(1)      DTSP(2)
*  0.0000E+00   0.0000E+00
*    IFSP(1)      IFSP(2)
*      0            0
*      IDTP         ISRT        ISET        ITST        IDSG
*      499          2           0           3           -499
*    SETP(1)      SETP(2)
*  5.0000E-01   5.0000E-01
*    DTSP(1)      DTSP(2)
*  0.0000E+00   0.0000E+00
*    IFSP(1)      IFSP(2)
*      0            0
*
* TRIP CONTROLLED TRIP CARDS
*      IDTN         INTN
*      -107         3
*    ITN(1)       ITN(2)      ITN(3)
*      105          106         601
*      IDTN         INTN
*      -199         2
*    ITN(1)       ITN(2)
*      117          118
*      IDTN         INTN
*      -299         2
*    ITN(1)       ITN(2)
*      117          228
*      IDTN         INTN
*      -399         2
*    ITN(1)       ITN(2)
*      117          338
*      IDTN         INTN
*      -497         2
*    ITN(1)       ITN(2)
*      117          497
*      IDTN         INTN
*      -498         2
*    ITN(1)       ITN(2)
*      117          49
*      IDTN         INTN
*      -499         2
*    ITN(1)       ITN(2)
*      479          601
*
* TRIP INITIATED PROBLEM TERMINATION CARDS
*      NDMP
*      1
*    IDMP()
*      -999
*
*
**                      6. COMPONENT DATA                 **
*
* COMPONENT NO. 01   VER 1.1 ************************************************
VESSEL          1           1         MAIN VESSEL
*    NASX         NRSX        NTSX        NCSR                  C 2
*     13           3           4           20
*    IDCU         IDCL        IDCR        ICRU        ICRL      C 3
*     1.           2           2           0           0
*    ICRR         ILCSP       IUCSP       IUHP        ICONC     C 4
*     0            3           7           12          0
 2  * ICRRG-NOTE USE ONLY WITH VERSION 12.0,TO OBTAIN CORE GLOBAL OUTPUT*
*    NFFA         NFFR        NFFT        NVENT                 C 5
*     0            0           0           0
*    IRPWTY       NDGX        NDHX        NRTS                  C 6
*     5            0           0           0
*    IZPWTR       IZPWSV      NZPWTB      NZPWSV      NZPWRF    C 8
*     0            0           0           0           0
*    RFTR         NMWRX       NFCI        NFCIL       NZMAX     C 9
*     0            0           0           1           0
*    NRODS        NODES       NODHS       INHSMX                C 10
*     0            0           5           1
*    REACT        TNEUT       RPWOFF      RRPWMX      RPWSCL    C 11
*     0.           0.          0.          0.          0.
*    RPOWRI       ZPWIN       ZPWOFF      RZPWMX                C 12
*     0.           0.          0.          0.
*    SHELV        PLDR        PDRAT       FUCRAC      HGAPO     C 13
*     0.           0.          0.          0.          0.
*    DTXHT(1)     DTXHT(2)    DZNHT                             C 14
*     0.           0.          0.
*
************************* VESSEL GEOMETRIE CARDS ***************************
*
     2.007        2.480       2.915       4.3825      5.850 S*     Z
     6.720        7.495       7.760       8.010 S          *     Z
     8.745        9.495       10.240      13.3915 E        *     Z
     1.168        2.185       2.435 E                      *     RAD
             1.570796               3.141593 S             *     TH
```

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          4.712389                6.283185 E          *    TH
*
***************************** VESSEL SOURCE CARDS ********************************
*
        11        6        3        40          * BL4-HL
        11       10        3        47          * BL4-CL
        11        5        3        10          * L1-HL
        11        8        3        20          * L2-HL
        11        7        3        30          * L3-HL
        11        9        3        17          * L1-CL
        11       12        3        27          *  L2-CL
        11       11        3        37          *  L3-CL
         6        1        3       501          *     CS
         6        2        3       502          *     CS
         6        3        3       503          *     CS
         6        4        3       504          *     CS
         6        5        3       505          *     CS
         6        6        3       506          *     CS
         6        7        3       507          *     CS
         6        8        3       508          *     CS
         1        5       -2       101          *DRAIN L1
         1        8       -2       102          *     L2
         1        7       -2       103          *     L3
         1        6       -2       104          *     L4
*
********************************** LEVEL 1 ***************************************
*
R 4   7.8042 R 4   9.2428 R 4   2.23572            E        *  HSA
R 1      0.0 R 1    0.005 R 1      0.01 R 1   0.013 R 1   0.015S * HSX- 1
R 1      0.0 R 1    0.005 R 1      0.01 R 1   0.013 R 1   0.015S * HSX- 2
R 1      0.0 R 1    0.005 R 1      0.01 R 1   0.013 R 1   0.015S * HSX- 3
R 1      0.0 R 1    0.005 R 1      0.01 R 1   0.013 R 1   0.015S * HSX- 4
R 1      0.0 R 1   0.0094 R 1     0.015 R 1   0.017 R 1  0.0188S * HSX- 5
R 1      0.0 R 1   0.0094 R 1     0.015 R 1   0.017 R 1  0.0188S * HSX- 6
R 1      0.0 R 1   0.0094 R 1     0.015 R 1   0.017 R 1  0.0188S * HSX- 7
R 1      0.0 R 1   0.0094 R 1     0.015 R 1   0.017 R 1  0.0188S * HSX- 8
R 1      0.0 R 1    0.025 R 1      0.04 R 1   0.047 R 1    0.05S * HSX- 9
R 1      0.0 R 1    0.025 R 1      0.04 R 1   0.047 R 1    0.05S * HSX-10
R 1      0.0 R 1    0.025 R 1      0.04 R 1   0.047 R 1    0.05S * HSX-11
R 1      0.0 R 1    0.025 R 1      0.04 R 1   0.047 R 1    0.05E * HSX-12
F         0. E                                       * CFZL-T
F         0. E                                       *      -Z
F         0. E                                       *      -R
F         0. E                                       * CFZV-T
F         0. E                                       *      -Z
F         0. E                                       *      -R
R 4   0.6178 R 4   0.4880 R 4   0.1987          E        *  VOL
R 4   0.4053 R 4   0.3344 R 4   0.2017          E        *  FA-T
R 4   0.5744 R 4  0.55347 R 4       1.        E          *     -Z
R 4   0.2361 R 4   0.3488 R 4   0.0           E          *     -R
R 4   0.65   R 4   1.79   R 4   0.54         E           *  HD-T
R 4   0.69   R 4   1.1414 R 4   0.95          E          *     -Z
R 4   0.69   R 4   1.885  R 4   0.0          E           *     -R
F      416.2 E                                       *  HSTN
F          6 E                                       * MATHS
F      1.000 E                                       *  ALPN
F         0. E                                       * VVN-T
F         0. E                                       *     -Z
F         0. E                                       *     -R
F         0. E                                       * VLN-T
F         0. E                                       *     -Z
F         0. E                                       *     -R
F     401.50 E                                       *    TVN
F     400.65 E                                       *    TLN
F   2.60E+05 E                                       *     PN
F         0. E                                       *   PAN
*
********************************** LEVEL 2 ***************************************
*
R 4   0.8752 R 4   1.8964 R 4   4.1274             E        *  HSA
R 1      0.0 R 1    0.005 R 1      0.01 R 1    0.013 R 1    0.015S * HSX- 1
R 1      0.0 R 1    0.005 R 1      0.01 R 1    0.013 R 1    0.015S * HSX- 2
R 1      0.0 R 1    0.005 R 1      0.01 R 1    0.013 R 1    0.015S * HSX- 3
R 1      0.0 R 1    0.005 R 1      0.01 R 1    0.013 R 1    0.015S * HSX- 4
R 1      0.0 R 1   0.0102 R 1   0.01634 R 1  0.01839 R 1  0.02043S * HSX- 5
R 1      0.0 R 1   0.0102 R 1   0.01634 R 1  0.01839 R 1  0.02043S * HSX- 6
R 1      0.0 R 1   0.0102 R 1   0.01634 R 1  0.01839 R 1  0.02043S * HSX- 7
R 1      0.0 R 1   0.0102 R 1   0.01634 R 1  0.01839 R 1  0.02043S * HSX- 8
R 1      0.0 R 1    0.025 R 1      0.04 R 1    0.047 R 1     0.05S * HSX- 9
R 1      0.0 R 1    0.025 R 1      0.04 R 1    0.047 R 1     0.05S * HSX-10
R 1      0.0 R 1    0.025 R 1      0.04 R 1    0.047 R 1     0.05S * HSX-11
R 1      0.0 R 1    0.025 R 1      0.04 R 1    0.047 R 1     0.05E * HSX-12
F         0. E                                       * CFZL-T
F         0. E                                       *      -Z
F         0. E                                       *      -R
F         0. E                                       * CFZV-T
F         0. E                                       *      -Z
F         0. E                                       *      -R
R 4   0.4735 R 4  0.77815 F        1.0 E                    *  VOL
R 4   0.3041 R 4  0.40059 F        1.0 E                    *  FA-T
R 4   0.4639 R 4  0.35834 R 4      1.0            E         *     -Z
R 4   0.1984 R 4   1.0000 R 4      0.0            E         *     -R
R 4   0.54   R 4   2.1754 R 4   1.02              E         *  HD-T
R 4   0.175  R 4  0.16824 R 4    0.700             E        *     -Z
R 4   0.36   R 4   1.49   R 4   0.00             E          *     -R
F      416.2 E                                       *  HSTN
F          6 E                                       * MATHS
F         1. E                                       *  ALPN
F         0. E                                       * VVN-T
```

```
F       0. E                                                  :  -Z
F       0. E                                                  :  -R
F       0. E                                                  : VLN-T
F       0. E                                                  :  -Z
F       0. E                                                  :  -R
F     402.15 E                                                 :  TVN
F     402.15 E                                                 :  TLN
F   2.60E+05 E                                                 :  PN
F       0. E                                                  :  PAN
*
********************************** LEVEL 3 **********************************
*
R 4   5.1750 R 4    9.9450 R 4    2.5394            E           * HSA
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 1
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 2
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 3
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 4
         0.0 R 1   0.05829 R 1   0.09326 R 1  0.10492 R 1  0.11658S * HSX- 5
         0.0 R 1   0.05829 R 1   0.09326 R 1  0.10492 R 1  0.11658S * HSX- 6
         0.0 R 1   0.05829 R 1   0.09326 R 1  0.10492 R 1  0.11658S * HSX- 7
R 1      0.0 R 1   0.05829 R 1   0.09326 R 1  0.10492 R 1  0.11658S * HSX- 8
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1  0.[illegible]S * HSX- 9
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05S * HSX-10
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05S * HSX-11
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05E * HSX-12
F       0. E                                            * CFZL-T
R 4     8.85 R 4   34.4293 F          0. E                  *  -Z
F       0. E                                            :  -R
F       0. E                                            * CFZV-T
R 4     8.85 R 4   34.4293 F          0. E                  *  -Z
F       0. E                                            *  -R
R 4   0.6342 R 4   0.45616 R 4    1.0000            E          :  VOL
R 4   0.0768 R 4   0.28274 R 4    1.0000            E          :  FA-T
R 4   0.1765 R 4   0.10026 R 4    1.0000            F          :   -Z
R 4   0.0652 R 4    0.0000 R 4       0.0           E         *  -R
R 4   0.245  R 4   0.09506 R 4   0.50000            E          :  HD-T
R 4   0.1100 R 4   0.09044 R 4      0.50 E                  *   -Z
R 4   0.364  R 4      0.01 F        0.01 E                 *  -R
F      416.2 E                                          * HSTN
F          6 E                                          : MATHS
F         1. E                                          : ALPN
F         0. E                                          : VVN-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
F         0. E                                          : VLN-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
R08  432.525 R04    401.64 E                               *  TVN
R08  432.525 R04    401.64 E                               *  TLN
F   2.60E+05 E                                          *  PN
F         0. E                                          * PAN
*
********************************** LEVEL 4 **********************************
*
R 4   7.5000 R 4    20.425 R 4    9.8858            E           * HSA
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 1
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 2
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 3
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 4
R 1      0.0 R 1    0.0107 R 1   0.01716 R 1  0.01930 R 1  0.02144S * HSX- 5
R 1      0.0 R 1    0.0107 R 1   0.01716 R 1  0.01930 R 1  0.02144S * HSX- 6
R 1      0.0 R 1    0.0107 R 1   0.01716 R 1  0.01930 R 1  0.02144S * HSX- 7
R 1      0.0 R 1    0.0107 R 1   0.01716 R 1  0.01930 R 1  0.02144S * HSX- 8
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05S * HSX- 9
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05S * HSX-10
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05S * HSX-11
R 1      0.0 R 1     0.025 R 1      0.04 R 1    0.047 R 1    0.05E * HSX-12
F         0. E                                          : CFZL-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
F         0. E                                          : CFZV-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
R 4   0.4924 R 4   0.57387 R 4    1.0000            E          :  VOL
R 4   0.0021 R 4   0.28124 R 4    1.0000            E          :  FA-T
R 4   .53919 R 4   0.29844 R 4    1.0000            E          :   -Z
R 4   0.0027 F         0.0 E                             *  -R
R 4   0.4182 R 4     .3227 R 4    0.5000            E          :  HD-T
R 4   0.4182 R 4     .1?77 R 4    0.5000            E          :   -Z
R 4      1.2 F        0.01 E                              *  -R
F      416.2 E                                          * HSTN
F          6 E                                          : MATHS
F         1. E                                          : ALPN
F         0. E                                          : VVN-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
F         0. E                                          : VLN-T
F         0. E                                          :  -Z
F         0. E                                          :  -R
R08  432.525 R04    401.64 E                               *  TVN
R08  432.525 R04    401.64 E                               *  TLN
F   2.60E+05 E                                          *  PN
F         0. E                                          * PAN
*
********************************** LEVEL 5 **********************************
*
R 4   7.6755 R 4   20.5750 R 4    9.8851            E           * HSA
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 1
R 1      0.0 R 1     0.005 R 1      0.01 R 1    0.013 R 1   0.015S * HSX- 2
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```
R 1     0.0 R 1    0.005 R 1     0.01 R 1     0.013 R 1     0.015S * HSX- 3
R 1     0.0 R 1    0.005 R 1     0.01 R 1     0.013 R 1     0.015S * HSX- 4
R 1     0.0 R 1  0.01070 R 1  0.01710 R 1   0.01926 R 1  0.021397S * HSX- 5
R 1     0.0 R 1  0.01070 R 1  0.01710 R 1   0.01926 R 1  0.021397S * HSX- 6
R 1     0.0 R 1  0.01070 R 1  0.01710 R 1   0.01926 R 1  0.021397S * HSX- 7
R 1     0.0 R 1  0.01070 R 1  0.01710 R 1   0.01926 R 1  0.021397S * HSX- 8
R 1     0.0 R 1    0.025 R 1     0.04 R 1     0.047 R 1      0.05S * HSX- 9
R 1     0.0 R 1    0.025 R 1     0.04 R 1     0.047 R 1      0.05S * HSX-10
R 1     0.0 R 1    0.025 R 1     0.04 R 1     0.047 R 1      0.05S * HSX-11
R 1     0.0 R 1    0.025 R 1     0.04 R 1     0.047 R 1      0.05E * HSX-12
F       0. E                                              * CFZL-T
F       0. E                                              *     -Z
F       0. E                                              *     -R
F       0. E                                              * CFZV-T
F       0. E                                              *     -Z
F       0. E                                              *     -R
R 4   0.5456 R 4   0.6131 R 4   1.0000          E               *   VOL
R 4   0.0404 R 4   0.2975 R 4   1.0000          E               *   FA-T
R 4   .53919 R 4  0.29844 R 4   1.0000          E               *     -Z
R 4   0.0619 F        0.0 E                               *   -R
R 4    .4182 R 4    .3227 R 4   0.5000          E               *   HD-T
R 4    .4182 R 4   .19772 R 4   0.5000          E               *     -Z
R 4      1.2 F       0.01 E                               *   -R
F      416.2 E                                            * HSTN
F          6 E                                            * MATHS
F         1. E                                            * ALPN
F         0. E                                            * VVN-T
F         0. E                                            *    -Z
F         0. E                                            *    -R
F         0. E                                            * VLN-T
F         0. E                                            *    -Z
F         0. E                                            *    -R
R08    432.525 R04    401.64 E                                 *  TVN
R08    432.525 R04    401.64 E                                 *  TLN
F    2.60E+05 E                                           *  PN
F         0. E                                            * PAN
*
********************************* LEVEL 6 *********************************
*
R 4   10.376 R 4   26.528 R 4   7.1972          E               *   HSA
R 1      0.0 R 1    0.005 R 1     0.01 R 1    0.013 R 1     0.015S * HSX- 1
R 1      0.0 R 1    0.005 R 1     0.01 R 1    0.013 R 1     0.015S * HSX- 2
R 1      0.0 R 1    0.005 R 1     0.01 R 1    0.013 R 1     0.015S * HSX- 3
R 1      0.0 R 1    0.005 R 1     0.01 R 1    0.013 R 1     0.015S * HSX- 4
R 1      0.0 R 1  0.00993 R 1  0.01589 R 1  0.01788 R 1   0.01987S * HSX- 5
R 1      0.0 R 1  0.00993 R 1  0.01589 R 1  0.01788 R 1   0.01987S * HSX- 6
R 1      0.0 R 1  0.00993 R 1  0.01589 R 1  0.01788 R 1   0[illegible]7S * HSX- 7
R 1      0.0 R 1  0.00993 R 1  0.01589 R 1  0.01788 R 1   0.01987S * HSX- 8
R 1      0.0 R 1    0.025 R 1     0.04 R 1    0.047 R 1      0.05S * HSX- 9
R 1      0.0 R 1    0.025 R 1     0.04 R 1    0.047 R 1      0.05S * HSX-10
R 1      0.0 R 1    0.025 R 1     0.04 R 1    0.047 R 1      0.05S * HSX-11
R 1      0.0 R 1    0.025 R 1     0.04 R 1    0.047 R 1      0.05E * HSX-12
F        0. E                                             * CF[illegible]-T
F        0. E                                             *   [illegible]
F        0. E                                             *     -R
F        0. E                                             * CFZV-T
F        0. E                                             *     -Z
F        0. E                                             *     -R
R 4   0.6467 R 4   0.6556 R 4   1.0000          E               *   VOL
R 4       0. R 4    .2678 R 4    1.0 E                          *  FA-T
R 4   .53919 R 4  0.29844 R 4   1.0000          E               *     -Z
R 4      0.0 F        0.0 E                               *   -R
R 4      1.2 R 4  0.66565 R 4   0.5000          E               *   HD-T
R 4      1.2 R 4  0.95555 R 4   0.5000          E               *     -Z
R 4      1.2 F      0.001 E                               *   -R
F      416.2 E                                            * HSTN
F          6 E                                            * MATHS
F         1. E                                            * ALPN
F         0. E                                            * VVN-T
F         0. E                                            *    -Z
F         0. E                                            *    -R
F         0. E                                            * VLN-T
F         0. E                                            *    -Z
F         0. E                                            *    -R
R08    432.525 R04    401.64 E                                 *  TVN
R08    432.525 R04    401.64 E                                 *  TLN
F    2.60E+05 E                                           *  PN
F         0. E                                            * PAN
*
********************************* LEVEL 7 *********************************
*
R 4 34.773600 R 4  51.32586 R 4   1.471840          E          *   HSA
R 1     0.000 R 1 0.0013700 R 1  0.00218000 R 1 .002460000 S        * HSX- 1
R 1  0.002730 S                                     * HSX- 1
R 1     0.000 R 1 0.0013700 R 1  0.00218000 R 1 .002460000 S        * HSX- 2
R 1  0.002730 S                                     * HSX- 2
R 1     0.000 R 1 0.0013700 R 1  0.00218000 R 1 .002460000 S        * HSX- 3
R 1  0.002730 S                                     * HSX- 3
R 1     0.000 R 1 0.0013700 R 1  0.00218000 R 1 .002460000 S        * HSX- 4
R 1  0.002730 S                                     * HSX- 4
R 1     0.000 R 1 0.0017580 R 1  0.00281300 R 1 .003164000 S        * HSX- 5
R 1  0.003576 S                                     * HSX- 5
R 1     0.000 R 1 0.0017580 R 1  0.00281300 R 1 .003164000 S        * HSX- 6
R 1  0.003576 S                                     * HSX- 6
R 1     0.000 R 1 0.0017580 R 1  0.00281300 R 1 .003164000 S        * HSX- 7
R 1  0.003576 S                                     * HSX- 7
R 1     0.000 R 1 0.0017580 R 1  0.00281300 R 1 .003164000 S        * HSX- 8
R 1  0.003576 S                                     * HSX- 8
R 1     0.000 R 1     .0463 R 1    .074000 R 1 .08330000 S        * HSX- 9
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R 1   0.09250 S                                                   * HSX- 9
R 1     0.000 R 1     .0463 R 1     .074000 R 1  .08330000 S            * HSX-10
R 1   0.09250 S                                                   * HSX-10
R 1     0.000 R 1     .0463 R 1     .074000 R 1  .08330000 S            * HSX-11
R 1   0.09250 S                                                   * HSX-11
R 1     0.000 R 1     .0463 R 1     .074000 R 1  .08330000 S            * HSX-12
R 1   0.09250 E                                                   * HSX-12
R 4     4.687 R 4    1.03911 F        0. E                          * CFZL-T
R 4        0. R 4   137.7815 R 4      0. E                          *   -Z
R 4      2.38 F       0. E                                        *     -R
R 4     4.687 R 4    1.03911 F        0. E                          * CFZV-T
R 4        0. R 4   137.7815 R 4      0. E                          *   -Z
R 4      2.38 F       0. E                                        *     -R
R 4 0.5392400 R 4 0.529270 R 4    1.000000            E           *  VOL
R 4 0.3526540 R 4 0.492560 R 4       1.0 E                        *  FA-T
R 4       .37 R 4  0.204703 R 4       1. E                        *    -Z
R 4 0.3526540 F        0.0 E                                      *    -R
R 4 0.0127650 R 4  0.157857 R 4  0.200000 E                       *  HD-T
R 4   0.01285 R 4  0.016840 R 4  0.200000 E                       *    -Z
R 4   .012765 F         .0 E                                      *    -R
R40   416.2 F  416.2 E                                            *  HSTN
F           6 E                                                  * MATHS
F        1.00 E                                                  *  ALPN
F         0.0 E                                                  * VVN-T
F         0.0 E                                                  *    -Z
F         0.0 E                                                  *    -R
F         0.0 E                                                  * VLN-T
F          0. E                                                  *    -Z
F         0.0 E                                                  *    -R
R08     432.525 R04     401.64 E                                  *  TVN
R08     432.525 R04     401.64 E                                  *  TLN
R 8  2.60E+05 F    2.60E+05 E                                     *  PN
F         0.0 E                                                  *  PAN
*********************************** LEVEL 8 ***********************************
*
R 4 21.653000 R 4  33.73010 R 4  1.883960              E          *  HSA
R 1     0.000 R 1 0.0007440 R 1 0.00119000 R 1 .001339000 S       * HSX- 1
R 1  0.001488 S                                                   * HSX- 1
R 1     0.000 R 1 0.0007440 R 1 0.00119000 R 1 .001339000 S       * HSX- 2
R 1  0.001488 S                                                   * HSX- 2
R 1     0.000 R 1 0.0007440 R 1 0.00119000 R 1 .001339000 S       * HSX- 3
R 1  0.001488 S                                                   * HSX- 3
R 1     0.000 R 1 0.0007440 R 1 0.00119000 R 1 .001339000 S       * HSX- 4
R 1  0.001488 S                                                   * HSX- 4
R 1     0.000 R 1 0.0015700 R 1 0.00251200 R 1 .002825500 S       * HSX- 5
R 1 0.0031395 S                                                   * HSX- 5
R 1     0.000 R 1 0.0015700 R 1 0.00251200 R 1 .002825500 S       * HSX- 6
R 1 0.0031395 S                                                   * HSX- 6
R 1     0.000 R 1 0.0015700 R 1 0.00251200 R 1 .002825500 S       * HSX- 7
R 1 0.0031395 S                                                   * HSX- 7
R 1     0.000 R 1 0.0015700 R 1 0.00251200 R 1 .002825500 S       * HSX- 8
R 1 0.0031395 S                                                   * HSX- 8
R 1     0.001 R 1    .04630 R 1     .07400 R 1   .0833000 S       * HSX- 9
R 1    0.0925 S                                                   * HSX- 9
R 1     0.001 R 1    .04630 R 1     .07400 R 1   .0833000 S       * HSX-10
R 1    0.0925 S                                                   * HSX-10
R 1     0.001 R 1    .04630 R 1     .07400 R 1   .0833000 S       * HSX-11
R 1    0.0925 S                                                   * HSX-11
R 1     0.001 R 1    .04630 R 1     .07400 R 1   .0833000 S       * HSX-12
R 1    0.0925 E                                                   * HSX-12
F         0.0 E                                                  * CFZL-T
R 4      4.75 R 4     2.79846 F      0.0 E                          *   -Z
F         0.0 E                                                  *    -R
F         0.0 E                                                  * CFZV-T
R 4      4.75 R 4     2.79846 F      0.0 E                          *   -Z
F         0.0 E                                                  *    -R
R 4 0.6934090 R 4  0.658832 R 4  1.000000          E              *  VOL
R 4 0.3386520 R 4  0.352803 R 4       1.0 E                       *  FA-T
R 4 0.4869400 R 4  0.269400 R 4    1.0000         E               *    -Z
R 4 0.3491100 F        0.0          E                             *    -R
R 4 0.0567390 R 4  0.113584 R 4  0.157500 E                       *  HD-T
R 4 0.0751430 R 4  0.087343 R 4  0.266000          E              *    -Z
R 4   .056739 F        0.00         E                             *    -R
R40     416.2 R20     416.2 F      416.2 E                        *  HSTN
F           6 E                                                  * MATHS
F        1.00 E                                                  *  ALPN
F         0.0 E                                                  * VVN-T
F         0.0 E                                                  *    -Z
F         0.0 E                                                  *    -R
F         0.0 E                                                  * VLN-T
F          0. E                                                  *    -Z
F         0.0 E                                                  *    -R
R08     432.525 R04     401.64 E                                  *  TVN
R08     432.525 R04     401.64 E                                  *  TLN
R 8  2.60E+05 F    2.60E+05 E                                     *  PN
F         0.0 E                                                  *  PAN
*********************************** LEVEL 9 ***********************************
*
R 4  5.287820 R 4  7.568010 R 4  1.839787          E              *  HSA
R 1     0.000 R 1  0.007720 R 1 0.0123400 R 1   0.01389 S         * HSX- 1
R 1  0.015430 S                                                   * HSX- 1
R 1     0.000 R 1  0.007720 R 1 0.0123400 R 1   0.01389 S         * HSX- 2
R 1  0.015430 S                                                   * HSX- 2
R 1     0.000 R 1  0.007720 R 1 0.0123400 R 1   0.01389 S         * HSX- 3
R 1  0.015430 S                                                   * HSX- 3
R 1     0.000 R 1  0.009984 R 1 0.0159740 R 1   0.01797 S         * HSX- 4
R 1  0.019967 S                                                   * HSX- 4
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R 1    0.000 R 1  0.009984 R 1 0.0159740 R 1   0.01797 S            * HSX- 5
R 1  0.019967 S                                              * HSX- 5  * HSX- 6
R 1    0.000 R 1  0.009984 R 1 0.0159740 R 1   0.01797 S
R 1  0.019967 S                                              * HSX- 6  * HSX- 7
R 1    0.000 R 1  0.009984 R 1 0.0159740 R 1   0.01797 S
R 1  0.019967 S                                              * HSX- 7  * HSX- 8
R 1    0.000 R 1  0.009984 R 1 0.0159740 R 1   0.01797 S
R 1  0.019967 S                                              * HSX- 8  * HSX- 9
R 1    0.000 R 1   .05630 R 1    .0900 R 1     .1013 S
R 1   0.11250 S                                              * HSX- 9  * HSX-10
R 1    0.000 R 1   .05630 R 1    .0900 R 1     .1013 S
R 1   0.11250 S                                              * HSX-10  * HSX-11
R 1    0.000 R 1   .05630 R 1    .0900 R 1     .1013 S
R 1   0.11250 S                                              * HSX-11  * HSX-12
R 1    0.000 R 1   .05630 R 1    .0900 R 1     .1013 S
R 1   0.11250 E                                              * HSX-12
F        0.0 E                                               * CFZL-T
F        0.0 E                                               *     -Z
R 4     2.38 F        0. E                                   *     -R
F        0.0 E                                               * CFZV-T
F        0.0 E                                               *     -Z
R 4     2.38 F        0. E                                   *     -R
R 4 0.727990 R 4 0.74698100 R 4 1.000000            E              * VOL
R 4 0.417246 R 4 0.4674220 R 4  1.00000             E              * FA-T
R 4 0.555720 R 4 0.70760000R 4 1.000000             E              * FA-Z
R 1 0.471050 R 1 0.4059000 R 1  0.47105 R 1  0.4059000 S           * FA-R
F     0.0  E                                         * FA-R
R 4 0.05743300R 4 0.15421700R 4 0.2500000           E              * HD-T
R 4   0.23990 F   0.250000 E                          * HD-Z
R 1 0.0647300 R 1  0.052107 R 1 0.064730 R 1  0.0521070 S          *  -R
F  0.0     E                                          *  -R
R40     416.2 R20     416.2 F      416.2 E                         * HSTN
F          6 E                                        * MATHS
F       1.00 E                                        * ALPN
F        0.0 E                                        * VVN-T
F        0.0 E                                        *     -Z
F        0.0 E                                        *     -R
F        0.0 E                                        * VLN-T
F         0. E                                        *     -Z
F        0.0 E                                        *     -R
R08     432.525 R01      400.78 R01       403.55  R02    400.78 E    * TVN
R08     432.525 R01      423.40 R01       403.55  R02    400.78 E    * TLN
R 8  2.60E+05 F    2.60E+05 E                                        * PN
F        0.0 E                                        * PAN
********************************** LEVEL 10 **************************************
*
R 4  4.698880 R 4  8.580000 R 4  2.599925            E         * HSA
R 1    0.000 R 1  0.007250 R 1 0.0115900 R 1   0.01304 S            * HSX- 1
R 1  0.014490 S                                              * HSX- 1  * HSX- 2
R 1    0.000 R 1  0.007250 R 1 0.0115900 R 1   0.01304 S
R 1  0.014490 S                                              * HSX- 2  * HSX- 3
R 1    0.000 R 1  0.007250 R 1 0.0115900 R 1   0.01304 S
R 1  0.014490 S                                              * HSX- 3  * HSX- 4
R 1    0.000 R 1  0.007250 R 1 0.0115900 R 1   0.01304 S
R 1  0.014490 S                                              * HSX- 4  * HSX- 5
R 1    0.000 R 1  0.008340 R 1 0.0133430 R 1   0.01501 S
R 1  0.016679 S                                              * HSX- 5  * HSX- 6
R 1    0.000 R 1  0.008340 R 1 0.0133430 R 1   0.01501 S
R 1  0.016679 S                                              * HSX- 6  * HSX- 7
R 1    0.000 R 1  0.008340 R 1 0.0133430 R 1   0.01501 S
R 1  0.016679 S                                              * HSX- 7  * HSX- 8
R 1    0.000 R 1  0.008340 R 1 0.0133430 R 1   0.01501 S
R 1  0.016679 S                                              * HSX- 8  * HSX- 9
R 1    0.000 R 1   .05630 R 1   .090000 R 1   0.10130 S
R 1   0.11250 S                                              * HSX- 9  * HSX-10
R 1    0.000 R 1   .05630 R 1   .090000 R 1    .10130 S
R 1   0.11250 S                                              * HSX-10  * HSX-11
R 1    0.000 R 1   .05630 R 1   .090000 R 1    .10130 S
R 1   0.11250 S                                              * HSX-11  * HSX-12
R 1    0.000 R 1   .05630 R 1   .090000 R 1    .10130 S
R 1   0.11250 E                                              * HSX-12
F        0.0 E                                               * CFZL-T
F        0.0 E                                               *     -Z
R 4     2.38 F        0. E                                   *     -R
F        0.0 E                                               * CFZV-T
F        0.0 E                                               *     -Z
R 4     2.38 F        0. E                                   *     -R
R 4 0.913520 R 4 0.86154000R 4  0.62667           E                * VOL
R 4 0.404970 R 4 0.5060670 R 1  0.66730 R 1 0.6375000 S            * FA-T
R 1 0.667300 R 1 0.6375000                        E                * FA-T
R 4 0.589280 R 4 0.7246980 R 4  0.683125               E           * FA-Z
R 4 0.393900 F      0.0                      E                     * FA-R
R 4 0.346220 R 4 0.53580000R 1  0.422780 R 1  0.40631 S            * HD-T
R 1 0.422780 R 1 0.40631000                  E                     * HD-T
R 4 0.239900 R 4 0.605 0900R 4  0.339170               E           *  -Z
R 4 0.181000 F      0.0              E                             *  -R
R20     416.2 R20     416.2 F      416.2 E                         * HSTN
F          6 E                                        * MATHS
F       1.00 E                                        * ALPN
F        0.0 E                                        * VVN-T
F        0.0 E                                        *     -Z
F        0.0 E                                        *     -R
F        0.0 E                                        * VLN-T
F         0. E                                        *     -Z
F        0.0 E                                        *     -R
R08     432.525 R01      400.78 R01       403.55  R02    400.78 E    * TVN
R08     432.525 R01      423.40 R01       403.55  R02    400.78 E    * TLN
R 8  2.60E+05 F    2.60E+05 E                                        * PN
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F        0.0 E                                                    * PAN
*********************************** LEVEL 11 ***********************************
*
R 4  4.748920 R 4  8.349300 R 4  3.161260               E          *   HSA
R 1     0.000 R 1 0.0070100 R 1 0.01122000R 1 .012620000S               * HSX- 1
R 1  0.014020 S                                          * HSX- 1
R 1     0.000 R 1 0.0070100 R 1 0.01122000R 1 .012620000S               * HSX- 2
R 1  0.014020 S                                          * HSX- 2
R 1     0.000 R 1 0.0070100 R 1 0.01122000R 1 .012620000S               * HSX- 3
R 1  0.014020 S                                          * HSX- 3
R 1     0.000 R 1 0.0070100 R 1 0.01122000R 1 .012620000S               * HSX- 4
R 1  0.015680 S                                          * HSX- 4
R 1     0.000 R 1 0.0078400 R 1 0.01254500R 1 .014113000S               * HSX- 5
R 1  0.015680 S                                          * HSX- 5
R 1     0.000 R 1 0.0078400 R 1 0.01254500R 1 .014113000S               * HSX- 6
R 1  0.015680 S                                          * HSX- 6
R 1     0.000 R 1 0.0078400 R 1 0.01254500R 1 .014113000S               * HSX- 7
R 1  0.015680 S                                          * HSX- 7
R 1     0.000 R 1 0.0078400 R 1 0.01254500R 1 .014113000S               * HSX- 8
R 1  0.015680 S                                          * HSX- 8
R 1     0.000 R 1  .0614600 R 1 0.0983400 R 1 .11063000 S          * HSX- 9
R 1     0.122926 S                                       * HSX- 9
R 1     0.000 R 1  .0614600 R 1 0.0983400 R 1 .11063000 S          * HSX-10
R 1     0.122926 S                                       * HSX-10
R 1     0.000 R 1   0.06146 R 1 0.0983400 R 1 .11063000 S          * HSX-11
R 1    0.122926 S                                        * HSX-11
R 1     0.000 R 1   0.06146 R 1 0.0983400 R 1 .11063000 S          * HSX-12
R 1    0.122926 E                                        * HSX-12
F         0.0 E                                          * CFZL-T
F         0.0 E                                          *     -Z
R 4      2.38 F        0. E                              *     -R
F         0.0 E                                          * CFZV-T
F         0.0 E                                          *     -Z
R 4      2.38 F        0. E                              *     -R
R 4  0.977230 R 4 0.9032550 R 4  0.371325            E        *  VOL
R 4  0.404970 R 4 0.5060600 R 1   0.84000 R 1 0.5600000 S        *  FA-T
R 1  0.840000 R 1 0.5600000                        E        *  FA-T
R 4  0.589280 R 4   0.72470 R 4   0.60653            E        *  FA-Z
R 4  0.393900 F     0.0              E               *  FA-R
R 4  0.346400 R 4   0.51200 R 1  0.360000 R 1   0.24000 S      *  HD-T
R 1  0.360000 R 1   0.24000                        E        *  HD-T
R 4  0.239900 R 4  0.610970 R 4   0.38667            E        *    -Z
R 4  0.184000 F    0.000010              E               *    -R
R20     416.2 R20     416.2 F       416.2 E                  *  HSTN
F          6 E                                           * MATHS
F        1.00 E                                          *  ALPN
F         0.0 E                                          * VVN-T
F         0.0 E                                          *    -Z
F         0.0 E                                          *    -R
F         0.0 E                                          * VLN-T
F         0.0 E                                          *    -Z
F          0. E                                          *    -R
R08   432.525 R04    423.40 E                                *  TVN
R08   432.525 R04    423.40 E                                *  TLN
R 8  2.60E+05 F    2.60E+05 E                                *  PN
F        0.0 E                                           * PAN
*********************************** LEVEL 12 ***********************************
*
R 4  6.905860 R 4  17.60332 R 4  5.32816                E          *   HSA
R 1     0.000 R 1 0.0077100 R 1 0.01233000R 1 .013880000S               * HSX- 1
R 1  0.015420 S                                          * HSX- 1
R 1     0.000 R 1 0.0077100 R 1 0.01233000R 1 .013880000S               * HSX- 2
R 1  0.015420 S                                          * HSX- 2
R 1     0.000 R 1 0.0077100 R 1 0.01233000R 1 .013880000S               * HSX- 3
R 1  0.015420 S                                          * HSX- 3
R 1     0.000 R 1 0.0077100 R 1 0.01233000R 1 .013880000S               * HSX- 4
R 1  0.015420 S                                          * HSX- 4
R 1     0.000 R 1 0.0119600 R 1 0.01914000R 1 .021530000S               * HSX- 5
R 1  0.023922 S                                          * HSX- 5
R 1     0.000 R 1 0.0119600 R 1 0.01914000R 1 .021530000S               * HSX- 6
R 1  0.023922 S                                          * HSX- 6
R 1     0.000 R 1 0.0119600 R 1 0.01914000R 1 .021530000S               * HSX- 7
R 1  0.023922 S                                          * HSX- 7
R 1     0.000 R 1 0.0119600 R 1 0.01914000R 1 .021530000S               * HSX- 8
R 1  0.023922 S                                          * HSX- 8
R 1     0.000 R 1   .056300 R 1   .0900000 R 1   .1080000 S      * HSX- 9
R 1      0.12 S                                          * HSX- 9
R 1     0.000 R 1   .056300 R 1   .0900000 R 1   .1080000 S      * HSX-10
R 1      0.12 S                                          * HSX-10
R 1     0.000 R 1    0.0600 R 1  0.0960000 R 1   .1080000 S      * HSX-11
R 1      0.12 S                                          * HSX-11
R 1     0.000 R 1    0.0600 R 1  0.0960000 R 1   .1080000 S      * HSX-12
R 1      0.12 E                                          * HSX-12
F         0.0 E                                          * CFZL-T
F         0.0 E                                          *     -Z
R 4      2.38 F        0. E                              *     -R
F         0.0 E                                          * CFZV-T
F         0.0 E                                          *     -Z
R 4      2.38 F        0. E                              *     -R
R 4  1.068148 R 4 1.02422000 R 4  0.475235             E        *  VOL
R 4  0.425200 R 4  0.5602600 R 1  0.475480 R 1  0.44663000 S     *  FA-T
R 1  0.475480 R 1  0.4466300                        E        *  FA-T
R 4  0.063943 R 4  0.0282280 R 4  0.00139258             E        *  FA-Z
R 4  0.424500 F         0. E                         *  FA-R
R 4  0.251160 R 4  0.3027900 R 1  0.271200 R 1  0.25894000 S     *  HD-T
R 1  0.271200 R 1  0.2589400                        E        *  HD-T
R 8  0.035763 R 4  0.000443              E               *    -Z
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```
R 4  0.19453  F    1.0E-12  E                                  *   -R
R30    416.2 R30      416.2 F        416.2 E                      *  HSTN
F        6 E                                            * MATHS
F      1.00 E                                           *  ALPN
F       0.0 E                                           * VVN-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
F       0.0 E                                           * VLN-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
F       0.0 E                                           *    -R
R08     432.525 R04      423.40 E                            *    TVN
R08     432.525 R04      423.40 E                            *    TLN
R 8  2.60E+05 F     2.60E+05 E                                *    PN
F       0.0 E                                           *  PAN
******************************* LEVEL 13 *******************************
R 4   30.1816 R 4   41.8896 R 4    9.1754          E            *   HSA
R 1     0.000 R 1 0.0070390 R 1 0.01126200R 1 .012670000S         * HSX- 1
R 1  0.014078 S                                          * HSX- 1
R 1     0.000 R 1 0.0070390 R 1 0.01126200R 1 .012670000S         * HSX- 2
R 1  0.014078 S                                          * HSX- 2
R 1     0.000 R 1 0.0070390 R 1 0.01126200R 1 .012670000S         * HSX- 3
R 1  0.014078 S                                          * HSX- 3
R 1     0.000 R 1 0.0070390 R 1 0.01126200R 1 .012670000S         * HSX- 4
R 1  0.014078 S                                          * HSX- 4
R 1     0.000 R 1 0.0108000 R 1 0.01728000R 1 .019440000S         * HSX- 5
R 1  0.021600 S                                          * HSX- 5
R 1     0.000 R 1 0.0108000 R 1 0.01728000R 1 .019440000S         * HSX- 6
R 1  0.021600 S                                          * HSX- 6
R 1     0.000 R 1 0.0108000 R 1 0.01728000R 1 .019440000S         * HSX- 7
R 1  0.021600 S                                          * HSX- 7
R 1     0.000 R 1 0.0108000 R 1 0.01728000R 1 .019440000S         * HSX- 8
R 1  0.021600 S                                          * HSX- 8
R 1     0.000 R 1    0.06500 R 1    0.10400 R 1   .117000 S      * HSX- 9
R 1     0.130 S                                          * HSX- 9
R 1     0.000 R 1    0.06500 R 1    0.10400 R 1   .117000 S      * HSX-10
R 1     0.130 S                                          * HSX-10
R 1     0.000 R 1    0.06500 R 1    0.10400 R 1   .117000 S      * HSX-11
R 1     0.130 S                                          * HSX-11
R 1     0.000 R 1    0.06500 R 1    0.10400 R 1   .117000 S      * HSX-12
R 1     0.130 E                                          * HSX-12
F       0.0 E                                           * CFZL-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
F       0.0 E                                           * CFZV-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
R 4  0.726035 R 4 0.40182000 R 4 0.208948            E          *   VOL
R 4  0.629690 R 4 0.59701000 R 4 0.100010 E                    *  FA-T
F       0.0 E                                           *  FA-Z
R 4  0.879560 R 4 0.27527000 R 4  0.0               E          *  FA-R
R 4  0.362360 R 4   0.8030750 R 4 0.186210 E                   *  HD-T
F     0.0001 E                                          *  HD-Z
R 4  0.491590 R 4  0.9099700 R 4 1.0E-12           E          *  HD-R
F      416.2 E                                          *  HSTN
F         6 E                                           * MATHS
F      1.00 E                                           *  ALPN
F       0.0 E                                           * VVN-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
F       0.0 E                                           * VLN-T
F       0.0 E                                           *    -Z
F       0.0 E                                           *    -R
F    432.525 E                                          *    TVN
F    432.525 E                                          *    TLN
F   2.60E+05 E                                          *    PN
F       0.0 E                                           *  PAN
* COMPONENT NO. 107 ***************************************************
FILL          107          107          VESSEL KTA DRAIN  *   C
*    JUN1         IFTY         IOFF                           C  2
      107            8            1
*    IFTR         IFSV         NFTB         NFSV         NFRF      C  3
      666          100            1            0            0
*    TWOLD         RFMX        CONCIN                            C  4
 .00000E+00      240.     .00000E+00
*    DXIN         VOLIN        ALPIN        VLIN         TLIN      C  5
      1.0        0.2514        0.0          0.0        308.15
*    PIN          PAIN         FLOWIN       VVIN         TVIN      C  6
   4.0E+05         0.0          0.0          0.0        308.15
*    VMSCL        VVSCL                                        C  9
        1            1
* VESSEL DRAIN  FILL TABLE PAIRS= 1 *
* TIME (S)   DRAIN FLOW (KG/S) *
0.00000E+00 0.00000E+00 E
* COMPONENT NO. 101 ***************************************************
TEE           101          101  VESSEL DRAIN LOOPS 2,3
*    JCELL        NODES         MAT         COST         ICHF      C  2
       04            4            6            0            0
*    ICONC1       NCELL1        JUN1         JUN2         IPOW1     C  3
        0           06          102          105            0
*    IQPTR1       IQPSV1       NQPTB1       NQPSV1       NQPRF1     C  5
        0            0            0            0            0
*    RADIN1         TH1        HOUTL1       HOUTV1       TOUTL1     C  6
   0.1965          .01           0.           0.          30
```

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*     TOUTV1      PWIN1      PWOFF1      RPWMX1      PWSCL1    C 7
      300.        0.         0.          0.          0.
*     QPIN1       QPOFF1     RQPMX1      QPSCL1               C 8
      0.          0.         0.          0.
*     ICONC2      NCELL2     JUN3        IPOW2               C 9
      0           2          103         0
*     IQPTR2      IQPSV2     NQPTB2      NQPSV2      NQPRF2    C 11
      0           0          0           0           0
*     RADIN2      TH2        HOUTL2      HOUTV2      TOUTL2    C 12
      0.1965      .01        0.          0.          300.
*     TOUTV2      PWIN2      PWOFF2      RPWMX2      PWSCL2    C 13
      300.        0.         0.          0.          0.
*     QPIN2       QPOFF2     RQPMX2      QPSCL2               C 14
      0.          0.         0.          0.
* PRIMARY *
      0.396       1.750      4.150       [illegible]  4.400 S  *  DX
      12.350      E
      0.0480      0.2123     0.5034      [illegible]  .5337 S  *  VOL
      1.4981      E
      0. F        0.1213 E                                     *  FA
      0           8.82E-3    3.21E-3     [illegible]      0 S  *  FRIC
      0           1.07E-3    E                                 *  FRIC
      0           8.82E-3    3.21E-3     2.80E-3          0 S  *  REVFRIC
      0           1.07E-3    E                                 *  REVFRIC
      -1.         -0.2731    -0.0093     -0.0086     -0.0100 S *  GRAV
      -0.0092     -0.3028    E                                 *  GRAV
R 7   0.393       E                                            *  HD
F     0 E                                                      *  ICFLAG
F     1 E                                                      *  NFF
F     1.0 E                                                    *  ALP
F     0.0 E                                                    *  VL
F     0.0 E                                                    *  VV
F     450.00 E                                                 *  TL
F     450.00 E                                                 *  TV
F     2.60E+05 E                                               *  P
F     0.0 E                                                    *  PA
F     0.0 E                                                    *  QPPP
F     6 E                                                      *  MATID
F     449.00 E                                                 *  TW
* SECONDARY *
      1.850       0.383      E                                 *  DX
      0.2244      0.0465 E                                     *  VOL
R 2   0.1213      0. E                                         *  FA
      0.          8.47E-3    0 E                               *  FRIC
      0.          8.47E-3    0 E                               *  RVFRIC
      0.          0.2689     1. E                              *  GRAV
F     0.393 E                                                  *  HD
F     0 E                                                      *  ICFLG
F     1 E                                                      *  NFF
F     1. E                                                     *  ALP
F     0. E                                                     *  VL
F     0. E                                                     *  VV
F     450.00 E                                                 *  TL
F     450.00 E                                                 *  TV
F     2.60E+05 E                                               *  P
F     0. E                                                     *  PA
F     0. E                                                     *  QPPP
F     6 E                                                      *  MATID
F     449.00 E                                                 *  TW
*
*
*
* COMPONENT NO. 102 *****************************************************
*
TEE           102          102   VESSEL DRAIN LOOPS 1,4
*     JCELL       NODES      MAT         COST        ICHF      C 2
      03          4          6           0.          0
*     ICONC1      NCELL1     JUN1        JUN2        IPOW1     C 3
      0           04         104         106         0
*     IQPTR1      IQPSV1     NQPTB1      NQPSV1      NQPRF1    C 5
      0           0          0           0           0
*     RADIN1      TH1        HOUTL1      HOUTV1      TOUTL1    C 6
      0.1965      .01        0.          0.          300.
*     TOUTV1      PWIN1      PWOFF1      RPWMX1      PWSCL1    C 7
      300.        0.         0.          0.          0.
*     QPIN1       QPOFF1     RQPMX1      QPSCL1               C 8
      0.          0.         0.          0.
*     ICONC2      NCELL2     JUN3        IPOW2               C 9
      0           2          101         0
*     IQPTR2      IQPSV2     NQPTB2      NQPSV2      NQPRF2    C 11
      0           0          0           0           0
*     RADIN2      TH2        HOUTL2      HOUTV2      TOUTL2    C 12
      0.1965      .01        0.          0.          300.
*     TOUTV2      PWIN2      PWOFF2      RPWMX2      PWSCL2    C 13
      300.        0.         0.          0.          0.
*     QPIN2       QPOFF2     RQPMX2      QPSCL2               C 14
      0.          0.         0.          0.
* PRIMARY *
      0.3960      1.750      3.150       7.350 E               *  DX
      0.0480      0.2123     0.2893      0.8916 E              *  VOL
      0. F        0.1213 E                                     *  FA
      0.          8.82E-3    3.86E-3     0.      1.80E-3 E     *  FRIC
      0.          8.82E-3    3.86E-3     0.      1.80E-3 E     *  RVFRIC
      -1.0        -0.1934    -0.0094     -0.0095  -0.3064 E    *  GRAV
R 5   0.393 E                                                  *  HD
F     0 E                                                      *  ICFLAG
F     1 E                                                      *  NFF
F     1.0 E                                                    *  ALP
F     0.0 E                                                    *  VL
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F       0.0 E                                   *  VV
F    450.00 E                                   *  TL
F    450.00 E                                   *  TV
F  2.60E+05 E                                   *  P
F       0.0 E                                   *  PA
F       0.0 E                                   *  QPPP
F         6 E                                   *  MATID
F    449.00 E                                   *  TW
* SECONDARY *
    1.750        0.391  E                       *  DX
   0.2123       0.0474  E                       *  VOL
R 2  0.1213          0. E                       *  FA
      0.     8.84E-03          0. E             *  FRIC
      0.     8.84E-03          0. E             *  REVFRIC
      0.       0.2032          1. E             *  GRAV
F     0.393 E                                   *  HD
F         0 E                                   *  ICFLG
F         1 E                                   *  NFF
F        1. E                                   *  ALP
F        0. E                                   *  VL
F        0. E                                   *  VV
F    450.00 E                                   *  TL
F    450.00 E                                   *  TV
F  2.60E+05 E                                   *  P
F        0. E                                   *  PA
F        0. E                                   *  QPPP
F         6 E                                   *  MATID
F    449.00 E                                   *  TW
*
*
*
* COMPONENT NO. 103 ****************************************************
*
TEE            103          103  VESSEL DRAIN PART2-TO FILL
*     JCELL       NODES        MAT        COST       ICHF      C  2
        02          4     6        .5        0
*     ICONC1      NCELL1       JUN1       JUN2       IPOW1     C  3
        0         03     105       107        0
*     IQPTR1      IQPSV1      NQPTB1     NQPSV1     NQPRF1     C  5
        0          0      0         0         0
*     RADIN1        TH1      HOUTL1     HOUTV1     TOUTL1     C  6
     0.1965        .01       0.        0.       300.
*     TOUTV1       PWIN1     PWOFF1     RPWMX1     PWSCL1     C  7
      300.          0       0.        0.        0.
*     QPIN1       QPOFF1     RQPMX1     QPSCL1                C  8
        0.         0.       0.        0.
*     ICONC2      NCELL2      JUN3       IPOW2                C  9
        0          2     106         0
*     IQPTR2      IQPSV2      NQPTB2     NQPSV2     NQPRF2     C 11
        0          0      0         0         0
*     RADIN2        TH2      HOUTL2     HOUTV2     TOUTL2     C 12
     0.1965        .01       0.        0.       300.
*     TOUTV2       PWIN2     PWOFF2     RPWMX2     PWSCL2     C 13
      306.          0       0.        0.        0.
*     QPIN2       QPOFF2     RQPMX2     QPSCL2                C 14
        0.         0.       0.        0.
* PRIMARY *
 5.332    2.461    2.514  E                     *  DX
 0.6468  0.2985   0.3049  E                     *  VOL
 F 0.1213  E                                    *  FA
 1.07E-03  3.86E-03  0.  0.  E                  *  FRIC
 1.07E-03  3.86E-03  0.  0.  E                  *  REVFRIC
 -0.3028  -0.6804  -0.0018 0. E                 *  GRAV
 R 4 0.393 E                                    *  HD
 F        0 E                                   *  ICFLAG
 F        1 E                                   *  NFF
 F      1.0 E                                   *  ALP
 F      0.0 E                                   *  VL
 F      0.0 E                                   *  VV
 F   450.00 E                                   *  TL
 F   450.00 E                                   *  TV
 F 2.60E+05 E                                   *  P
 F      0.0 E                                   *  PA
 F      0.0 E                                   *  QPPP
 F        6 E                                   *  MATID
 F   449.00 E                                   *  TW
* SECONDARY *
 2.528  3.143  E                                *  DX
 0.3066  0.3812  E                              *  VOL
 F  0.1213  E                                   *  FA
 1.95E-0"  8.56E-04  1.80E-03     E             *  FRIC
 1.95E-03  8.56E-04  1.80E-03     E             *  RVFRIC
  .4348 0.9367  0.3064  E                       *  GRAV
 F  0.393 E                                     *  HD
 F        0 E                                   *  ICFLG
 F        1 E                                   *  NFF
 F       1. E                                   *  ALP
 F       0. E                                   *  VL
 F       0. E                                   *  VV
 F   450.00 E                                   *  TL
 F   450.00 E                                   *  TV
 F 2.60E+05 E                                   *  P
 F       0. E                                   *  PA
 F       0. E                                   *  QPPP
 F        6 E                                   *  MATID
 F   449.00 E                                   *  TW
*
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* COMPONENT NO. 501 ************************************************************
*TEE            501         501  CORE SIMULATOR TEE CELL 1  *    C 1
*    JCELL      NODES          MAT          COST        ICHF      C 2
      3         0          6     1.          0
*    ICONC1     NCELL1        JUN1          JUN2        IPOW1     C 3
      0         4         701        501         0
*    RADIN1     TH1        HOUTL1        HOUTV1        TOUTL1     C 6
      .65       .006       0.          0.           300.
*    TOUTV1     PWIN1      PWOFF1        RPWMX1        PWSCL1     C 7
      300.      0.         0.          0.           0.
*    ICONC2     NCELL2        JUN3          IPOW2                 C 9
      0         2         601          0
*    RADIN2     TH2        HOUTL2        HOUTV2        TOUTL2     C 12
      .65       .006       0.          0.           300.
*    TOUTV2     PWIN2      PWOFF2        RPWMX2        PWSCL2     C 13
      300.      0.         0.          0.           0.
* PRIMARY *
F       0.9 E                                          *  DX
R 2     0.52 F      .52 E                                *  VOL
R 3   .577710 F   .577710 E                                *  FA
F       0. E                                           *  FRIC
F     1.0E15 E                                          *  RVFRIC
F       0. E                                           *  GRAV
F    0.7184 E                                            *  HD
F       0 E                                            *  ICFLG
F       0 E                                            *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F   432.525 E                                            *  TL
F   432.525 E                                            *  TV
F  2.60E+05 E                                            *  P
F       0. E                                           *  PA
* SECONDARY *
F       0.9 E                                          *  DX
F       0.52 E                                         *  VOL
F   0.577710 E                                           *  FA
F     1.E15 E                                            *  FRIC
F       0. E                                           *  RVFRIC
F       0. E                                           *  GRAV
F    0.7184 E                                            *  HD
F       0 E                                            *  ICFLG
F       0 E                                            *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F   432.525 E                                            *  TL
F   432.525 E                                            *  TV
F  2.60E+05 E                                            *  P
F       0. E                                           *  PA
* COMPONENT NO. 502 ************************************************************
*TEE            502         502  CORE SIMULATOR TEE CELL 2
*    JCELL      NODES          MAT          COST        ICHF      C 2
      3         0          6     1.          0
*    ICONC1     NCELL1        JUN1          JUN2        IPOW1     C 3
      0         4         702        502         0
*    RADIN1     TH1        HOUTL1        HOUTV1        TOUTL1     C 6
      .65       .006       0.          0.           300.
*    TOUTV1     PWIN1      PWOFF1        RPWMX1        PWSCL1     C 7
      300.      0.         0.          0.           0.
*    ICONC2     NCELL2        JUN3          IPOW2                 C 9
      0         2         602          0
*    RADIN2     TH2        HOUTL2        HOUTV2        TOUTL2     C 12
      .65       .006       0.          0.           300.
*    TOUTV2     PWIN2      PWOFF2        RPWMX2        PWSCL2     C 13
      300.      0.         0.          0.           0.
* PRIMARY *
F       0.9 E                                          *  DX
R 2     0.52 F      .52 E                                *  VOL
R 3   .577710 F   .577710 E                                *  FA
F       0. E                                           *  FRIC
F     1.0E15 E                                          *  RVFRIC
F       0. E                                           *  GRAV
F    0.7184 E                                            *  HD
F       0 E                                            *  ICFLG
F       0 E                                            *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F   432.525 E                                            *  TL
F   432.525 E                                            *  TV
F  2.60E+05 E                                            *  P
F       0. E                                           *  PA
* SECONDARY *
F       0.9 E                                          *  DX
F       0.52 E                                         *  VOL
F   0.577710 E                                           *  FA
F     1.E15 E                                            *  FRIC
F       0. E                                           *  RVFRIC
F       0. E                                           *  GRAV
F    0.7184 E                                            *  HD
F       0 E                                            *  ICFLG
F       0 E                                            *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
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F     432.525 E                                   *  TL
F     432.525 E                                   *  TV
F   2.60E+05 E                                    *  P
F        0. E                                  *  PA
*
* COMPONENT NO. 503 ***********************************************************
*
TEE              503          503   CORE SIMULATOR TEE CELL 3
*    JCELL       NODES        MAT        COST        ICHF       C  2
       3           0     6       1.         0
*    ICONC1      NCELL1       JUN1       JUN2        IPOW1      C  3
       0           4    703      503        0
*    RADIN1      TH1         HOUTL1      HOUTV1      TOUTL1     C  6
      .65        .006   0.       0.         300.
*    TOUTV1      PWIN1       PWOFF1      RPWMX1      PWSCL1     C  7
      300.        0.    0.       0.          0.
*    ICONC2      NCELL2       JUN3       IPOW2                  C  9
       0           2    603       0
*    RADIN2      TH2         HOUTL2      HOUTV2      TOUTL2     C 12
      .65        .006   0.       0.         300.
*    TOUTV2      PWIN2       PWOFF2      RPWMX2      PWSCL2     C 13
      300.        0.    0.       0.          0.
* PRIMARY *
F       0.9 E                                     *  DX
R 2    0.52 F        .52 E                        *  VOL
R 3 .577710 F    .577710 E                        *  FA
F        0. E                                     *  FRIC
F    1.0E15 E                                     *  RVFRIC
F        0. E                                     *  GRAV
F    0.7184 E                                     *  HD
F         0 E                                     *  ICFLG
F         0 E                                     *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F   432.525 E                                     *  TL
F   432.525 E                                     *  TV
F  2.60E+05 E                                     *  P
F        0. E                                     *  PA
* SECONDARY *
F       0.9 E                                     *  DX
F      0.52 E                                     *  VOL
F  0.577710 E                                     *  FA
F     1.E15 E                                     *  FRIC
F        0. E                                     *  RVFRIC
F        1. E                                     *  GRAV
F    0.7184 E                                     *  HD
F         0 E                                     *  ICFLG
F         0 E                                     *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F   432.525 E                                     *  TL
F   432.525 E                                     *  TV
F  2.60E+05 E                                     *  P
F        0. E                                     *  PA
*
* COMPONENT NO. 504 ***********************************************************
*
TEE              504          504   CORE SIMULATOR TEE CELL 4
*    JCELL       NODES        MAT        COST        ICHF       C  2
       3           0     6       1.         0
*    ICONC1      NCELL1       JUN1       JUN2        IPOW1      C  3
       0           4    704      504        0
*    RADIN1      TH1         HOUTL1      HOUTV1      TOUTL1     C  6
      .65        .006   0.       0.         300.
*    TOUTV1      PWIN1       PWOFF1      RPWMX1      PWSCL1     C  7
      300.        0.    0.       0.          0.
*    ICONC2      NCELL2       JUN3       IPOW2                  C  9
       0           2    604       0
*    RADIN2      TH2         HOUTL2      HOUTV2      TOUTL2     C 12
      .65        .006   0.       0.         300.
*    TOUTV2      PWIN2       PWOFF2      RPWMX2      PWSCL2     C 13
      300.        0.    0.       0.          0.
* PRIMARY *
F       0.9 E                                     *  DX
R 2    0.52 F        .52 E                        *  VOL
R 3 .577710 F    .577710 E                        *  FA
F        0. E                                     *  FRIC
F    1.0E15 E                                     *  RVFRIC
F        0. E                                     *  GRAV
F    0.7184 E                                     *  HD
F         0 E                                     *  ICFLG
F         0 E                                     *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F   432.525 E                                     *  TL
F   432.525 E                                     *  TV
F  2.60E+05 E                                     *  P
F        0. E                                     *  PA
* SECONDARY *
F       0.9 E                                     *  DX
F      0.52 E                                     *  VOL
F  0.577710 E                                     *  FA
F     1.E15 E                                     *  FRIC
F        0. E                                     *  RVFRIC
F        0. E                                     *  GRAV
F    0.7184 E                                     *  HD
```

```
F       0 E                                    * ICFLG
F       0 E                                    *  NFF
F      1. E                                    *  ALP
F      0. E                                    *  VL
F      0. E                                    *  VV
F   432.525 E                                   *   TL
F   432.525 E                                   *   TV
F  2.60E+05 E                                   *   P
F      0. E                                    *  PA
* COMPONENT NO. 505 ***********************************************************
*TEE            505      505  CORE SIMULATOR TEE CELL 5
*    JCELL      NODES        MAT       COST       ICHF     C  2
      3          0      6      1.        0
*    ICONC1     NCELL1       JUN1      JUN2       IPOW1    C  3
      0          4      705      505       0
*    RADIN1       TH1     HOUTL1     HOUTV1      TOUTL1    C  6
      .65       .006    0.       0.       300.
*    TOUTV1      PWIN1     PWOFF1     RPWMX1      PWSCL1    C  7
      300.       0.     0.       0.        0.
*    ICONC2     NCELL2       JUN3      IPOW2               C  9
      0          2      605       0
*    RADIN2       TH2     HOUTL2     HOUTV2      TOUTL2    C 12
      .65       .006    0.       0.       300.
*    TOUTV2      PWIN2     PWOFF2     RPWMX2      PWSCL2    C 13
      300.       0.     0.       0.        0.
* PRIMARY *
F      0.9 E                                    *   DX
R 2  0.719356 F  0.719356 E                       *   VOL
R 3  .7999284 F  .7999284 E                       *   FA
F      0. E                                    * FRIC
F   1.0E15 E                                    * RVFRIC
F      0. E                                    * GRAV
F    0.861 E                                    *  HD
F       0 E                                    * ICFLG
F       0 E                                    *  NFF
F      1. E                                    *  ALP
F      0. E                                    *  VL
F      0. E                                    *  VV
F   432.525 E                                   *   TL
F   432.525 E                                   *   TV
F  2.60E+05 E                                   *   P
F      0. E                                    *  PA
* SECONDARY *
F      0.9 E                                    *  DX
F  0.7193560 E                                  *   VOL
F  0.7999284 E                                  *   FA
F    1.E15 E                                    *  FRIC
F      0. E                                    * RVFRIC
F      0. E                                    *  GRAV
F    0.861 E                                    *  HD
F       0 E                                    * ICFLG
F       0 E                                    *  NFF
F      1. E                                    *  ALP
F      0. E                                    *  VL
F      0. E                                    *  VV
F   432.525 E                                   *   TL
F   432.525 E                                   *   TV
F  2.60E+05 E                                   *   P
F      0. E                                    *  PA
* COMPONENT NO. 506 ***********************************************************
*TEE            506      506  CORE SIMULATOR TEE CELL 6
*    JCELL      NODES        MAT       COST       ICHF     C  2
      3          0      6      1.        0
*    ICONC1     NCELL1       JUN1      JUN2       IPOW1    C  3
      0          4      706      506       0
*    RADIN1       TH1     HOUTL1     HOUTV1      TOUTL1    C  6
      .65       .006    0.       0.       300.
*    TOUTV1      PWIN1     PWOFF1     RPWMX1      PWSCL1    C  7
      300.       0.     0.       0.        0.
*    ICONC2     NCELL2       JUN3      IPOW2               C  9
      0          2      606       0
*    RADIN2       TH2     HOUTL2     HOUTV2      TOUTL2    C 12
      .65       .006    0.       0.       300.
*    TOUTV2      PWIN2     PWOFF2     RPWMX2      PWSCL2    C 13
      300.       0.     0.       0.        0.
* PRIMARY *
F      0.9 E                                    *   DX
R 2  .719356 F   .719356 E                        *   VOL
R 3  .7999284 F  .7999284 E                       *   FA
F      0. E                                    * FRIC
F   1.0E15 E                                    * RVFRIC
F      0. E                                    * GRAV
F    0.861 E                                    *  HD
F       0 E                                    * ICFLG
F       0 E                                    *  NFF
F      1. E                                    *  ALP
F      0. E                                    *  VL
F      0. E                                    *  VV
F   432.525 E                                   *   TL
F   432.525 E                                   *   TV
F  2.60E+05 E                                   *   P
F      0. E                                    *  PA
* SECONDARY *
F      0.9 E                                    *  DX
F   .719356 E                                   *   VOL
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F   0.7999284 E                                    *  FA
F      1.E15 E                                    *  FRIC
F        0. E                                     *  RVFRIC
F        0. E                                     *  GRAV
F     0.861 E                                     *  HD
F        0                                        *  ICFLG
F                                                 *  NFF
F                                                 *  ALP
F                                                 *  VL
F                                                 *  VV
F     432.525 E                                   *  TL
F     432.525 E                                   *  TV
F    2.60E+05 E                                   *  P
F        0. E                                     *  PA
*
* COMPONENT NO. 507 ********************************************************
*
TEE            507      507  CORE SIMULATOR TEE CELL 7
*   JCELL      NODES       MAT        COST        ICHF      C  2
      3          0      6      1.        0
*   ICONC1     NCELL1      JUN1       JUN2        IPOW1     C  3
      0          4      707      507       0
*   RADIN1     TH1      HOUTL1      HOUTV1      TOUTL1      C  6
     .65       .006     0.       0.       300.
*   TOUTV1     PWIN1     PWOFF1      RPWMX1       PWSCL1      C  7
     300.      0.       0.       0.       0.
*   ICONC2     NCELL2      JUN3      IPOW2                  C  9
      0          2      607       0
*   RADIN2     TH2      HOUTL2      HOUTV2      TOUTL2      C 12
     .65       .006     0.       0.       300.
*   TOUTV2     PWIN2     PWOFF2      RPWMX2       PWSCL2      C 13
     300.      0.       0.       0.       0.
* PRIMARY *
F      0.9 E                                      *  DX
R 2   .719356 F    .7193566 E                     *  VOL
R 3   .7999284 F   .7999284 E                     *  FA
F        0. E                                     *  FRIC
F     1.0E15 E                                    *  RVFRIC
F        0. E                                     *  GRAV
F     0.861 E                                     *  HD
F        0 E                                      *  ICFLG
F        0 E                                      *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F     432.525 E                                   *  TL
F     432.525 E                                   *  TV
F    2.60E+05 E                                   *  P
F        0. E                                     *  PA
* SECONDARY *
F      0.9 E                                      *  DX
F     .719356 E                                   *  VOL
F     .7999284 E                                  *  FA
F      1.E15 E                                    *  FRIC
F        0. E                                     *  RVFRIC
F        0. E                                     *  GRAV
F     0.861 E                                     *  HD
F        0 E                                      *  ICFLG
F        0 E                                      *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F     432.525 E                                   *  TL
F     432.525 E                                   *  TV
F    2.60E+05 E                                   *  P
F        0. E                                     *  PA
*
* COMPONENT NO. 508 ********************************************************
*
TEE            508      508  CORE SIMULATOR TEE CELL 8
*   JCELL      NODES       MAT        COST        ICHF      C  2
      3          0      6      1.        0
*   ICONC1     NCELL1      JUN1       JUN2        IPOW1     C  3
      0          4      708      508       0
*   RADIN1     TH1      HOUTL1      HOUTV1      TOUTL1      C  6
     .65       .006     0.       0.       300.
*   TOUTV1     PWIN1     PWOFF1      RPWMX1       PWSCL1      C  7
     300.      0.       0.       0.       0.
*   ICONC2     NCELL2      JUN3      IPOW2                  C  9
      0          2      608       0
*   RADIN2     TH2      HOUTL2      HOUTV2      TOUTL2      C 12
     .65       .006     0.       0.       300.
*   TOUTV2     PWIN2     PWOFF2      RPWMX2       PWSCL2      C 13
     300.      0.       0.       0.       0.
* PRIMARY *
F      0.9 E                                      *  DX
R 2   .719356 F    .719356 E                      *  VOL
R 3   .7999284 F   .7999284 E                     *  FA
F        0. E                                     *  FRIC
F     1.0E15 E                                    *  RVFRIC
F        0. E                                     *  GRAV
F     0.861 E                                     *  HD
F        0 E                                      *  ICFLG
F        0 E                                      *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F     432.525 E                                   *  TL
F     432.525 E                                   *  TV
```

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F    2.60E+05 E                                   *  P
F        0. E                                     *  PA
* SECONDARY *
F       0.9 E                                     *  DX
F   .719356 E                                     *  VOL
F  .7999284 E                                     *  FA
F     1.E15 E                                     *  FRIC
F        0. E                                     *  RVFRIC
F        0. E                                     *  GRAV
F     0.861 E                                     *  HD
F         0 E                                     *  ICFLG
F         0 E                                     *  NFF
F        1. E                                     *  ALP
F        0. E                                     *  VL
F        0. E                                     *  VV
F   452.525 E                                     *  TL
F   432.525 E                                     *  TV
F  2.60E+05 E                                     *  P
F        0. E                                     *  PA
*
* COMPONENT NO.701 **************************************************
*
FILL           701         701  CORE FEEDBACK FILL CELL 01  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     701       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0.
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9        .52         1.    0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      T[illegible]
 19.8[illegible]E+05  0.        0.        0.    461.14
* COMPONENT NO.702 **************************************************
*
FILL           702         702  CORE FEEDBACK FILL CELL 02  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     702       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0.
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9        .52      1.      0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      TVIN      C  6
 19.88E+05     0.           0.        0.    461.14
* COMPONENT NO.703 **************************************************
*
FILL           703         703  CORE FEEDBACK FILL CELL 03  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     703       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0.
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9        .52      1.      0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      TVIN      C  6
 19.88E+05     0.           0.        0.    461.14
* COMPONENT NO.704 **************************************************
*
FILL           704         704  CORE FEEDBACK FILL CELL 04  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     704       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9        .52         1.    0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      TVIN      C  6
 19.88E+05     0.           0.        0.    461.14
* COMPONENT NO.705 **************************************************
*
FILL           705         705  CORE FEEDBACK FILL CELL 05  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     705       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0.
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9     .719356        1.    0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      TVIN      C  6
 19.88E+05     0.           0.        0.    461.14
* COMPONENT NO.706 **************************************************
*
FILL           706         706  CORE FEEDBACK FILL CELL 06  *   C  1
*    JUN1      IFTY         IOFF                     C  2
     706       2           1
*    IFTR      IFSV         NFTB      NFSV      NFRF      C  3
     0         0           0    0         0
*    TWTOLD       RFMX         CONCIN                     C  4
     0.0       30.         0.
*    DXIN      VOLIN        ALPIN     VLIN      TLIN      C  5
     .9     .719356        1.    0.    461.14
*    PIN       PAIN         FLOWIN    VVIN      TVIN      C  6
 10.88E+05     0.           0.        0.    461.14
* COMPONENT NO.707 **************************************************
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*
FILL           707        707  CORE FEEDBACK FILL CELL 07  *   C
*    JUN1        IFTY        IOFF                          C  2
     707           2           1
*    IFTR        IFSV        NFTB       NFSV       NFRF     C  3
      0           0           0          0          0
*   TWTOLD          RFMX       CONCIN                       C  4
     0.0         30.         0.
*    DXIN        VOLIN       ALPIN       VLIN       TLI     C  5
      .9       .719356        1.          0.       461.14
*    PIN         PAIN        FLOWIN      VVIN       TVIN    C  6
   19.88E+05      0.           0.         0.       461.14
* COMPONENT NO.708 ***********************************************
*
FILL           708        708  CORE FEEDBACK FILL CELL 08  *   C  1
*    JUN1        IFTY        IOFF                          C  2
     708           2           1
*    IFTR        IFSV        NFTB       NFSV       NFRF     C  3
      0           0           0          0          0
*   TWTOLD          RFMX       CONCIN                       C  4
     0.0         50.         0.
*    DXIN        VOLIN       ALPIN       VLIN       TLIN    C  5
      .9       .719356        1.          0.       461.14
*    PIN         PAIN        FLOWIN      VVIN       TVIN    C  6
   19.88E+05      0.           0.         0.       461.14
* COMPONENT NO.601 ***********************************************
*
FILL           601        601 BASE STEAM-WATER FILL CELL 1
*    JUN1        IFTY        IOFF                          C  2
     601           6           0
*    IFTR        IFSV        NFTB       NFSV       NFRF     C  3
     600         100           9          0
*   TWTOLD          RFMX       CONCIN                       C  4
      0.         100.        C.
*    DXIN        VOLIN       ALPIN       VLIN       TLIN    C  5
      .9          .52        1.0          0.       484.15
*    PIN         PAIN        FLOWIN      VVIN       TVIN    C  6
   19.4E+05       0.          0.                   484.15
*    VMSCL       VVSCL                               C  9
     1.0          1.0
*    TLSCL       TVSCL       PSCL       PASCL       CONSCL   C 10
     1.0          1.0       1.E+05       1.         1.0
*    T(S)        VLTB(M/S)
      0.00        0.0  S
     20.00        0.0  S
     30.00        0.0  S
     32.50        0.0  S
     36.00        0.0  S
     40.00        0.0  S
    120.00        0.0  S
    121.00        0.0  S
    140.00        0.0  E
*    T(S)        VVTB(M/S)
      0.00        0.00     S
     20.00        0.00     S
     30.00        0.00     S
     32.50        4.09     S
     36.00        2.51     S
     40.00        2.54     S
    120.00        2.57     S
    121.00        0.35     S
    140.00        0.21     E
*    T(S)         TL
      0.00       484.15    S
     20.00       484.15    S
     30.00       482.95    S
     32.50       480.[illegible]    S
     36.00       4[illegible].95    S
     40.00       4[illegible].65    S
    120.00       477.15    S
    121.00       477.65    S
    140.00       481.15    E
*    T(S)         TV
      0.00       484.15    S
     20.00       484.15    S
     30.00       482.95    S
     32.50       480.15    S
     36.00       481.95    S
     40.00       481.65    S
    120.00       477.15    S
    121.00       477.65    S
    140.00       481.15    E
*    T            ALPHA
      0.00        1.0    S
     20.00        1.0    S
     30.00        1.0    S
     32.50        1.0    S
     36.00        1.0    S
     40.00        1.0    S
    120.00        1.0    S
    121.00        1.0    S
    140.00        1.0    E
*    T(S)          P(BAR)
      0.00        1.94E+01  S
     20.00        1.94E+01  S
     30.00        1.9E+01   S
     32.50        1.79E+01  S
     36.00        1.87E+01  S
     40.00        1.85E+01  S
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        120.00          1.69E+01  S
        121.00          1.71E+01  S
        140.00          1.84E+01  E
*       T(S)            PA(BAR)
         0.00           0.0     S
        20.00           0.0     S
        30.00           0.0     S
        32.50           0.0     S
        36.00           0.0     S
        40.00           0.0     S
       120.00           0.0     S
       121.00           0.0     S
       140.00           0.0     E
* COMPONENT NO.602 ***************************************************
*
FILL            602        602 BASE STEAM-WATER FILL CELL 2
*      JUN1        IFTY       IOFF                           C  2
        602         6          0
*      IFTR        IFSV       NFTB       NFSV      NFRF      C  3
        600        100         9          0         0
*    TWTOLD           RFMX       CONCIN                      C  4
        0.         100.        0.
*      DXIN        VOLIN      ALPIN      VLIN      TLIN      C  5
        .9          .52        1.0        0.       484.15
*      PIN         PAIN       FLOWIN     VVIN      TVIN      C  6
     19.4E+05       0.         0.         0.       484.15
*     VMSCL        VVSCL                              C  9
        1.0         1.0
*     TLSCL        TVSCL       PSCL      PASCL        CONSCL   C 10
        1.0         1.0      1.E+05       1.       1.0
*       T(S)        VLTB(M/S)
         0.00        0.0  S
        20.00        0.0  S
        30.00        0.0  S
        32.50        0.0  S
        36.00        0.0  S
        40.00        0.0  S
       120.00        0.0  S
       121.00        0.0  S
       140.00        0.0  E
*       T(S)        VVTB(M/S)
         0.00        0.00 S
        20.00        0.00 S
        30.00        0.00 S
        32.50        4.09 S
        36.00        2.51 S
        40.00        2.34 S
       120.00        2.57 S
       121.00        0.35 S
       140.00        0.21 E
*       T            TL
         0.00       484.15        S
        20.00       484.15        S
        30.00       482.95        S
        32.50       480.15        S
        36.00       481.95        S
        40.00       481.65        S
       120.00       477.15        S
       121.00       477.65        S
       140.00       481.15        E
*       T(S)         TV
         0.00       484.15        S
        20.00       484.15        S
        30.00       482.95        S
        32.50       480.15        S
        36.00       481.95        S
        40.00       481.65        S
       120.00       477.15        S
       121.00       477.65        S
       140.00       481.15        E
*       T            ALPHA
         0.00        1.0        S
        20.00        1.0        S
        30.00        1.0        S
        32.50        1.0        S
        36.00        1.0        S
        40.00        1.0        S
       120.00        1.0        S
       121.00        1.0        S
       140.00        1.0        E
*       T(S)         P(BAR)
         0.00        1.94E+01  S
        20.00        1.94E+01  S
        30.00        1.9E+01   S
        32.50        1.79E+01  S
        36.00        1.87E+01  S
        40.00        1.85E+01  S
       120.00        1.69E+01  S
       121.00        1.71E+01  S
       140.00        1.84E+01  E
*       T(S)         PA(BAR)
         0.00        0.0       S
        20.00        0.0       S
        30.00        0.0       S
        32.50        0.0       S
        36.00        0.0       S
        40.00        0.0       S
       120.00        0.0       S
       121.00        0.0       S
```

```
*       140.00          0.0     E
* COMPONENT NO.603 ************************************************************
FILL            603         603 BASE STEAM-WATER FILL CELL 3
*       JUN1        IFTY        IOFF                        C 2
        603         6           0
*       IFTR        IFSV        NFTB        NFSV        NFRF        C 3
        600         100         9           0           0
*       TWTOLD      RFMX        CONCIN                              C 4
        0.          100.        0.
*       DXIN        VOLIN       ALPIN       VLIN        TLIN        C 5
        .9          .52         1.0         0.          484.15
*       PIN         PAIN        FLOWIN      VVIN        TVIN        C 6
        19.4E+05    0.          0.          0.          484.15
*       VMSCL       VVSCL                                           C 9
        1.0         1.0
*       TLSCL       TVSCL       PSCL        PASCL       CONSCL      C 10
        1.0         1.0         1.E+05      1.          1.0
*       T(S)        VLTB(M/S)
        0.00        0.0 S
        20.00       0.0 S
        30.00       0.0 S
        32.50       0.0 S
        36.00       0.0 S
        40.00       0.0 S
        120.00      0.0 S
        121.00      0.0 S
        140.00      0.0 E
*       T(S)        VVTS(M/S)
        0.00        0.00 S
        20.00       0.00 S
        30.00       0.00 S
        32.50       4.09 S
        36.00       2.51 S
        40.00       2.34 S
        120.00      2.57 S
        121.00      [illegible].35 S
        140.00      0.21 E
*       T           TL
        0.00        484.15      S
        20.00       484.15      S
        30.00       482.95      S
        32.50       480.15      S
        36.00       481.95      S
        40.00       481.65      S
        120.00      477.15      S
        121.00      477.65      S
        140.00      481.15      E
*       T(S)        TV
        0.00        484.15      S
        20.00       484.15      S
        30.00       482.95      S
        32.50       480.15      S
        36.00       481.95      S
        40.00       481.65      S
        120.00      477.15      S
        121.00      477.65      S
        140.00      481.15      E
*       T           ALPHA
        0.00        1.0     S
        20.00       1.0     S
        30.00       1.0     S
        32.50       1.0     S
        36.00       1.0     S
        40.00       1.0     S
        120.00      1.0     S
        121.00      1.0     S
        140.00      1.0     E
*       T(S)        P(BAR)
        0.00        1.94E+01  S
        20.00       1.94E+01  S
        30.00       1.9E+01   S
        32.50       1.79E+01  S
        36.00       1.87E+01  S
        40.00       1.85E+01  S
        120.00      1.69E+01  S
        121.00      1.71E+01  S
        140.00      1.84E+01  E
*       T(S)        PA(BAR)
        0.00        0.0     S
        20.00       0.0     S
        30.00       0.0     S
        32.50       0.0     S
        36.00       0.0     S
        40.00       0.0     S
        120.00      0.0     S
        121.00      0.0     S
        140.00      0.0     E
* COMPONENT NO.604 ************************************************************
FILL            604         604 BASE STEAM-WATER FILL CELL 4
*       JUN1        IFTY        IOFF                        C 2
        604         6           0
*       IFTR        IFSV        NFTB        NFSV        NFRF        C 3
        600         100         9           0           0
*       TWTOLD      RFMX        CONCIN                              C 4
        0.          100.        0.
```

```
*     DXIN       VOLIN      ALPIN      VLIN        TLIN     C 5
      9        .53       1.0       0.       484.15
*     PIN        PAIN      FLOWIN      VVIN        TVIN     C 6
  19.4E+05      0.       0.        0.       484.15
*    VMSCL       VVSCL                              C 9
     1.0        1.0
*    TLSCL       TVSCL      PSCL      PASCL        CONSCL   C 10
     1.0        1.0     1.E+05     1.      1.0
*    T(S)        VLTB(M/S)
*
      0.00       0.0 S
     20.00       0.0 S
     30.00       0.0 S
     32.50       0.0 S
     36.00       0.0 S
     40.00       0.0 S
    120.00       0.0 S
    121.00       0.0 S
    140.00       0.0 E
*    T(S)        VVTB(M/S)
      0.00       0.00 S
     20.00       0.00 S
     30.00       0.00 S
     32.50       4.09 S
     36.00       2.51 S
     40.00       2.54 S
    120.00       2.57 S
    121.00       0.35 S
    140.00       0.21 E
*     T           TL
      0.00      484.15    S
     20.00      484.15    S
     30.00      482.95    S
     32.50      480.15    S
     36.00      481.95    S
     40.00      481.65    S
    120.00      477.15    S
    121.00      477.65    S
    140.00      481.15    E
*    T(S)         TV
      0.00      484.15    S
     20.00      484.15    S
     30.00      482.95    S
     32.50      480.15    S
     36.00      481.95    S
     40.00      481.65    S
    120.00      477.15    S
    121.00      477.65    S
    140.00      481.15    E
*     T           ALPHA
      0.00       1.0    S
     20.00       1.0    S
     30.00       1.0    S
     32.50       1.0    S
     36.00       1.0    S
     40.00       1.0    S
    120.00       1.0    S
    121.00       1.0    S
    140.00       1.0    E
*    T(S)         P(BAR)
      0.00      1.94E+01  S
     20.00      1.94E+01  S
     30.00      1.9[illegible]E+01  S
     32.50      1.79E+01  S
     36.00      1.87E+01  S
     40.00      1.85E+01  S
    120.00      1.69E+01  S
    121.00      1.71E+01  S
    140.00      1.84E+01  E
*    T(S)         PA(BAR)
      0.00       0.0    S
     20.00       0.0    S
     30.00       0.0    S
     32.50       0.0    S
     36.00       0.0    S
     40.00       0.0    S
    120.00       0.0    S
    121.00       0.0    S
    140.00       0.0    E
* COMPONENT NO.605 ***************************************************
*
FILL           605        605 BASE STEAM-WATER FILL CELL 5
*     JUN1       IFTY       IOFF                         C 2
      605        6          0
*     IFTR       IFSV       NFTB       NFSV       NFRF     C 3
      600        100        9          0          0
*    TWTOLD      RFMX       CONCIN                       C 4
      0          100     0.
*     DXIN       VOLIN      ALPIN      VLIN        TLIN     C 5
      9       .719356     1.0       0.       484.15
*     PIN        PAIN      FLOWIN      VVIN        TVIN     C 6
  19.4E+05      0         0.        0.       484.15
*    VLSCL       VVSCL                              C 9
     1.0        0.725
*    TLSCL       TVSCL      PSCL      PASCL        CONSCL   C 10
     1.0        1.0     1.E+05     1.      1.0
*    T(S)        VLTB(M/S)
*
      0.00       0.0 S
```

```
     20.00        0.0 S
     30.00        0.0 S
     32.50        0.0 S
     36.00        0.0 S
     40.00        0.0 S
    120.00        0.0 S
    121.00        0.0 S
    140.00        0.0 E
*    T(S)         VVTB(M/S)
      0.00        0.00 S
     20.00        0.00 S
     30.00        0.00 S
     32.50        4.09 S
     36.00        2.51 S
     40.00        2.34 S
    120.00        2.57 S
    121.00        0.35 S
    140.00        0.21 E
*    T            TL
      0.00        484.15    S
     20.00        484.15    S
     30.00        482.95    S
     32.50        480.15    S
     36.00        481.95    S
     40.00        481.65    S
    120.00        477.15    S
    121.00        477.65    S
    140.00        481.15    E
*    T(S)         TV
      0.00        484.15    S
     20.00        484.15    S
     30.00        482.95    S
     32.50        480.15    S
     36.00        481.95    S
     40.00        481.65    S
    120.00        477.15    S
    121.00        477.65    S
    140.00        481.15    E
*    T            ALPHA
      0.00        1.0    S
     20.00        1.0    S
     30.00        1.0    S
     32.50        1.0    S
     36.00        1.0    S
     40.00        1.0    S
    120.00        1.0    S
    121.00        1.0    S
    140.00        1.0    E
*    T(S)         P(BAR)
      0.00        1.94E+01  S
     20.00        1.94E+01  S
     30.00        1.9E+01   S
     32.50        1.79E+01  S
     36.00        1.87E+01  S
     40.00        1.85E+01  S
    120.00        1.69E+01  S
    121.00        1.71E+01  S
    140.00        1.84E+01  E
*    T(S)         PA(BAR)
      0.00        0.0    S
     20.00        0.0    S
     30.00        0.0    S
     32.50        0.0    S
     36.00        0.0    S
     40.00        0.0    S
    120.00        0.0    S
    121.00        0.0    S
    140.00        0.0    E
* COMPONENT NO.606 ****************************************************
*
FILL          606        606 BASE STEAM-WATER FILL CELL 6
*   JUN1      IFTY       IOFF                              C 2
    606       6          0
*   IFTR      IFSV       NFTB      NFSV      NFRF          C 3
    600       100        9         0         0
*   TWTOLD    RFMX       CONCIN                            C 4
    0.        100.       0.
*   DXIN      VOLIN      ALPIN     VLIN      TLIN          C 5
    .9        .719356    1.0       0.        484.15
*   PIN       PAIN       FLOWIN    VVIN      TVIN          C 6
    19.4E+05  0.         0.        0.        484.15
*   VLSCL     VVSCL                                        C 9
    1.0       0.725
*   TLSCL     TVSCL      PSCL      PASCL     CONSCL        C 10
    1.0       1.0        1.E+05    1.        1.0
*   T(S)      VLTB(M/S)
*
      0.00        0.0 S
     20.00        0.0 S
     30.00        0.0 S
     32.50        0.0 S
     36.00        0.0 S
     40.00        0.0 S
    120.00        0.0 S
    121.00        0.0 S
    140.00        0.0 E
*    T(S)         VVTB(M/S)
      0.00        0.00 S
     20.00        0.00 S
```

```
       30.00         0.00 S
       32.50         4.09 S
       36.00         2.51 S
       40.[illegible]         2.34 S
      120.00         2.57 S
      121.00         0.35 S
      140.00         0.21 E
*      T            TL
        0.00       484.15      S
       20.00       484.15      S
       30.00       482.95      S
       32.50       480.15      S
       36.00       481.95      S
       40.00       481.65      S
      120.00       477.15      S
      121.00       477.65      S
      140.00       481.15      E
*      T(S)         TV
        0.00       484.15      S
       20.00       484.15      S
       30.00       482.95      S
       32.50       480.15      S
       36.00       481.95      S
       40.00       481.65      S
      120.00       477.15      S
      121.00       477.65      S
      140.00       481.15      E
*      T            ALPHA
        0.00        1.0     S
       20.00        1.0     S
       30.00        1.0     S
       32.50        1.0     S
       36.00        1.0     S
       40.00        1.0     S
      120.00        1.0     S
      121.00        1.0     S
      140.00        1.0     E
*      T(S)         P(BAR)
        0.00        1.94E+01  S
       20.00        1.94E+01  S
       30.00        1.9E+01  S
       32.50        1.79E+01  S
       36.00        1.87E+01  S
       40.00        1.85E+01  S
      120.00        1.69E+01  S
      121.00        1.71E [illegible]01  S
      140.00        1.84E+01  E
*      T(S)         PA(BAR)
        0.00        0.0     S
       20.00        0.0     S
       30.00        0.0     S
       32.50        0.0     S
       36.00        0.0     S
       40.00        0.0     S
      120.00        0.0     S
      121.00        0.0     S
      140.00        0.0     E
* COMPONENT NO.607 ************************************************************
*
FILL             607        607  BASE STEAM-WATER FILL CELL 7
*      JUN1        IFTY        IOFF                       C  2
       607         6           0
*      IFTR        IFSV        NFTB        NFSV      NFRF    C  3
       600         100         9          0         0
*    TWTOLD          RFMX        CONCIN                      C  4
       0.          100.          0.
*      DXIN        [illegible]LIN       ALPIN       VLIN       TLIN    C  5
       .9         .71[illegible]6        1.0        0.   484.15
*      PIN         PAIN        FLOWIN      VVIN       TVIN    C  6
   19.4E+05        0.          0.          0.        484.15
*      VLSCL       VVSCL                           C  9
       1.0         0.725
*      TLSCL       TVSCL       PSCL        PASCL      CONSCL    C 10
       1.0         1.0     1.E+05      1.        1.0
*      T(S)        VLTB(M/S)
*
*
        0.00        0.0  S
       20.00        0.0  S
       30.00        0.0  S
       32.50        0.0  S
       36.00        0.0  S
       40.00        0.0  S
      120.00        0.0  S
      121.00        0.0  S
      140.00        0.0  E
*      T(S)        VVTB(M/S)
        0.00        0.00 S
       20.00        0.00 S
       30.00        0.00 S
       32.50        4.09 S
       36.00        2.51 S
       40.00        2.34 S
      120.00        2.57 S
      121.00        0.35 S
      14[illegible]        0.21 E
*      T            TL
        0.00       484.15      S
       20.00       484.15      S
       30.00       482.95      S
```

```
     32.50      480.15     S
     36.00      481.95     S
     40.00      481.65     S
    120.00      477.15     S
    121.00      477.65     S
    140.00      481.15     E
*    T(S)        TV
      0.00      484.15     S
     20.00      484.15     S
     30.00      482.95     S
     32.50      480.15     S
     36.00      481.95     S
     40.00      481.65     S
    120.00      477.15     S
    121.00      477.65     S
    140.00      481.15     E
*    T           ALPHA
      0.00      1.0        S
     20.00      1.0        S
     30.00      1.0        S
     32.50      1.0        S
     36.00      1.0        S
     40.00      1.0        S
    120.00      1.0        S
    121.00      1.0        S
    140.00      1.0        E
*    T(S)        P(BAR)
      0.00      1.94E+01   S
     20.00      1.94E+01   S
     30.00      1.9E+01    S
     32.50      1.79E+01   S
     36.00      1.87E+01   S
     40.00      1.85E+01   S
    120.00      1.69E+01   S
    121.00      1.71E+01   S
    140.00      1.84E+01   E
*    T(S)        PA(BAR)
      0.00      0.0        S
     20.00      0.0        S
     30.00      0.0        S
     32.50      0.0        S
     36.00      0.0        S
     40.00      0.0        S
    120.00      0.0        S
    121.00      0.0        S
    140.00      0.0        E
* COMPONENT NO.608 ***************************************************
*
FILL            608        608  BASE STEAM-WATER FILL CELL 8
*    JUN1       IFTY       IOFF                          C  2
     608        6          0
*    IFTR       IFSV       NFTB       NFSV       NFRF    C  3
     600        100        9          0          0
*    TWTOLD     RFMX       CONCIN                        C  4
     0.         100.       0.
*    DXIN       VOLIN      ALPIN      VLIN       TLIN    C  5
     .9         .719356    1.0        0.         484.15
*    PIN        PAIN       FLOWIN     VVIN       TVIN    C  6
     19.4E+05   0.         0.         0.         484.15
*    VLSCL      VVSCL                                    C  9
     1.0        0.725
*    TLSCL      TVSCL      PSCL       PASCL      CONSCL  C 10
     1.0        1.0        1.E+05     1.         1.0
*    T(S)       VLTB(M/S)
*
      0.00      0.0  S
     20.00      0.0  S
     30.00      0.0  S
     32.50      0.0  S
     36.00      0.0  S
     40.00      0.0  S
    120.00      0.0  S
    121.00      0.0  S
    140.00      0.0  E
*    T(S)       VVTB(M/S)
      0.00      0.00 S
     20.00      0.00 S
     30.00      0.00 S
     32.50      4.09 S
     36.00      2.51 S
     40.00      2.34 S
    120.00      2.57 S
    121.00      0.35 S
    140.00      0.21 E
*    T          TL
      0.00      484.15     S
     20.00      484.15     S
     30.00      482.95     S
     32.50      480.15     S
     36.00      481.95     S
     40.00      481.65     S
    120.00      477.15     S
    121.00      477.65     S
    140.00      481.15     E
*    T(S)       TV
      0.00      484.15     S
     20.00      484.15     S
     30.00      482.95     S
     32.50      480.15     S
```

```
      36.00       481.95    S
      40.00       481.65    S
     120.00       477.15    S
     121.00       477.65    S
     140.00       481.15    E
*     T             ALPHA
       0.00        1.0    S
      20.00        1.0    S
      30.00        1.0    S
      32.50        1.0    S
      36.00        1.0    S
      40.00        1.0    S
     120.00        1.0    S
     121.00        1.0    S
     140.00        1.0    E
*     T(S)          P(BAR)
       0.00      1.94E+01  S
      20.00      1.94E+01  S
      30.00      1.9E+C1   S
      32.50      1.79E+01  S
      36.00      1.87E+01  S
      40.00      1.85E+01  S
     120.00      1.69E+01  S
     121.00      1.71E+01  S
     140.00      1.84E+01  E
*     T(S)          PA(BAR)
       0.00        0.0    S
      20.00        0.0    S
      30.00        0.0    S
      32.50        0.0    S
      36.00        0.0    S
      40.00        0.0    S
     120.00        0.0    S
     121.00        0.0    S
     140.00        0.0    E
**************************** L O O P  1 ******************************
* COMPONENT NO. 10 ***************************************************
* HOT LEG LOOP 1 *****************************************************
*
TEE              10          10        HOT-LEG LOOP 1
*     JCELL         NODES         MAT          COST        ICHF      C 2
       4            4        6     -1.          1
*     ICONC1        NCELL1        JUN1         JUN2        IPOW1     C 3
       0            9        10    11           0
*     IQPTR1        IQPSV1        NQPTB1       NQPSV1      NQPRF1    C 5
       0            0        0     0            0
*     RADIN1        TH1           HOUTL1       HOUTV1      TOUTL1    C 6
      .375          .01      0.    0.           300.
*     TOUTV1        PWIN1         PWOFF1       RPWMX1      PWSCL1    C 7
      300.          0.       0.    0.           0.
*     QPIN1         QPOFF1        RQPMX1       QPSCL1                C 8
       0.           0.       0.    0.
*     ICONC2        NCELL2        JUN3         IPOW2                 C 9
       0            1        15    0
*     IQPTR2        IQPSV2        NQPTB2       NQPSV2      NQPRF2    C 11
       0            0        0     0            0
*     RADIN2        TH2           HOUTL2       HOUTV2      TOUTL2    C 12
      .11           .01      0.    0.           300.
*     TOUTV2        PWIN2         PWOFF2       RPWMX2      PWSCL2    C 13
      300.          0.       0.    0.           0.
*     QPIN2         QPOFF2        RQPMX2       QPSCL2                C 14
       0.           0.       0.    0.
* PRIMARY *
R 3   .5107 R 3   1.2867      1.337     1.0420      .6260 E*   DX
R 3   .2256 R 3   0.5113      .5907     .4603       .2766 E*   VOL
R 3   .44179 R 3   .3974 R 4   .44179 E                  *     FA
R 2      .0 R 6   0.016 R 2    0.0 E                    *   FRIC
R 2      0. R 6    .016 R 2    0. E                     * RVFRIC
R 7    0.0        0.1802      0.5612    0.6803 E         *   GRAV
R 3     .75 R 3   .6388 F       .75 E                   *    HD
R 4      0          1 F        0 E                      *  ICFLG
R 1      0 F        1 E                                 *    NFF
F        1. E                                          *  ALP
F        0. E                                          *  VL
F        0. E                                          *  VV
F    418.95 E                                           *    TL
F    418.95 E                                           *    TV
F  2.60E+05 E                                           *     P
F        0. E                                          *  PA
F        0. E                                          *  QPPP
F        6 E                                           * MATID
F    418.95 E                                           *    TW
* SECONDARY *
F       10. E                                          *   DX
F    .40660 E                                           *   VOL
F    .04066 E                                           *    FA
F       0.0 E                                          *  FRIC
F        0. E                                          * RVFRIC
F       0.0 E                                           *  GRAV
F   .2 77 E                                             *   HL
F        0 E                                           * ICFLG
F        1 E                                           *   NFF
F       0.0 E                                           *   ALP
F        0. E                                          *   VL
F        0. E                                          *   VV
F    418.95 E                                           *    TL
F    418.95 E                                            *    TV
F  2.60E+05 E                                            *     P
F        0. E                                          *   PA
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F        0. E                                        * QPPP
F        6 E                                         * MATID
F   418.95 E                                          * TW
* COMPONENT NO. 11 ***********************************************
* SEPARATOR BOTTOM LOOP 1 ******************************************
*
* TEE              11        11    SEPARATOR-BOTTOM LOOP 1
      JCELL        NODES        MAT        COST        ICHF     C 2
        1            4      6      0.0        1
*     ICONC1       NCELL1       JUN1       JUN2        IPOW1    C 3
        0            4      11      12         0
*     IQPTR1       IQPSV1       NQPTB1     NQPSV1      NQPRF1   C 5
        0            0      0       0          0
*     RADIN1       TH1          HOUTL1     HOUTV1      TOUTL1   C 6
        1.25        .025    0.      0.         300.
*     TOUTV1       PWIN1        PWOFF1     RPWMX1      PWSCL1   C 7
        300.         0.     0.      0.         0.
*     QPIN1        QPOFF1       RQPMX1     QPSCL1               C 8
        0.           0.     0.      0.
*     ICONC2       NCELL2       JUN3       IPOW2                C 9
        0            1      18      0
*     IQPTR2       IQPSV2       NQPTB2     NQPSV2      NQPRF2   C 11
        0            0      0       0          0
*     RADIN2       TH2          HOUTL2     HOUTV2      TOUTL2   C 12
        1.25        .025    0.      0.         300.
*     TOUTV2       PWIN2        PWOFF2     RPWMX2      PWSCL2   C 13
        300.         0.     0.      0.         0.
*     QPIN2        QPOFF2       RQPMX2     QPSCL2               C 14
        0.           0.     0.      0.
* PRIMARY *
      .95560        .3251      .3251       .424 E          * DX
        2.597       1.5266     1.5253      .2587 E          * VOL
     0.44179        4.5584     4.7298 R 2  0.6101 E          * FA
R 4     0.          .3621 E                              * FRIC
R 4     0.0         .9053 E                              * RVFRI
      0.6803 F       1.0 E                               * GRAV
        0.75 R 2    2.30 R 2   .1583 E                    * HD
F          0 E                                       * ICFLG
F          1 E                                       * NFF
F          1. E                                      * ALP
F          0. E                                      * VL
F          0. E                                      * VV
F     418.95 E                                        * TL
F     418.95 E                                        * TV
F   2.60E+05 E                                        * P
F          0. E                                      * PA
F          0. E                                      * QPPP
F          6 E                                       * MATID
F     418.95 E                                        * TW
* SECONDARY *
      0.2000 E                                       * DX
      0.0107 E                                       * VOL
     0.05326 E                                       * FA
F        0.0 E                                       * FRIC
F         0. E                                       * RVFRIC
          0.        -.4220 E                         * GRAV
F     0.2604 E                                       * HD
F          0 E                                       * ICFLG
F          1 E                                       * NFF
F          1. E                                      * ALP
F          0. E                                      * VL
F          0. E                                      * VV
F     418.95 E                                        * TL
F     418.95 E                                        * TV
F   2.60E+05 E                                        * P
F          0. E                                      * PA
F          0. E                                      * QPPP
F          6 E                                       * MATID
F     418.95 E                                        * TW
*
* COMPONENT NO. 12 ***********************************************
* SEPARATOR MIDDLE LOOP 1 ******************************************
*
* TEE              12        12    SEPARATOR-MIDDLE LOOP 1
      JCELL        NODES        MAT        COST        ICHF     C 2
        4            4      6      1.0        1
*     ICONC1       NCELL1       JUN1       JUN2        IPOW1    C 3
        0            4      12      13         0
*     IQPTR1       IQPSV1       NQPTB1     NQPSV1      NQPRF1   C 5
        0            0      0       0          0
*     RADIN1       TH1          HOUTL1     HOUTV1      TOUTL1   C 6
        1.25        .025    0.      0.         300.
*     TOUTV1       PWIN1        PWOFF1     RPWMX1      PWSCL1   C 7
        300.         0.     0.      0.         0.
*     QPIN1        QPOFF1       RQPMX1     QPSCL1               C 8
        0.           0.     0.      0.
*     ICONC2       NCELL2       JUN3       IPOW2                C 9
        0            4      19      0
*     IQPTR2       IQPSV2       NQPTB2     NQPSV2      NQPRF2   C 11
        0            0      0       0          0
*     RADIN2       TH2          HOUTL2     HOUTV2      TOUTL2   C 12
        1.25        .025    0.      0.         300.
*     TOUTV2       PWIN2        PWOFF2     RPWMX2      PWSCL2   C 13
        300.         0.     0.      0.         0
*     QPIN2        QPOFF2       RQPMX2     QPSCL2               C 14
        0.           0.     0.      0
* PRIMARY *
        .188        0.710      0.710        .2 E          * DX
```

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      .1574      0.7558      0.7558      0.2129 E          *  VOL
     0.6101      1.0645      1.0645 R 2  1.0645 E           *  FA
      .3621 R 3      0.      1.E30  E                    *  FRIC
      .9053 R 4      0. E                               *  RVFRI
F      1.0 E                                           *  GRAV
      .15830 F   0.2091 E                                 *
F        0 E                                           *  ICFLG
F        1 E                                           *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F    418.95 E                                           *  TL
F    418.95 E                                           *  TV
F  2.60E+05 E                                          *   P
F       0. E                                           *  PA
F       0. E                                           *  QPPP
F        6 E                                           *  MATID
F    418.95 E                                           *  TW
* SECONDARY *
     0.7100        .710        .188        .424 E          *  DX
     2.4617      2.4617      0.7057      1.7130 E          *  VOL
R 3  3.4673   R 2  4.0401 E                              *  FA
F      0.0 E                                           *  FRIC
F       0. E                                           *  RVFRIC
F     -1.0 E                                           *  GRAV
F     0.44 E                                           *  HD
F        0 E                                           *  ICFLG
F        1 E                                           *  NFF
R 3      1.      1.00 E                                *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
     418.95  F   418.95 E                               *  TL
     418.95  F   418.95 E                               *  TV
F  2.60E+05 E                                          *   P
F       0. E                                           *  PA
F       0. E                                           *  QPPP
F        6 E                                           *  MATID
F    418.95 E                                           *  TW
*
* COMPONENT NO. 13 ****************************************************
* SEPARATOR TOP LOOP 1 ************************************************
*
TEE              13        13    SEPARATOR-TOP LOOP 1
*     JCELL       NODES       MAT        COST        ICHF      C  2
        3           4         6   0.0      1
*     ICONC1      NCELL1      JUN1       JUN2        IPOW1     C  3
        0           4        13    14       0
*     IQPTR1      IQPSV1      NQPTB1     NQPSV1      NQPRF1    C  5
        0           0         0     0       0
*     RADIN1      TH1         HOUTL1     HOUTV1      TOUTL1    C  6
       1.25       .025        0.    0.     300.
*     TOUTV1      PWIN1       PWOFF1     RPWMX1      PWSCL1    C  7
       300.        0.         0.    0.      0.
*     QPIN1       QPOFF1      RQPMX1     QPSCL1                C  8
        0.         0.         0.    0.
*     ICONC2      NCELL2      JUN3       IPOW2                 C  9
        0           1       115     0
*     IQPTR2      IQPSV2      NQPTB2     NQPSV2      NQPRF2    C 1:
        0           0         0     0       0
*     RADIN2      TH2         HOUTL2     HOUTV2      TOUTL2    C 12
       1.25       .025        0.    0.     300.
*     TOUTV2      PWIN2       PWOFF2     RPWMX3      PWSCL2    C 13
       300.        0.         0.    0.      0.
*     QPIN2       QPOFF2      RQPMX2     QPSCL2                C 14
        0.         0.         0.    0.
* PRIMARY *
        0.2       .285        0.4      0.810 E             *  DX
     0.2129     1.5732     1.8919     3.0974 E             *  VOL
R 2  1.0645 R 2  4.7298    0.44179 E                      *  FA
      1.E30 F     0.0 E                                 *  FRIC
F       0. E                                           *  RVFRIC
F      1.0 E                                           *  GRAV
R 2  0.2091 R 2  2.454        0.75 E                     *  HD
F        0 E                                           *  ICFLG
F        1 E                                           *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F    418.95 E                                           *  TL
F    418.95 E                                           *  TV
F  2.60E+05 E                                          *   P
F       0. E                                           *  PA
F       0. E                                           *  QPPP
F        6 E                                           *  MATID
F    418.95 E                                           *  TW
* SECONDARY *
F      1.0 E                                           *  DX
F     .126 E                                           *  VOL
F     .126 E                                           *  FA
F      0.0 E                                           *  FRIC
F       0. E                                           *  RVFRIC
F      0.0 E                                           *  GRAV
F       .4 E                                           *  HD
F        0 E                                           *  ICFLG
F        1 E                                           *  NFF
F       1. E                                           *  ALP
F       0. E                                           *  VL
F       0. E                                           *  VV
F    418.95 E                                           *  TL
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F      418.95 E                                        *  TV
F   2.60E+05 E                                          *  P
F         0. E                                       *  PA
F         0. E                                       *  QPPP
F          6 E                                       * MATID
F      418.95 E                                       *   TW
*
* COMPONENT NO. 14 ***************************************************
* LOOP SEAL AND COLD LEG LOOP 1 ****************************************
*
TEE            14        14  LOOP-SEAL COLD-LEG LOOP 1
*    JCELL        NODES         MAT         COST         ICHF      C  2
      17           4        6        .5          1
*    ICONC1       NCELL1        JUN1        JUN2        IPOW1      C  3
      0           21       14        17          0
*    IQPTR1       IQPSV1       NQPTB1       NQPSV1       NQPRF1     C  5
      0            0        0         0          0
*    RADIN1        TH1         HOUTL1       HOUTV1       TOUTL1     C  6
     .375         .01       0.        0.         300.
*    TOUTV1        PWIN1       PWOFF1       RPWMX1       PWSCL1     C  7
     300.          0        0.        0.          0.
*    QPIN1        QPOFF1       RQPMX1       QPSCL1                  C  8
      0.           0.       0.        0.
*    ICONC2       NCELL2        JUN3        IPOW2                   C  9
      0            1       160        0
*    IQPTR2       IQPSV2       NQPTB2       NQPSV2       NQPRF2     C 11
      0            0        0         0          0
*    RADIN2        TH2         HOUTL2       HOUTV2       TOUTL2     C 12
     .11          .01       0.        0.         300.
*    TOUTV2        PWIN2       PWOFF2       RPWMX2       PWSCL2     C 13
     300.          0        0.        0.          0.
*    QPIN2        QPOFF2       RQPMX2       QPSCL2                  C 14
      0.           0.       0.        0.
* PRIMARY *
        1.2 R 2    1.9125        1.2 R 3    2.317       1.514 *    DX
R 2    1.665 R 3    1.092          .658                            *  DX
        .600 R 2    1.495        1.5050      1.9110  R 2  1.6825 *    DX
       0.710 E                                                   *  DX
       .5301 R 2    .8449         .5301 R 3   1.0236      .6689 *    VOL
R 2    .7356 R 2    .4824          .7200       .9480 S             *  VOL
R 2  0.66048   0.66489   0.40247 R 2  0.74331   0.38058 E       *     VOL
R 12  .44179      .00000         .6892 R 7    .44179       .6362 E*     FA
        0. R 11     .019        10.76 R 8     .008        .0205 E*  FRIC
        0. R 11     .019         7.75 R 8     .008        .0205 E*  RVFRIC
        1.0        .2313          0.0     -.2313 R 4      -1.0 F*   GRAV
      -.49350       0.0         .7978        1.0          .572 *   GRAV
      -.7752       .1411 R 7      0.0 E                        *   GRAV
R 21     .75        0.90 E                                     *  HD
R 12      0           1 F          0 E                         * ICFLAG
F          1 E                                                 *  NFF
R07       1.    1.0    1.0    1.    1.0  S                     *   ALP
R10             1.0     E
F        0.0 E                                                 *   VL
F        0.0 E                                                 *   VV
F     411.18 E                                                  *   TL
F     411.18 E                                                  *   TV
F   2.60E+05 E                                                  *   P
F        0.0 E                                                 *  PA
F        0.0 E                                                 *  QPPP
F          6 E                                                 * MATID
F     411.18 E                                                  *   TW
* SECONDARY *
F      0.050 E                                                  *  DX
F      0.019 E                                                  *  VOL
F  3.8010E-02 E                                                  *   FA
F         0. E                                                 *  FRIC
F         0. E                                                 * RVFRIC
F        +1. E                                                  *  GRAV
F  2.2000E-01 E                                                  *   HD
F          0 E                                                 * ICFLG
F          1 E                                                 *  NFF
F         1. E                                                 *  ALP
F         0. E                                                 *  VL
F         0. E                                                 *  VV
F     411.18 E                                                  *   TL
F     411.18 E                                                  *   TV
F   2.60E+05 E                                                  *   P
F         0. E                                                 *  PA
F         0. E                                                 *  QPPP
F          6 E                                                 * MATID
F     411.18 E                                                  *   TW
* COMPONENT NO. 18 ***************************************************
* SEPARATOR DRAIN TEE LOOP 1 *******************************************
*
TEE            18        18     SEP. DRAIN TEE LOOP 1
*    JCELL        NODES         MAT         COST         ICHF      C  2
      5            4        6       0.0          1
*    ICONC1       NCELL1        JUN1        JUN2        IPOW1      C  3
      0            6       19       119          0
*    IQPTR1       IQPSV1       NQPTB1       NQPSV1       NQPRF1     C  5
      0            0        0         0          0
*    RADIN1        TH1         HOUTL1       HOUTV1       TOUTL1     C  6
     0.1         .025       0.        0.         300.
*    TOUTV1        PWIN1       PWOFF1       RPWMX1       PWSCL1     C  7
     300.          0        0.        0.          0.
*    QPIN1        QPOFF1       RQPMX1       QPSCL1                  C  8
      0.           0.       0.        0.
*    ICONC2       NCELL2        JUN3        IPOW2                   C  9
      0            1       130        0
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*      IQPTR2      IQPSV2     NQPTB2      NQPSV2      NQPRF2     C 11
          0           0      0      0          0
*      RADIN2         TH2      HOUTL2      HOUTV2      TOUTL2     C 12
         0.1        .025       0.      0.     300.
*      TOUTV2      PWIN2      PWOFF2      RPWMX2      PWSCL2     C 13
         300.        0.     0.      0.         0.
*      QPIN2       QPOFF2     RQPMX2      QPSCL2                 C 14
          0.          0.     0.      0.
* PRIMARY *
         0.9 R 2    0.925 R 3   0.4913 E                     *   DX
      0.0283 R 2    0.029 R 3   0.0964 E                     *   VOL
      4.0401 R 2   0.0314 R 4   0.1963 E                     *   FA
F         0. E                                               *   FRIC
F         0. E                                               *   RVFRIC
        -1.0     -0.3364        0.      -0.3470 R 3    -1.0 E*   GRAV
        0.44 R 2     0.2 F      0.5 E                        *   HD
F          0 E                                               *   ICFLG
F          1 E                                               *   NFF
R05       1. R01        1.0 E                                *   ALP
F         0. E                                               *   VL
F         0. E                                               *   VV
R 5   418.95         308.15E                                 *   TL
R05   418.95         308.15E                                 *   TV
F   2.60E+05 E                                               *   P
F         0. E                                               *   PA
F         0. E                                               *   QPPP
F          6 E                                               *   MATID
  R 20 418.95  F 308.15 E                                    *   TW
* SECONDARY *
F        0.5 E                                               *   DX
F     0.0266 E                                               *   VOL
F    0.05326 E                                               *   FA
F        0.0 E                                               *   FRIC
F         0. E                                               *   RVFRIC
F        0.0 E                                               *   GRAV
F     0.2604 E                                               *   HD
F          0 E                                               *   ICFLG
F          1 E                                               *   NFF
F         0. E                                               *   ALP
F         0. E                                               *   VL
F         0. E                                               *   VV
F     418.95 E                                               *   TL
F     418.95 E                                               *   TV
F   2.60E+05 E                                               *   P
F         0. E                                               *   PA
F         0. E                                               *   QPPP
F          6 E                                               *   MATID
F     418.95 E                                               *   TW
*
* COMPONENT NO. 19 ***********************************************************
* SEPARATOR DRAIN VALVE LOOP 1 ***********************************************
*
VALVE            19           19   SEPARATOR DRAIN VALVE
*      NCELLS       NODES       JUN1        JUN2        MAT
            2           4     130    18           6
*      ICHF         ICONC      IVTY        IVPS        NVTB2
            1           0      1      3           0
*      IVTR         IVSV       NVTB1       NVSV        NVRF
            1         100      2      0           0
*      IQP3TR       IQP3SV     NQP3TB      NQP3SV      NQP3RF
            0           0      0      0           0
*      IVTROV       IVTYOV
            0           0
*      RVMX         RVOV       FMINOV      FMAXOV
         1.E10          0.     0.     1.
*      RADIN          TH       HOUTL       HOUTV       TOUTL
         .015        .005      0.      0.       300.
*      TOUTV        AVLVE      HVLVE       FAVLVE      XPOS
         300.       .03140     .20     1.          0.
*      QP3IN        QP3OFF     RQP3MX      QP3SCL
           0.          0.     0.      0.
          0.5         1.0 E                                  *   DX
       0.0266     0.05326 E                                  *   VOL
F     0.05326 E                                              *   FA
           0.       1.944 F      0. E                        *   FRIC
           0.       1.944 F      0. E                        *   RVFRIC
R 2        0.       .4220 E                                  *   GRAV
F      0.2604 E                                              *   HD
F           0 E                                              *   ICFLG
F           1 E                                              *   NFF
           1.          1. E                                  *   ALP
F          0. E                                              *   VL
F          0. E                                              *   VV
F      418.95 E                                              *   TL
F      418.95 E                                              *   TV
F    2.60E+05 E                                              *   P
F          0. E                                              *   PA
F          0. E                                              *   QPPP
F           6 E                                              *   MATID
F      418.95 E                                              *   TW
*
*        T(S)      POS(-)
           0.        1. S                                    *   VTB1
        300.0        1. E                                    *   VTB1
*
*
* COMPONENT NO.113 ***********************************************************
* STEAM SUPPLY FILL LOOP 1 ***************************************************
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FILL            113         113     STEAM SUPPLY LOOP 1
*     JUN1          IFTY         IOFF                          C  2
      113           5           0
*     IFTR          IFSV         NFTB        NFSV        NFRF      C  3
        0         -901         0           0           0
*    TWTOLD          RFMX         CONCIN                         C  4
        0.         15.          0.
*     DXIN          VOLIN        ALPIN        VLIN        TLIN      C  5
        1.          .126         1.          0.       401.88
*     PIN           PAIN        FLOWIN        VVIN        TVIN      C  6
   19.88E+05         0.          0.          0.       401.88
* COMPONENT NO. 119 ****************************************************
* SEPARATOR DRAIN FILL LOOP 1 ******************************************
*
FILL            119         119  SEPARATOR DRAIN FILL LOOP 1
*     JUN1          IFTY         IOFF                          C  2
      119           8           1
*     IFTR          IFSV         NFTB        NFSV        NFRF      C  3
      666          100          -2           0           0
*    TWTOLD          RFMX         CONCIN                         C  4
        0.         20.0          0.
*     DXIN          VOLIN        ALPIN        VLIN        TLIN      C  5
   0.4913        0.09640         0.          0.       308.15
*     PIN           PAIN        FLOWIN        VVIN        TVIN      C  6
   2.60E+05          0.          0.          0.       308.15
*    VMSCL          VVSCL                                    C  9
        1.           1.
*   TIME (S)    MASS FLOW (KG/S)   *
        0.           0. S
        5.         -25. E
*
* COMPONENT NO. 15 *****************************************************
* HOT LEG ECC FILL LOOP 1 **********************************************
*
FILL             15          15         HOT-LEG-ECC LOOP 1
*     JUN1          IFTY         IOFF                          C  2
       15           8           0
*     IFTR          IFSV         NFTB        NFSV        NFRF      C  3
      666          100          -6           0           0
*    TWTOLD          RFMX         CONCIN                         C  4
        0.        1.E10          0.
*     DXIN          VOLIN        ALPIN        VLIN        TLIN      C  5
       3.3          .134         0.          0.       303.35
*     PIN           PAIN        FLOWIN        VVIN        TVIN      C  6
   19.80E+05         0.          0.          0.       303.35
*    VMSCL          VVSCL                                    C  9
        1.           1.
*   TIME (S)    MASS FLOW (KG/S)   *
        0.           0. S
        .5           0. S
        2.         500. S
       12.         500. S
       52.         400. S
      110.         300. E
*  *
*  *
*
* COMPONENT NO. 16 *****************************************************
* COLD LEG ECC FILL LOOP 1 *********************************************
*
FILL             16          16         COLD-LEG-ECC LOOP 1
*     JUN1          IFTY         IOFF                          C  2
       16           6           0
*     IFTR          IFSV         NFTB        NFSV        NFRF      C  3
      116          100          12           0           0
*    TWTOLD          RFMX         CONCIN                         C  4
        0.        1.E10          0.
*     DXIN          VOLIN        ALPIN        VLIN        TLIN      C  5
       3.3          .125         0.          0.       379.65
*     PIN           PAIN        FLOWIN        VVIN        TVIN      C  6
   11.0E+05          0.          0.          0.        457.3
*    VMSCL          VVSCL                                    C  9
        1.           1.
*    TLSCL          TVSCL        PSCL       PASCL        CONSCL   C 10
       1.0          1.0       1.E+05        1.        1.0
*       T(S)          VLTB(M/S)
         0.00          0.00   S
        38.00          0.00   S
        42.00          0.00   S
        45.00         13.72   S
        50.00         13.76   S
        57.80         13.70   S
        80.00         13.83   S
        90.00         13.80   S
       118.00         13.87   S
       120.00         11.66   S
       125.00          0.00   S
       140.00          0.00   E
*       T(S)          VVTB(M/S)
         0.00          0.0    S
        38.00          0.0    S
        42.00          0.0    S
        45.00          0.0    S
        50.00          0.0    S
        57.80          0.0    S
        80.00          0.0    S
        90.00          0.0    S
       118.00          0.0    S
       120.00          0.0    S
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       125.00       0.0     S
       140.00       0.0     E
*      T(S)          TL
        0.00      379.65    S
       38.00      380.15    S
       42.00      380.15    S
       45.00      379.15    S
       50.00      381.90    S
       57.80      377.15    S
       80.00      384.65    S
       90.00      386.15    S
      118.00      392.35    S
      120.00      392.65    S
      125.00      392.85    S
      140.00      392.40    E
*      T(S)          TV
        0.00      457.3     S
       38.00      457.3     S
       42.00      457.3     S
       45.00      457.3     S
       50.00      457.3     S
       57.80      457.3     S
       80.00      457.3     S
       90.00      457.3     S
      118.00      457.3     S
      120.00      457.3     S
      125.00      457.3     S
      140.00      457.3     E
*      T(S)        ALPHA
        0.00       0.0      S
       38.00       0.0      S
       42.00       0.0      S
       45.00       0.0      S
       50.00       0.0      S
       57.80       0.0      S
       80.00       0.0      S
       90.00       0.0      S
      118.00       0.0      S
      120.00       0.0      S
      125.00       0.0      S
      140.00       0.0      E
*      T(S)        P(BARS)
        0.00      11.0      S
       38.00      11.0      S
       42.00      11.0      S
       45.00      11.0      S
       50.00      11.0      S
       57.80      11.0      S
       80.00      11.0      S
       90.00      11.0      S
      118.00      11.0      S
      120.00      11.0      S
      125.00      11.0      S
      140.00      11.0      E
*      T(S)        PA(BARS)
        0.00       0.0      S
       38.00       0.0      S
       42.00       0.0      S
       45.00       0.0      S
       50.00       0.0      S
       57.80       0.0      S
       80.00       0.0      S
       90.00       0.0      S
      118.00       0.0      S
      120.00       0.0      S
      125.00       0.0      S
      140.00       0.0      E
************************************** L O O P 2 ****************************
* COMPONENT NO. 20 * *********************************************************
*
TEE                 20          20         HOT-LEG LOOP 2
*     JCELL        NODES         MAT        COST         ICHF      C  2
        4            4       6       -1.       1
*     ICONC1       NCELL1        JUN1        JUN2         IPOW1     C  3
        0            5       20      227       0
*     IQPTR1       IQPSV1       NQPTB1      NQPSV1       NQPRF1     C  5
        0            0       0       0
*     RADIN1        TH1      HOUTL1       HOUTV1       TOUTL1     C  6
       .375         .01      0.      0.      300.
*     TOUTV1        PWIN1       PWOFF1      RPWMX1       PWSCL1     C  7
       300.          0.      0.      0.      0.
*     QPIN1        QPOFF1       RQPMX1      QPSCL1                  C  8
        0.           0.      0.      0.
*     ICONC2       NCELL2        JUN3        IPOW2                  C  9
        0            1       25      0
*     IQPTR2       IQPSV2       NQPTB2      NQPSV2       NQPRF2     C 11
        0            0       0       0       0
*     RADIN2        TH2      HOUTL2       HOUTV2       TOUTL2     C 12
       .11          .01      0.      0.      300.
*     TOUTV2        PWIN2       PWOFF2      RPWMX2       PWSCL2     C 13
       300.          0.      0.      0.      0.
*     QPIN2        QPOFF2       RQPMX2      QPSCL2                  C 14
        0.           0.      0.      0.
* PRIMARY *
R 3     .5107 R 2    1.2867 E                             *    DX
R 3     .2256 R 2     .5113 E                             *    VOL
R 3    .44179 R 3     .3974 E                             *    FA
R 2        0. R 4      .016 E                             *  FRIC
R 2        0. R 4      .016 E                             * RVFRIC
```

```
R 6      0. E                                   * GRAV
R 3     .75 R 3     .6388 E                     *  HD
R 3      0           1 R 3         0 E          * ICFLG
R 1      0 R 5       1 E                        *  NFF
F        1. E                                   * ALP
F        0. E                                   * VL
F        0. E                                   * VV
F      422.275 E                                *   TL
F      422.275 E                                *   TV
F     2.60E+05 E                                *   P
F        0. E                                   * PA
F        0. E                                   * QPPP
F        6 E                                    * MATID
F      422.275 E                                *   TW
* SECONDARY *
F       10. E                                   * DX
F      .40660 E                                 *  VOL
F      .04066 E                                 *   FA
F       0.0 E                                   * FRIC
F       0. E                                    * RVFRIC
F      -1.0 E                                   *  GRAV
F      .2077 E                                  *   HD
F        0 E                                    * ICFLG
F        1 E                                    *  NFF
F       1.0 E                                   *   ALP
F       0. E                                    *  VL
F       0. E                                    *  VV
F      422.275 E                                *   TL
F      422.275 E                                *   TV
F     2.60E+05 E                                *   P
F       0. E                                    * PA
F       0. E                                    * QPPP
F       6 E                                     * MATID
F    422.275 E                                  *   TW
*
* COMPONENT NO. 27 ***************************************************
TEE               27          27       PRESSURIZER TEE
*    JCELL       NODES       MAT        COST        ICHF      C 2
       1           4     6      0.         1
*    ICONC1      NCELL1      JUN1       JUN2        IPOW1     C 3
       0           4    227      21         0
*    IQPTR1      IQPSV1      NQPTB1     NQPSV1      NQPRF1    C 5
       0           0     0       0          0
*    RADIN1      TH1         HOUTL1     HOUTV1      TOUTL1    C 6
      .375        .01    0.       0.        300.
*    TOUTV1      PWIN1       PWOFF1     RPWMX1      PWSCL1    C 7
      300.        0.     0.       0.         0.
*    QPIN1       QPOFF1      RQPMX1     QPSCL1                C 8
       0.         0.     0.       0.
*    ICONC2      NCELL2      JUN3       IPOW2                 C 9
       0           2    228       0
*    IQPTR2      IQPSV2      NQPTB2     NQPSV2      NQPRF2    C 11
       0           0     0       0          0
*    RADIN2      TH2         HOUTL2     HOUTV2      TOUTL2    C 12
      .26         .01    0.       0.        300.
*    TOUTV2      PWIN2       PWOFF2     RPWMX2      PWSCL2    C 13
      300.        0.     0.       0.         0.
*    QPIN2       QPOFF2      RQPMX2     QPSCL2                C 14
       0.         0.     0.       0.
* PRIMARY *
 R 1   1.2867      1.337       1.0420      0.626 E          *   DX
 R 1   0.5113      .5907       .4603       .2766 E          *   VOL
R 1     .3974 R 4  .44179 E                                 *   FA
R 3     .016 R 2     0. E                                   * FRIC
R 3     .016 R 2     0. E                                   * RVFRIC
R 2      0.0       0.1802      0.5612      0.6803 E         *   GRAV
R 2     .6388 F     .75 E                                   *  HD
F         0 E                                               * ICFLG
F         1 E                                               * NFF
F         1. E                                              * ALP
F         0. E                                              * VL
F         0. E                                              * VV
F      422.275 E                                            *   TL
F      422.275 E                                            *   TV
F     2.60E+05 E                                            *   P
F         0. E                                              * PA
F         0. E                                              * QPPP
F         6 E                                               * MATID
F      422.275 E                                            *   TW
* SECONDARY *
        .56         .7184 E                                 *  DX
       .03339       .06833 E                                *   VOL
       .031416 F     .09115 E                               *   FA
        0.          .0182          0. E                     * FRIC
F        0. E                                               * RVFRIC
        .7005       .36217       -.97929 E                  *   GRAV
        .2 F        .348 E                                  *  HD
F         0 E                                               * ICFLG
F         1 E                                               * NFF
F         1. E                                              * ALP
F         0. E                                              * VL
F         0. E                                              * VV
F      422.275 E                                            *   TL
F      422.275 E                                            *   TV
F     2.60E+05 E                                            *   P
F         0. E                                              * PA
F         0. E                                              * QPPP
F         6 E                                               * MATID
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F       422.275 E                                    *    TW
*
* COMPONENT NO. 21 ********************************************************
* SEPARATOR BOTTOM LOOP 2 ****************************************************
*
 TEE                  21          21    SEPARATOR-BOTTOM LOOP 2
*      JCELL        NODES           MAT         COST         ICHF      C  2
        1            4         6     0.0          1
*      ICONC1       NCELL1          JUN1         JUN2         IPOW1     C  3
        0            4        21           22
*      IQPTR1       IQPSV1       NQPTB1       NQPSV1       NQPRF1      C  5
        0            0         0     0            0
*      RADIN1        TH1         HOUTL1       HOUTV1       TOUTL1      C  6
       1.25         .025       0.      0.          300.
*      TOUTV1        PWIN1        PWOFF1       RPWMX1       PWSCL1     C  7
       300.          0.        0.        0.
*      QPIN1        QPOFF1        RQPMX1       QPSCL1                  C  8
        0.           0.       0.        0.
*      ICONC2       NCELL2         JUN3        IPOW2                   C  9
        0            1        28          0
*      IQPTR2       IQPSV2       NQPTB2       NQPSV2       NQPRF2      C 11
        0            0         0     0            0
*      RADIN2        TH2         HOUTL2       HOUTV2       TOUTL2      C 12
       1.25         .025       0.      0.          300.
*      TOUTV2        PWIN2        PWOFF2       RPWMX2       PWSCL2     C 13
       300.          0.        0.        0.
*      QPIN2        QPOFF2        RQPMX2       QPSCL2                  C 14
        0.           0.       0.        0.
* PRIMARY *
       .95560       .3251        .3251       .424 E          *   DX
         2.597      1.5266       1.5253       .2587 E         *   VOL
       0.44179      4.5584       4.7298 R 2   0.6101 E          *    FA
R 4    0.           .3621 E                                 *  FRIC
R 4      0.0        .9053 E                                 *  RVFRI
       0.6803 F      1.0 E                                  *   GRAV
         0.75 R 2    2.30 R 2    .1583 E                    *      HD
F            0 E                                            * ICFLG
F            1 E                                            *   NFF
F            1. E                                           *   ALP
F            0. E                                           *   VL
F            0. E                                           *   VV
F       422.275 E                                            *    TL
F       422.275 E                                            *    TV
F      2.60E+05 E                                            *    P
F            0. E                                           *   PA
F            0. E                                           *  QPPP
F            6 E                                            * MATID
F       422.275 E                                            *    TW
* SECONDARY *
       0.2000 E                                             *   DX
       0.0107 E                                             *   VOL
       0.05326 E                                            *     FA
F        0.0 E                                              *  FRIC
F         0. E                                              * RVFRIC
         0.          -.4220 E                               *   GRAV
F      0.2604 E                                             *     HD
F            0 E                                            * ICFLG
F            1 E                                            *   NFF
F            1. E                                           *   ALP
F            0. E                                           *   VL
F            0. E                                           *   VV
F       422.275 E                                            *    TL
F       422.275 E                                            *    TV
F      2.60E+05 E                                            *    P
F            0. E                                           *   PA
F            0. E                                           *  QPPP
F            6 E                                            * MATID
F       422.275 E                                            *    TW
*
* COMPONENT NO. 22 ********************************************************
* SEPARATOR MIDDLE LOOP 2 ****************************************************
*
 TEE                  22          22    SEPARATOR-MIDDLE LOOP 2
*      JCELL        NODES           MAT         COST         ICHF      C  2
        4            4         6     1.0          1
*      ICONC1       NCELL1          JUN1         JUN2         IPOW1     C  3
        0            4        22           23
*      IQPTR1       IQPSV1       NQPTB1       NQPSV1       NQPRF1      C  5
        0            0         0     0            0
*      RADIN1        TH1         HOUTL1       HOUTV1       TOUTL1      C  6
       1.25         .025       0.      0.          300.
*      TOUTV1        PWIN1        PWOFF1       RPWMX1       PWSCL1     C  7
       300.          0.        0.        0.
*      QPIN1        QPOFF1        RQPMX1       QPSCL1                  C  8
        0.           0.       0.        0.
*      ICONC2       NCELL2         JUN3        IPOW2                   C  9
        0            4        29          0
*      IQPTR2       IQPSV2       NQPTB2       NQPSV2       NQPRF2      C 11
        0            0         0     0            0
*      RADIN2        TH2         HOUTL2       HOUTV2       TOUTL2      C 12
       1.25         .025       0.      0.          300.
*      TOUTV2        PWIN2        PWOFF2       RPWMX2       PWSCL2     C 13
       300.          0.        0.        0.
*      QPIN2        QPOFF2        RQPMX2       QPSCL2                  C 14
        0.           0.       0.        0.
* PRIMARY *
        .188        0.710        0.710         .2 E          *   DX
        .1574       0.7558       0.7558       0.2129 E        *   VOL
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     0.6101      1.0645      1.0645 R 2   1.0645 E        *  FA
      .3621 R 3   0.         1.E30  E                    * FRIC
      .9053 R 4   0. E                                  * RVFRI
F       1.0 E                                           * GRAV
     .15830 F     0.2091 E                              *
F         0 E                                           * ICFLG
F         1 E                                           * NFF
F        1. E                                           * ALP
F        0. E                                           * VL
F        0. E                                           * VV
F   422.275 E                                           *   TL
F   422.275 E                                           *   TV
F 2.60E+05 E                                            *   P
F        0. E                                           * PA
F        0. E                                           * QPPP
F         6 E                                           * MATID
F   422.275 E                                           *   TW
* SECONDARY *
     0.7100       .710       .188       .424 E          *  DX
     2.4617     2.4617     0.7057     1.7130 E          *   VOL
R 3  3.4673  R 2  4.0401 E                              *   FA
F       0.0 E                                           * FRIC
F        0. E                                           * RVFRIC
F      -1.0 E                                           * GRAV
F      0.44 E                                           * HD
F         0 E                                           * ICFLG
F         1 E                                           * NFF
R 3      1.       1.00 E                                *  ALP
F        0. E                                           * VL
F        0. E                                           * VV
    422.275  F    422.275 E                             *    TL
    422.275  F    422.275 E                             *    TV
F  2.60E+05 E                                           *  P
F        0. E                                           * PA
F        0. E                                           * QPPP
F         6 E                                           * MATID
F   422.275 E                                           *   TW
*
* COMPONENT NO. 23 *****************************************************
* SEPARATOR TOP LOOP 2 *************************************************
*
TEE             23        23    SEPARATOR-TOP LOOP 2
*     JCELL       NODES       MAT        COST       ICHF      C  2
          3           4         6         0.0          1
*     ICONC1      NCELL1      JUN1       JUN2       IPOW1     C  3
          0           4        23          24          0
*     IQPTR1      IQPSV1      NQPTB1     NQPSV1     NQPRF1    C  5
          0           0         0           0          0
*     RADIN1      TH1         HOUTL1     HOUTV1     TOUTL1    C  6
       1.25        .025        0.          0.        300.
*     TOUTV1      PWIN1       PWOFF1     RPWMX1     PWSCL1    C  7
       300.          0.        0.          0.          0.
*     QPIN1       QPOFF1      RQPMX1     QPSCL1               C  8
         0.          0.        0.          0.
*     ICONC2      NCELL2      JUN3       IPOW2                C  9
          0           1       223           0
*     IQPTR2      IQPSV2      NQPTB2     NQPSV2     NQPRF2    C 11
          0           0         0           0          0
*     RADIN2      TH2         HOUTL2     HOUTV2     TOUTL2    C 12
       1.25        .025        0.          0.        300.
*     TOUTV2      PWIN2       PWOFF2     RPWMX2     PWSCL2    C 13
       300.          0.        0.          0.          0.
*     QPIN2       QPOFF2      RQPMX2     QPSCL2               C 14
         0.          0.        0.          0.
* PRIMARY *
        0.2        .285       0.4      0.810 E          *  DX
     0.2129      1.5732    1.8919      3.0974 E         *   VOL
R 2  1.0645 R 2  4.7298    0.44179 E                    *    FA
      1.E30 F     0.0 E                                 * FRIC
F        0. E                                           * RVFRIC
F       1.0 E                                           * GRAV
R 2  0.2091 R 2   2.454      0.75 E                     *    HD
F         0 E                                           * ICFLG
F         1 E                                           * NFF
F        1. E                                           * ALP
F        0. E                                           * VL
F        0. E                                           * VV
F   422.275 E                                           *   TL
F   422.275 E                                           *   TV
F  2.60E+05 E                                           *   P
F        0. E                                           * PA
F        0. E                                           * QPPP
F         6 E                                           * MATID
F   422.275 E                                           *   TW
* SECONDARY *
F       1.0 E                                           * DX
F      .126 E                                           * VOL
F      .126 E                                           * FA
F       0.0 E                                           * FRIC
F        0. E                                           * RVFRIC
F       0.0 E                                           * GRAV
F        .4 E                                           * HD
F         0 E                                           * ICFLG
F         1 E                                           * NFF
F        1. E                                           * ALP
F        0. E                                           * VL
F        0. E                                           * VV
F   422.275 E                                           *   TL
F   422.275 E                                           *   TV
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F    2.60E+05 E                                  *  P
F        0. E                                   *  PA
F        0. E                                   *  QPPP
F        6 E                                    *  MATID
F    422.275 E                                  *  TW
* COMPONENT NO. 24 *******************************************************
* LOOP SEAL AND COLD LEG LOOP 2 *********************************************
*
TEE          24         24  LOOP-SEAL COLD-LEG LOOP 2
*    JCELL        NODES        MAT        COST        ICHF      C 2
      17           4        6      .5          1
*    ICONC1       NCELL1       JUN1        JUN2        IPOW1     C 3
      0           21       24      27          0
*    IQPTR1       IQPSV1      NQPTB1      NQPSV1      NQPRF1     C 5
      0            0        0       0           0
*    RADIN1        TH1        HOUTL1      HOUTV1      TOUTL1     C 6
     .375         .01       0.      0.         300.
*    TOUTV1        PWIN1      PWOFF1      RPWMX1      PWSCL1     C 7
     300.          0.       0.      0.          0.
*    QPIN1        QPOFF1      RQPMX1      QPSCL1                 C 8
      0.           0.       0.      0.
*    ICONC2       NCELL2       JUN3       IPOW2                  C 9
      3            1      260       0
*    IQPTR2       IQPSV2      NQPTB2      NQPSV2      NQPRF2     C 11
      0            0        0       0           0
*    RADIN2        TH2        HOUTL2      HOUTV2      TOUTL2     C 12
     .11          .01       0.      0.         300.
*    TOUTV2        PWIN2      PWOFF2      RPWMX2      PWSCL2     C 13
     300.          0.       0.      0.          0.
*    QPIN2        QPOFF2      RQPMX2      QPSCL2                 C 14
      0.           0.       0.      0.
* PRIMARY *
        1.2 R 2   1.9125         1.2 R 3   2.317       1.514  *   DX
R 2    1.665 R 2    1.092          .65S                        *  DX
        .600 R 2   1.495   1.5050   1.9110 R 2  1.6825        *   DX
      0.710 E                                             *  DX
       .5301 R 2   .8449         .5301 R 3   1.0236       .6689  *  VOL
R 2     .7356 R 2   .4824         .7200       .9480 S          *  VOL
R 2  0.66048       0.66489       0.40247 R 2  0.74331   0.38058 E  *  VOL
R 12   .44179      .00000        .6892 R 7    .44179      .6362 E *  FA
         0. R 11    .019         10.76 R 8    .008       .0205 E * FRIC
         0. R 11    .019          7.75 R 8    .008       .0205 E * RVFRIC
       1.0         .2313          0.0      -.2313 R 4    -1.0  *  GRAV
     -.49350        0.0          .7978        1.0         .372  *  GRAV
      -.7752       .1411 R 7      0.0 E                        *  GRAV
R 21    .75         0.90 E                                    *  HD
R 12     0            1 F          0 E                        *  ICFLAG
F        1 E                                               *  NFF
R07      1.    1.0    1.    1.0     1.0  S                     *  ALP
R10           1.0   E
F        0.0 E                                            *  VL
F        0.0 E                                            *  VV
F      414.15 E                                           *  TL
F      414.15 E                                           *  TV
F    2.60E+05 E                                           *  P
F        0.0 E                                            *  PA
F        0.0 E                                            *  QPPP
F        6 E                                              *  MATID
F      414.15 E                                           *  TW
* SECONDARY *
F      0.050 E                                            *  DX
F      0.019 E                                            *  VOL
F   3.8010E-02 E                                          *  FA
F        0. E                                             *  FRIC
F        0. E                                             *  RVFRIC
F       +1.0 E                                            *  GRAV
F   2.2000E-01 E                                          *  HD
F        0 E                                              *  ICFLG
F        1 E                                              *  NFF
F        1. E                                             *  ALP
F        0. E                                             *  VL
F        0. E                                             *  VV
F      414.15 E                                           *  TL
F      414.15 E                                           *  TV
F    2.60E+05 E                                           *  P
F        0 E                                              *  PA
F        0. E                                             *  QPPP
F        6 E                                              *  MATID
F      414.15 E                                           *  TW
* COMPONENT NO. 28 *******************************************************
* SEPARATOR DRAIN TEE LOOP 2 ***********************************************
*
TEE          28         28      SEP. DRAIN TEE LOOP 2
*    JCELL        NODES        MAT        COST        ICHF      C 2
      5            4        6     0.0          1
*    ICONC1       NCELL1       JUN1        JUN2        IPOW1     C 3
      0            6       29     229          0
*    IQPTR1       IQPSV1      NQPTB1      NQPSV1      NQPRF1     C 5
      0            0        0       0           0
*    RADIN1        TH1        HOUTL1      HOUTV1      TOUTL1     C 6
     0.1          .025      0.      0.         300.
*    TOUTV1        PWIN1      PWOFF1      RPWMX1      PWSCL1     C 7
     300.          0.       0.      0.          0.
*    QPIN1        QPOFF1      RQPMX1      QPSCL1                 C 8
      0.           0.       0.      0.
*    ICONC2       NCELL2       JUN3       IPOW2                  C 9
      0            1      230       0
*    IQPTR2       IQPSV2      NQPTB2      NQPSV2      NQPRF2     C 11
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     0          0         0          0          0
*    RADIN2         TH2        HOUTL2       HOUTV2       TOUTL2      C 12
     0.1        .025      0.         0.         300.
*    TOUTV2         PWIN2       PWOFF2       RPWMX2       PWSCL2      C 13
     300.       0.        0.         0.         0.
*    QPIN2      QPOFF2        RQPMX2       QPSCL2                    C 14
     0.         0.        0.         0.
* PRIMARY *
       0.9 R 2     0.925 R 3   0.4913 E                          *  DX
     0.0283 R 2    0.029 R 3   0.0964 E                          *  VOL
     4.0401 R 2    0.0314 R 4  0.1963 E                          *  FA
F       0. E                                                     * FRIC
F       0. E                                                     * RVFRIC
       -1.0     -0.3364       0.    -0.3470 R 3    -1.0 E*  GRAV
       0.44 R 2     0.2 F      0.5 E                             * HD
F        0 E                                                     * ICFLG
F        1 E                                                     * NFF
F       1.0 E                                                    * ALP
F       0. E                                                     * VL
F       0. E                                                     * VV
R 5    422.75       308.15  E                                    * TL
F      422.75 E                                                  * TV
F    2.60E+05 E                                                  * P
F       0. E                                                     * PA
F       0. E                                                     * QPPP
F        6 E                                                     * MATID
 R 20 422.75    F 308.15 E
* SECONDARY *
F       0.5 E                                                    * DX
F     0.0266 E                                                   * VOL
F    0.05326 E                                                   * FA
F       0.0 E                                                    * FRIC
F       0. E                                                     * RVFRIC
F       0.0 E                                                    * GRAV
F     0.2604 E                                                   * HD
F        0 E                                                     * ICFLG
F        1 E                                                     * NFF
F       1. E                                                     * ALP
F       0. E                                                     * VL
F       0. E                                                     * VV
F      422.75 E                                                  * TL
F      422.75 E                                                  * TV
F    2.60E+05 E                                                  * P
F       0. E                                                     * PA
F       0. E                                                     * QPPP
F        6 E                                                     * MATID
F      422.75 E                                                  * TW
*
* COMPONENT NO. 29 ********************************************************
* SEPARATOR DRAIN VALVE LOOP 2 ********************************************
*
VALVE            29          29     SEPARATOR DRAIN VALVE
*    NCELLS        NODES        JUN1         JUN2          MAT
     2          4         230        28         6
*    ICHF          ICONC        IVTY         IVPS          NVTB2
     1          0         1          2          0
*    IVTR          IVSV         NVTB1        NVSV          NVRF
     0          100       2          0          0
*    IQP3TR        IQP3SV       NQP3TB       NQP3SV        NQP3RF
     0          0         0          0          0
*    IVTROV        IVTYOV
     0          0
*    RVMX          RVOV         FMINOV       FMAXOV
     1.E10      0.        0          1.
*    RADIN         TH           HOUTL        HOUTV         TOUTL
     .015       .005      0.         0.         300.
*    TOUTV         AVLVE        HVLVE        FAVLVE        XPOS
     300.       .03140    .20        1.         0.
*    QP3IN         QP3OFF       RQP3MX       QP3SCL
     0.         0.        0.         0.
       0.5       1.0 E                                           * DX
     0.0266     0.05326 E                                        * VOL
F    0.05326 E                                                   * FA
       0.        1.944 F      0. E                               * FRIC
       0.        1.944 F      0. E                               * RVFRIC
R 2    0.         .4220 E                                        * GRAV
F     0.2604 E                                                   * HD
F        0 E                                                     * ICFLG
F        1 E                                                     * NFF
       1.         1. E                                           * ALP
F       0. E                                                     * VL
F       0. E                                                     * VV
F      422.75 E                                                  * TL
F      422.75 E                                                  * TV
F    2.60E+05 E                                                  * P
F       0. E                                                     * PA
F       0. E                                                     * QPPP
F        6 E                                                     * MATID
F      422.75 E                                                  * TW
*
*      T(S)        POS(-)
       0.          1. S                                          * VTB1
     300.0         1. E                                          * VTB1
*
*
* COMPONENT NO.223 ********************************************************
* STEAM SUPPLY FILL LOOP 2 ************************************************
*
FILL             223         223      STEAM SUPPLY LOOP 2
```

```
*      JUN1        IFTY        IOFF                          C 2
       223         5           0
*      IFTR        IFSV        NFTB        NFSV        NFRF       C 3
       0           902         0           0           0
*      TWTOLD      RFMX        CONCIN                             C 4
       0.          15.         0.
*      DXIN        VOLIN       ALPIN       VLIN        TLIN       C 5
       1.          .126        1.          0.          422.75
*      PIN         PAIN        FLOWIN      VVIN        TVIN       C 6
       19.88E+05   0.          0.          0.          422.75
* COMPONENT NO. 229 **********************************************************
* SEPARATOR DRAIN FILL LOOP 2 **************************************************
*
FILL               229         229 SEPARATOR DRAIN FILL LOOP 2
*      JUN1        IFTY        IOFF                          C 2
       229         8           1
*      IFTR        IFSV        NFTB        NFSV        NFRF       C 3
       666         100         -2          0           0
*      TWTOLD      RFMX        CONCIN                             C 4
       0.          20.0        0.
*      DXIN        VOLIN       ALPIN       VLIN        TLIN       C 5
       0.4913      0.09640     0.          0.          308.15
*      PIN         PAIN        FLOWIN      VVIN        TVIN       C 6
       2.60E+05    0.          0.          0.          308.15
*      VMSCL       VVSCL                                     C 9
       1.          1.
*      TIME (S)    MASS FLOW (KG/S)    *
       0.          0. S
       5.          -25. E
*
* COMPONENT NO. 228 **********************************************************
* PRESSURIZER FILL **********************************************************
*
FILL               228         228         PRESSURIZER FILL
*      JUN1        IFTY        IOFF                          C 2
       228         8           0
*      IFTR        IFSV        NFTB        NFSV        NFRF       C 3
       666         100         -9          0           0
*      TWTOLD      RFMX        CONCIN                             C 4
       0           1.E10       0.
*      DXIN        VOLIN       ALPIN       VLIN        TLIN       C 5
       .7184       .06833      1.          0.          422.75
*      PIN         PAIN        FLOWIN      VVIN        TVIN       C 6
       2.60E+05    0.          0.          0.          422.75
*      VMSCL       VVSCL                                     C 9
       1.          1.
*      TIME (S)    MASS FLOW(KG/S)    *
       0.          0. S
       2.          100. S
       3           84. S
       5.          56. S
       7.          40. S
       9.          36. S
       11.         30. S
       13.2        0. S
       100.        0. E
*
* COMPONENT NO. 25 **********************************************************
* HOT LEG ECC FILL LOOP 2 ****************************************************
*
FILL               25          25          HOT-LEG-ECC LOOP 2
*      JUN1        IFTY        IOFF                          C 2
       25          8           0
*      IFTR        IFSV        NFTB        NFSV        NFRF       C 3
       666         100         -6          0           0
*      TWTOLD      RFMX        CONCIN                             C 4
       0.          1.E10       0.
*      DXIN        VOLIN       ALPIN       VLIN        TLIN       C 5
       3.3         .134        0.          0.          303.35
*      PIN         PAIN        FLOWIN      VVIN        TVIN       C 6
       19.80E+05   0.          0.          0.          303.35
*      VMSCL       VVSCL                                     C 9
       1.          1.
*
* VMTB  * R02 0.0000E+00  2.5000E+00  5.0000E+02  1.2500E+01  5.0000E+02
* VMTB  *     1.2500E+01  5.0000E+02  3.2500E+01  4.0000E+02  1.1050E+02
* VMTB  *     3.0000E+02E
*
*
* COMPONENT NO. 26 **********************************************************
* COLD LEG ECC FILL LOOP 2 ***************************************************
*
FILL               26          26          COLD-LEG-ECC LOOP 2
*      JUN1        IFTY        IOFF                          C 2
       26          6           0
*      IFTR        IFSV        NFTB        NFSV        NFRF       C 3
       116         100         12          0           0
*      TWTOLD      RFMX        CONCIN                             C 4
       0.          1.E10       0.
*      DXIN        VOLIN       ALPIN       VLIN        TLIN       C 5
       3.3         .125        0.          0.          392.65
*      PIN         PAIN        FLOWIN      VVIN        TVIN       C 6
       11.00E+05   0.          0.          0.          394.15
*      VMSCL       VVSCL                                     C 9
       1           1
*      TLSCL       TVSCL       PSCL        PASCL       CONSCL     C 10
       1.0         1.0         1.E+05      1.          1.0
*      T(S)        VLTB(M/S)
       0.00        0.00    S
```

```
   38.00     0.00    S
   42.00     0.00    S
   45.00    13.78    S
   50.00    13.93    S
   57.80    13.78    S
   80.00    13.88    S
   90.00    13.89    S
  118.00    13.90    S
  120.00    11.68    S
  125.00     0.00    S
  140.00     0.00    S
*  T(S)     VVTB(M/S)
    0.00     0.0     S
   38.00     0.0     S
   42.00     0.0     S
   45.00     0.0     S
   50.00     0.0     S
   57.80     0.0     S
   80.00     0.0     S
   90.00     0.0     S
  118.00     0.0     S
  120.00     5.0     S
  125.00     0.0     S
  140.00     0.0     S
*  T(S)      TL
    0.00   392.65    S
   38.00   392.65    S
   42.00   385.15    S
   45.00   384.15    S
   50.00   385.65    S
   57.80   384.15    S
   80.00   393.45    S
   90.00   394.15    S
  118.00   394.65    S
  120.00   394.85    S
  125.00   394.45    S
  140.00   394.15    S
*  T(S)      TV
    0.00   457.3     S
   38.00   457.3     S
   42.00   457.3     S
   45.00   457.3     S
   50.00   457.3     S
   57.80   457.3     S
   80.00   457.3     S
   90.00   457.3     S
  118.00   457.3     S
  120.00   457.3     S
  125.00   457.3     S
  140.00   457.3     S
*  T(S)      ALPHA
    0.00     0.0     S
   38.00     0.0     S
   42.00     0.0     S
   45.00     0.0     S
   50.00     0.0     S
   57.80     0.0     S
   80.00     0.0     S
   90.00     0.0     S
  118.00     0.0     S
  120.00     0.0     S
  125.00     0.0     S
  140.00     0.0     S
*  T(S)      P(BARS)
    0.00    11.0     S
   38.00    11.0     S
   42.00    11.0     S
   45.00    11.0     S
   50.00    11.0     S
   57.80    11.0     S
   80.00    11.0     S
   90.00    11.0     S
  118.00    11.0     S
  120.00    11.0     S
  125.00    11.0     S
  140.00    11.0     S
*  T(S)      PA(BARS)
    0.00     0.0     S
   38.00     0.0     S
   42.00     0.0     S
   45.00     0.0     S
   50.00     0.0     S
   57.80     0.0     S
   80.00     0.0     S
   90.00     0.0     S
  118.00     0.0     S
  120.00     0.0     S
  125.00     0.0     S
  140.00     0.0     S
*
*
****************************** L O O P 3 ******************************
* COMPONENT NO. 30 ***********************************************************
* HOT LEG LOOP 3 *************************************************************
*
TEE            30         30          HOT-LEG LOOP 3
*    JCELL       NODES        MAT        COST        ICHF     C 2
      4           4      6     -1.         1
*    ICONC1      NCELL1       JUN1       JUN2        IPOW1    C 3
```

```
        0          9         30         31          0
*    IQPTR1     IQPSV1     NQPTB1     NQPSV1     NQPRF1     C 5
        0          0          0          0          0
*    RADIN1     TH1        HOUTL1     HOUTV1     TOUTL1     C 6
     .375       .01        0.         0.         300.
*    TOUTV1     PWIN1      PWOFF1     RPWMX1     PWSCL1     C 7
     300.       0.         0.         0.         0.
*    QPIN1      QPOFF1     RQPMX1     QPSCL1                C 8
        0.      0.         0.         0.
*    ICONC2     NCELL2     JUN3       IPOW2      C 9
        0          1         35          0
*    IQPTR2     IQPSV2     NQPTB2     NQPSV2     NQPRF2     C 11
        0          0          0          0          0
*    RADIN2     TH2        HOUTL2     HOUTV2     TOUTL2     C 12
      .11       .01        0.         0.         300.
*    TOUTV2     PWIN2      PWOFF2     RPWMX2     PWSCL2     C 13
     300.       0.         0.         0.         0.
*    QPIN2      QPOFF2     RQPMX2     QPSCL2                C 14
        0.      0.         0.         0.
* PRIMARY *
R 3    .5107 R 3   1.2867       1.337       1.0420       .6260 E*    DX
R 3    .2256 R 3    .5113        .5907       .4603       .2766 E*    VOL
R 3   .44179 R 3    .3974 R 4   .44179 E                      *      FA
R 2       .0 R 6   0.016 R 2     0.0 E                       *  FRIC
R 2       0. R 6    .016 R 2      0. E                       * RVFRIC
R 7      0.0        .802        0.5612      0.6803 E         *   GRAV
R 3      .75 R      .388 F        .75 E                      *   HD
R 4        0             F         0 E                       * ICFLG
R 1        0 F               E                               *  NFF
F         1. E                                               * ALP
F         0. E                                               * VL
F         0. E                                               * VV
F     422.75 E                                               *   TL
F     422.75 E                                               *   TV
F   2.60E+05 E                                               *   P
F         0. E                                               * PA
F         0. E                                               * QPPP
F          6 E                                               * MATID
F     422.75 E                                               *   TW
* SECONDARY *
F        10. E                                               *  DX
F     .40660 E                                               *   VOL
F     .04066 E                                               *   FA
F        0.0 E                                               * FRIC
F         0. E                                               *RVFRIC
F       -1.0 E                                               *  GRAV
F      .2077 E                                               *   HD
F          0 E                                               * ICFLG
F          1 E                                               *  NFF
F         1. E                                               *  ALP
F         0. E                                               *  VL
F         0. E                                               *  VV
F     422.75 E                                               *   TL
F     422.75 E                                               *   TV
F   2.60E+05 E                                               *   P
F         0. E                                               * PA
F         0. E                                               * QPPP
F          6 E                                               * MATID
F     422.75 E                                               *   TW
* COMPONENT NO. 31 ***********************************************************
* SEPARATOR BOTTOM LOOP 3 *******************************************************
*
TEE             31         31     SEPARATOR-BOTTOM LOOP 3
*    JCELL      NODES      MAT        COST       ICHF       C 2
        1          4          6       0.0          1
*    ICONC1     NCELL1     JUN1       JUN2       IPOW1      C 3
        0          4         31         32          0
*    IQPTR1     IQPSV1     NQPTB1     NQPSV1     NQPRF1     C 5
        0          0          0          0          0
*    RADIN1     TH1        HOUTL1     HOUTV1     TOUTL1     C 6
     1.25       .025       0.         0.         300.
*    TOUTV1     PWIN1      PWOFF1     RPWMX1     PWSCL1     C 7
     300.       0.         0.         0.         0.
*    QPIN1      QPOFF1     RQPMX1     QPSCL1                C 8
        0       0.         0.         0.
*    ICONC2     NCELL2     JUN3       IPOW2      C 9
        0          1         38          0
*    IQPTR2     IQPSV2     NQPTB2     NQPSV2     NQPRF2     C 11
        0          0          0          0          0
*    RADIN2     TH2        HOUTL2     HOUTV2     TOUTL2     C 12
     1.25       .025       0.         0.         300.
*    TOUTV2     PWIN2      PWOFF2     RPWMX2     PWSCL2     C 13
     300.       0.         0.         0.         0.
*    QPIN2      QPOFF2     RQPMX2     QPSCL2                C 14
        0.      0.         0.         0.
* PRIMARY *
       .95560     .3251       .3251       .424 E             *   DX
        2.597     1.5266      1.5253      .2587 E            *  VOL
      0.44179     4.5584      4.7298 R 2  0.6101 E           *    FA
R 4    0.         .3621 E                                    * FRIC
R 4    0.0        .9053 E                                    * RVFRI
       0.6803 F     1.0 E                                    * GRAV
       0.75 R 2   2.30 R 2    .1583 E                        *    HD
F         0 E                                                * ICFLG
F         1 E                                                *  NFF
F        1. E                                                *  ALP
F        0. E                                                *  VL
F        0. E                                                *  VV
F    422.75 E                                                *   TL
```

```
F       422.75 E                                              *  TV
F   2.60E+05 E                                                 *  P
F          0. E                                               *  PA
F          0. E                                               *  QPPP
F           6 E                                               *  MATID
F       422.75 E                                               *  TW
* SECONDARY *
      0.2000 E                                                *  DX
      0.0107 E                                                *  VOL
F     0.05326 E                                                *  FA
F         0.0 E                                               *  FRIC
F          0. E                                               *  RVFRIC
          0.        -.4220 E                                   *  GRAV
F     0.2604 E                                                 *  HD
F           0 E                                               *  ICFLG
F           1 E                                               *  NFF
F          1. E                                               *  ALP
F          0. E                                               *  VL
F          0. E                                               *  VV
F      422.75 E                                                *  TL
F      422.75 E                                                *  TV
F   2.60E+05 E                                                 *  P
F          0. E                                               *  FA
F          0. E                                               *  QPPP
F           6 E                                               *  MATID
F      422.75 E                                                *  TW
*
*
* COMPONENT NO. 32 ****************************************************
* SEPARATOR MIDDLE LOOP 3 *************************************************
*
TEE                32          32    SEPARATOR-MIDDLE LOOP 3
*     JCELL        NODES         MAT         COST        ICHF     C  2
        4            4      6      1.0         1
*     ICONC1       NCELL1        JUN1        JUN2        IPOW1    C  3
        0            4     32       33         0
*     IQPTR1       IQPSV1       NQPTB1       NQPSV1      NQPRF1   C  5
        0            0      0        0         0
*     RADIN1         TH1       HOUTL1       HOUTV1      TOUTL1    C  6
       1.25        .025     0.       0.        300.
*     TOUTV1        PWIN1      PWOFF1       RPWMX1      PWSCL1    C  7
       300.          0.     0.       0.         0.
*      QPIN1       QPOFF1      RQPMX1       QPSCL1                C  8
        0.           0.     0.       0.
*     ICONC2       NCELL2        JUN3        IPOW2                C  9
        0            4     39        0
*     IQPTR2       IQPSV2       NQPTB2       NQPSV2      NQPRF2   C 11
        0            0      0        0         0
*     RADIN2         TH2       HOUTL2       HOUTV2      TOUTL2    C 12
       1.25        .025     0.       0.        300.
*     TOUTV2        PWIN2      PWOFF2       RPWMX2      PWSCL2    C 13
       300.          0.     0.       0.         0.
*      QPIN2       QPOFF2      RQPMX2       QPSCL2                C 14
        0.           0.     0.       0.
* PRIMARY *
       .188        0.710       0.710          .2 E          *  DX
       .1574       0.7558      0.7558     0.2129 E           *  VOL
      0.6101       1.0645      1.0645 R 2  1.0645 E          *  FA
       .3621 R 3   0.          1.E30  E                    *  FRIC
       .9053 R 4   0. E                                    *  RVFRI
F        1.0 E                                             *  GRAV
      .15830 F     0.2091 E                                   *
F           0 E                                            *  ICFLG
F           1 E                                            *  NFF
F          1. E                                            *  ALP
F          0. E                                            *  VL
F          0. E                                            *  VV
F      422.75 E                                              *  TL
F      422.75 E                                              *  TV
F   2.60E+05 E                                                *  P
F          0. E                                            *  PA
F          0. E                                            *  QPPP
F           6 E                                            *  MATID
F      422.75 E                                              *  TW
* SECONDARY *
      0.7100        .710        .188         .424 E          *  DX
      2.4517       2.4617      0.7057      1.7130 E           *  VOL
R 3   3.4673   R 2  4.0401 E                                  *  FA
F         0.0 E                                            *  FRIC
F          0. E                                            *  RVFRIC
F        -1.0 E                                            *  GRAV
F        0.44 E                                            *  HD
F           0 E                                            *  ICFLG
F           1 E                                            *  NFF
R 3        1.      1.00 E                                   *  ALP
F          0. E                                            *  VL
F          0. E                                            *  VV
     422.752 F     422.75 E                                   *  TL
     422.752 F     422.75 E                                   *  TV
F   2.60E+05 E                                              *  P
F          0. E                                            *  PA
F          0. E                                            *  QPPP
F           6 E                                            *  MATID
F      422.75 E                                              *  TW
*
* COMPONENT NO. 33 ****************************************************
* SEPARATOR TOP LOOP 3 ******************************************************
*
TEE                33          33    SEPARATOR-TOP LOOP 3
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```
*      JCELL        NODES          MAT          COST         ICHF      C  2
       3            4         6          0.0          1
*      ICONC1       NCELL1         JUN1         JUN2         IPOW1     C  3
       0            4         33         34           0
*      IQPTR1       IQPSV1         NQPTB1       NQPSV1       NQPRF1    C  5
       0            0         0          0            0
*      RADIN1       TH1            HOUTL1       HOUTV1       TOUTL1    C  6
       1.25         .025      0.         0.           300.
*      TOUTV1       PWIN1          PWOFF1       RPWMX1       PWSCL1    C  7
       300.         0.        0.         0.           0.
*      QPIN1        QPOFF1         RQPMX1       QPSCL1                 C  8
       0.           0.        0.         0.
*      ICONC2       NCELL2         JUN3         IPOW2                  C  9
       0            1         33[illegible]
*      IQPTR2       IQPSV2         NQPT[illegible]  NQPSV2    NQPRF2    C 11
       0            0         0          [illegible]  0
*      RADIN2       TH2            HOUTL2       HOUTV2       TOUTL2    C 12
       1.25         .025      0.         0.           300.
*      TOUTV2       PWIN2          PWOFF2       RPWMX2       PWSCL2    C 13
       300.         0.        0.         0.           0.
*      QPIN2        QPOFF2         RQPMX2       QPSCL2                 C 14
       0.           0.        0.         0.
* PRIMARY *
       0.2          .285           0.4          0.810 E            *  DX
       0.2129       1.5732         1.8919       3.0974 E           *  VOL
R 2    1.0645 R 2   4.7298         0.44179 E                       *  FA
       1.E30 F      0.0 E                                          *  FRIC
F      0. E                                                        *  RVFRIC
F      1.0 E                                                       *  GRAV
R 2    0.2091 R 2   2.454          0.75 E                          *  HD
F      0 E                                                         *  ICFLG
F      1 E                                                         *  NFF
F      1. E                                                        *  ALP
F      0. E                                                        *  VL
F      0. E                                                        *  VV
F      422.75 E                                                    *  TL
F      422.75 E                                                    *  TV
F      2.60E+05 E                                                  *  P
F      0. E                                                        *  PA
F      0. E                                                        *  QPPP
F      6 E                                                         *  MATID
F      422.75 E                                                    *  TW
* SECONDARY *
F      1.0 E                                                       *  DX
F      .126 E                                                      *  VOL
F      .126 E                                                      *  FA
F      0.0 E                                                       *  FRIC
F      0. E                                                        *  RVFRIC
F      0.0 E                                                       *  GRAV
F      .4 E                                                        *  HD
F      0 E                                                         *  ICFLG
F      1 E                                                         *  NFF
F      1. E                                                        *  ALP
F      0. E                                                        *  VL
F      0. E                                                        *  VV
F      422.75 E                                                    *  TL
F      422.75 E                                                    *  TV
F      2.60E+05 E                                                  *  P
F      0. E                                                        *  PA
F      0. E                                                        *  QPPP
F      6 E                                                         *  MATID
F      422.75 E                                                    *  TW
*
* COMPONENT NO. 34 ****************************************************
* LOOP SEAL AND COLD LEG LOOP 3 ***************************************
*
TEE             34            34  LOOP-SEAL COLD-LEG LOOP 3
*      JCELL        NODES          MAT          COST         ICHF      C  2
       17           4         6          .5           1
*      ICONC1       NCELL1         JUN1         JUN2         IPOW1     C  3
       0            21        34         37           0
*      IQPTR1       IQPSV1         NQPTB1       NQPSV1       NQPRF1    C  5
       0            0         0          0            0
*      RADIN1       TH1            HOUTL1       HOUTV1       TOUTL1    C  6
       .375         .01       0.         0.           300.
*      TOUTV1       PWIN1          PWOFF1       RPWMX1       PWSCL1    C  7
       300.         0.        0.         0.           0.
*      QPIN1        QPOFF1         RQPMX1       QPSCL1                 C  8
       0.           0.        0.         0.
*      ICONC2       NCELL2         JUN3         IPOW2                  C  9
       0            1         360        0
*      IQPTR2       IQPSV2         NQPTB2       NQPSV2       NQPRF2    C 11
       0            0         0          0            0
*      RADIN2       TH2            HOUTL2       HOUTV2       TOUTL2    C 12
       .11          .01       0.         0.           300.
*      TOUTV2       PWIN2          PWOFF2       RPWMX2       PWSCL2    C 13
       300.         0.        0.         0.           0.
*      QPIN2        QPOFF2         RQPMX2       QPSCL2                 C 14
       0.           0.        0.         0.
* PRIMARY *
       1.2 R 2      1.9125         1.2 R 3      2.317        1.514   *  DX
R 2    1.665 R 2    1.092          .65S                              *  DX
       .600 R 2     1.495          1.5050       1.9110  R 2  1.6825  *  DX
       0.710 E                                                       *  DX
       .5301 R 2    .8449          .5301 R 3    1.0236       .6689   *  VOL
R 2    .7356 R 2    .4824          .7200        .9480 S              *  VOL
R 2    0.66048      0.66489        0.40247 R 2  0.74331      0.38038 E  *  VOL
R 12   .44179       .00000         .6892 R 7    .44179       .6362 E *  FA
       0. R 11      .019           10.76 R 8    .008         .0205 E *  FRIC
```

```
       0. R 11   .019        7.75 R 8    .008        .0205 E* RVFRIC
     1.0       .2313        0.0      -.2313 R 4    -1.   F   GRAV
  -.49350       0.0        .7978       1.0        .372  *   GRAV
   -.7752      .1411 R 7     0.0 E                      *   GRAV
R 21   .75        0.90 E                                *   HD
R 12    0          1 F        0 E                       * ICFLAG
F       1 E                                             *  NFF
R07     1.     1.0   1.    1.0    1. E                  *   ALP
R10     1. E
F      0.0 E                                            *   VL
F      0.0 E                                            *   VV
F    416.78 E                                           *    TL
F    416.78 E                                           *    TV
F  2.60E+05 E                                           *     P
F      0.0 E                                            *   PA
F      0.0 E                                            *  QPPP
F      6 E                                              * MATID
F    416.78 E                                           *    TW
* SECONDARY *
F      0.50 E                                           *   DX
F     0.019 E                                           *   VOL
F  *.8010E-02 E                                         *    FA
F      0. E                                             *  FRIC
F      0. E                                             * RVFRIC
F     +1. E                                             *  GRAV
F  2.2000E-01 E                                         *    HD
F       0 E                                             * ICFLG
F       1 E                                             *  NFF
F      1. E                                             *  ALP
F      0. E                                             *   VL
F      0. E                                             *   VV
F    416.78 E                                           *    TL
F    416.78 E                                           *    TV
F  2.60E+05 E                                           *     P
F      0. E                                             *   PA
F      0. E                                             *  QPPP
F      6 E                                              * MATID
F    416.78 E                                           *    TW
* COMPONENT NO. 38 ******************************************************
* SEPARATOR DRAIN TEE LOOP 3 **********************************************
*
TEE           38          38    SEP. DRAIN TEE LOOP 3
*    JCELL        NODES        MAT        COST       ICHF      C  2
       5            4          6    0.0       1
*    ICONC1       NCELL1       JUN1       JUN2       IPOW1     C  3
       0            6         39    339        0
*    IQPTR1       IQPSV1      NQPTB1      NQPSV1     NQPRF1    C  5
       0            0          0       0       0
*    RADIN1        TH1        HOUTL1      HOUTV1     TOUTL1    C  6
      0.1         .025         0.      0.      300.
*    TOUTV1        PWIN1      PWOFF1      RPWMX1     PWSCL1    C  7
      300.          0.         0.      0.       0.
*    QPIN1        QPOFF1      RQPMX1      QPSCL1               C  8
       0.           0.         0.      0.
*    ICONC2       NCELL2       JUN3       IPOW2                C  9
       0            1        330       0
*    IQPTR2       IQPSV2      NQPTB2      NQPSV2     NQPRF2    C 11
       0            0          0       0       0
*    RADIN2        TH2        HOUTL2      HOUTV2     TOUTL2    C 12
      0.1         .025         0.      0.      300.
*    TOUTV2        PWIN2      PWOFF2      RPWMX2     PWSCL2    C 13
      300.          0.         0.      0.       0.
*    QPIN2        QPOFF2      RQPMX2      QPSCL2               C 14
       5.           0.         0.      0.
* PRIMARY *
       0.9 R 2    0.925 R 3   0.4913 E                         *   DX
    0.0283 R 2    0.029 R 3   0.0964 E                         *   VOL
    4.0401 R 2   0.0314 R 4   0.1963 E                         *    FA
F      0. E                                                    *  FRIC
F      0. E                                                    * RVFRIC
      -1.0      -0.3364        0.     -0.3470 R 3    -1.0 E*   GRAV
      0.44 R 2     0.2 F       0.5 E                           *    HD
F       0 E                                                    * ICFLG
F       1 E                                                    *  NFF
R05     1.0 R01     1. E                                       *   ALP
F      0. E                                                    *   VL
F      0. E                                                    *   VV
R 5   422.75       308.15  E                                   *    TL
R05   422.75       308.15  E                                   *    TV
F  2.60E+05 E                                                  *     P
F      0. E                                                    *   PA
F      0. E                                                    *  QPPP
F      6 E                                                     * MATID
R 20 422.75   F 308.15 E
* SECONDARY *
F      0.5 E                                                   *   DX
F    0.0266 E                                                  *   VOL
F   0.05326 E                                                  *    FA
F      0.0 E                                                   *  FRIC
F      0. E                                                    * RVFRIC
F      0.0 E                                                   *  GRAV
F    0.2604 E                                                  *    HD
F       0 E                                                    * ICFLG
F       1 E                                                    *  NFF
F      1.0 E                                                   *   ALP
F      0. E                                                    *   VL
F      0. E                                                    *   VV
F    422.75 E                                                  *    TL
F    422.75 E                                                  *    TV
```

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F     2.60E+05 E                                        *   P
F          0. E                                        *  PA
F          0. E                                        *  QPPP
F           6 E                                        * MATID
F       422.75 E                                       *   TW
* COMPONENT NO. 39 ****************************************************
* SEPARATOR DRAIN VALVE LOOP 3 *******************************************
*VALVE          39         39       SEPARATOR DRAIN VALVE
*   NCELLS       NODES       JUN1        JUN2        MAT
         2           4        330          38           6
*    ICHF        ICONC       IVTY        IVPS        NVTB2
         1           0          1           2           0
*    IVTR         IVSV       NVTB1       NVSV        NVRF
         0         100          2           0           0
*   IQP3TR       IQP3SV     NQP3TB      NQP3SV      NQP3RF
         0           0          0           0           0
*   IVTROV       IVTYOV
         0           0
*    RVMX         RVOV      FMINOV      FMAXOV
      1.E10          0.          0.          1.
*   RADIN          TH        HOUTL       HOUTV       TOUTL
      .015        .005          0.          0.        300.
*   TOUTV        AVLVE       HVLVE       FAVLVE      XPOS
      300.      .03140         .20         1.0          0
*   QP3IN        QP3OFF      RQP3MX      QP3SCL
        0.           0.         0.          0.
       0.5        1.0 E                                *  DX
    0.0266     0.05326 E                                *  VOL
F  0.05326 E                                            *  FA
        0.       1.944 F      0. E                      *  FRIC
        0.       1.944 F      0. E                      * RVFRIC
R 2     0.       .4220 E                                *  GRAV
F   0.2604 E                                            *  HD
F        0 E                                            * ICFLG
F        1 E                                            *  NFF
       1.0          1. E                                *  ALP
F       0. E                                            *  VL
F       0. E                                            *  VV
F   422.75 E                                            *   TL
F   422.75 E                                            *   TV
F 2.60E+05 E                                            *   P
F       0. E                                            *  PA
F       0. E                                            *  QPPP
F        6 E                                            * MATID
F   422.75 E                                            *   TW
*     T(S)       POS(-)
        0.        1.0 S                                 * VTB1
     300.0        1.0 E                                 * VTB1
*
*
* COMPONENT NO.333 *****************************************************
* STEAM SUPPLY FILL LOOP 3 ***********************************************
*FILL          333         333     STEAM SUPPLY LOOP 3
*   JUN1         IFTY        IOFF                        C 2
       333           5          0
*   IFTR         IFSV        NFTB        NFSV        NFRF     C 3
         0        -003          0           0           0
*   TWTOLD       RFMX        CONCIN                           C 4
        0.          15.         0.
*   DXIN         VOLIN       ALPIN       VLIN        TLIN     C 5
         1         .126          1.         0.      422.75
*   PIN          PAIN        FLOWIN      VVIN        TVIN     C 6
  19.88E+05          0.          0.          0.     422.75
* COMPONENT NO. 339 ****************************************************
* SEPARATOR DRAIN FILL LOOP 3 ********************************************
*FILL          339         339 SEPARATOR DRAIN FILL LOOP 3
*   JUN1         IFTY        IOFF                        C 2
       339           6          1
*   IFTR         IFSV        NFTB        NFSV        NFRF     C 3
       666         100         -2           0           0
*   TWTOLD       RFMX        CONCIN                           C 4
        0.        20.0          0.
*   DXIN         VOLIN       ALPIN       VLIN        TLIN     C 5
    0.4913     0.09640          0.          0.      308.15
*   PIN          PAIN        FLOWIN      VVIN        TVIN     C 6
  2.60E+05          0.          0.          0.      308.15
*   VMSCL        VVSCL                                    C 9
         1.          1.
*  TIME (S)    MASS FLOW (KG/S)    *
        0.        0. S
        5.      -25. E
*
* COMPONENT NO. 35 *****************************************************
* HOT LEG ECC FILL LOOP 3 ************************************************
*FILL           35          35     HOT-LEG-ECC LOOP 3
*   JUN1         IFTY        IOFF                        C 2
        35           8          0
*   IFTR         IFSV        NFTB        NFSV        NFRF     C 3
       666         100         -6           0           0
*   TWTOLD       RFMX        CONCIN                           C 4
        0.       1.E10          0.
*   DXIN         VOLIN       ALPIN       VLIN        TLIN     C 5
       3.3         .134         0.          0.      303.35
```

```
*      PIN        PAIN      FLOWIN       VVIN       TVIN     C 6
   2.60E+05        0.         0.        0.    303.35
*    VMSCL        VVSCL                              C 9
       1.           1.
*   TIME (S)    MASS FLOW (KG/S),    *
       0.          0. S
       2.5       500. S
      12.5       500. S
      12.5       500. S
      32.5       400. S
     110.5       300. E
*  *
*  *
*
* COMPONENT NO. 36 ***********************************************************
* COLD LEG ECC FILL LOOP 3 ***************************************************
*
FILL             36          36      COLD-LEG-ECC LOOP 3
*     JUN1        IFTY        IOFF                        C 2
       36          6          0
*     IFTR        IFSV        NFTB       NFSV       NFRF     C 3
      116         100         12          0          0
*    TWTOLD           RFMX       CONCIN                      C 4
       0.        1.E10        0.
*     DXIN        VOLIN       ALPIN       VLIN       TLIN     C 5
      3.3         .125         0.         0.      381.65
*     PIN         PAIN       FLOWIN      VVIN       TVIN     C 6
   11.0E+05        0.          0.         0.      386.15
*    VMSCL        VVSCL                             C 9
       1.          1.
*    TL3CL        TVSCL       PSCL      PASCL        CONSCL   C 10
      1.0          1.0      1.E+05      1.          1.0
*     T(S)        VLTB(M/S)
      0.00         0.00    S
     38.00         0.00    S
     42.00         0.00    S
     45.00        13.76    S
     50.00        13.77    S
     57.80        13.78    S
     80.00        13.86    S
     90.00        13.87    S
    118.00        13.89    S
    120.00        11.67    S
    125.00         0.00    S
    140.00         0.00    E
*     T(S)        VVTB(M/S)
      0.00         0.0     S
     38.00         0.0     S
     42.00         0.0     S
     45.00         0.0     S
     50.00         0.0     S
     57.80         0.0     S
     80.00         0.0     S
     90.00         0.0     S
    118.00         0.0     S
    120.00         0.0     S
    125.00         0.0     S
    140.00         0.0     E
*     T(S)          TL
      0.00       381.65    S
     38.00       381.65    S
     42.00       381.85    S
     45.00       382.15    S
     50.00       383.65    S
     57.80       384.15    S
     80.00       391.65    S
     90.00       392.40    S
    118.00       393.65    S
    120.00       393.65    S
    125.00       393.55    S
    140.00       393.45    E
*     T(S)          TV
      0.00        457.3    S
     38.00        457.3    S
     42.00        457.3    S
     45.00        457.3    S
     50.00        457.3    S
     57.80        457.3    S
     80.00        457.3    S
     90.00        457.3    S
    118.00        457.3    S
    120.00        457.3    S
    125.00        457.3    S
    140.00        457.3    E
*     T(S)         ALPHA
      0.00         0.0     S
     38.00         0.0     S
     42.00         0.0     S
     45.00         0.0     S
     50.00         0.0     S
     57.80         0.0     S
     80.00         0.0     S
     90.00         0.0     S
    118.00         0.0     S
    120.00         0.0     S
    125.00         0.0     S
    140.00         0.0     E
*     T(S)        P(BARS)
      0.00        11.0     S
```

```
        38.00        11.0   S
        42.00        11.0   S
        45.00        11.0   S
        50.00        11.0   S
        57.80        11.0   S
        80.00        11.0   S
        90.00        11.0   S
       118.00        11.0   S
       120.00        11.0   S
       125.00        11.0   S
       140.00        11.0   E
*       T(S)         PA(BARS)
         0.00        0.0    S
        38.00        0.0    S
        42.00        0.0    S
        45.00        0.0    S
        50.00        0.0    S
        57.80        0.0    S
        80.00        0.0    S
        90.00        0.0    S
       118.00        0.0    S
       120.00        0.0    S
       125.00        0.0    S
       140.00        0.0    E
*
*
* COMPONENT NO. 40 *******************************************************
*
TEE            40        40        HOT-LEG LOOP 4
*   JCELL      NODES      MAT       COST       ICHF      C 2
      4          4         6         -1.          1
*   ICONC1     NCELL1     JUN1      JUN2       IPOW1     C 3
      0          8        40         41          0
*   IQPTR1     IQPSV1     NQPTB1    NQPSV1     NQPRF1    C 5
      0          0         0          0          0
*   RADIN1     TH1        HOUTL1    HOUTV1     TOUTL1    C 6
     .375       .01        0.         0.        300.
*   TOUTV1     PWIN1      PWOFF1    RPWMX1     PWSCL1    C 7
     300.        0.        0.         0.         0.
*   QPIN1      QPOFF1     RQPMX1    QPSCL1               C 8
      0.         0.        0.         0.
*   ICONC2     NCELL2     JUN3      IPOW2                C 9
      0          1        45          0
*   IQPTR2     IQPSV2     NQPTB2    NQPSV2     NQPRF2    C 11
      0          0         0          0          0
*   RADIN2     TH2        HOUTL2    HOUTV2     TOUTL2    C 12
     .11        .01        0.         0.        300.
*   TOUTV2     PWIN2      PWOFF2    RPWMX2     PWSCL2    C 13
     300.        0.        0.         0.         0.
*   QPIN2      QPOFF2     RQPMX2    QPSCL2               C 14
      0.         0.        0.         0.
* PRIMARY *
R 3     .5107 R 2    1.8718       2.135      .9817     .6396 E*   DX
R 3     .2256 R 2     .732         .9432     .4337     .2826 E*   VOL
R 3    .44179 R 2     .3913 R 4   .44179 E                      * FA
R 2        .0 R 5    0.016 R 2     0.0 E                        * FRIC
R 2        0. R 5     .016 R 2      0. E                        * RVFRIC
R 7       0.0         .776        0.766 E                       * GRAV
R 3       .75 R 2     .6329 F       .75 E                       * HD
R 3        0          1 F           0 E                         * ICFLG
R 1        0 F        1 E                                       * NFF
F          1. E                                                 * ALP
F          0. E                                                 * VL
F          0. E                                                 * VV
F      423.15 E                                                 * TL
F      423.15 E                                                 * TV
F   2.60E+05 E                                                  * P
F          0. E                                                 * PA
F          0. E                                                 * QPPP
F           6 E                                                 * MATID
F      423.15 E                                                 * TW
* SECONDARY *
F         10. E                                                 * DX
F      .40660 E                                                 * VOL
F      .04066 E                                                 * FA
F         0.0 E                                                 * FRIC
F          0. E                                                 * RVFRIC
F        -1.0 E                                                 * GRAV
F       .2077 E                                                 * HD
F           0 E                                                 * ICFLG
F           1 E                                                 * NFF
F         1.0 E                                                 * ALP
F          0. E                                                 * VL
F          0. E                                                 * VV
F      419.08 E                                                 * TL
F      419.08 E                                                 * TV
F   2.60E+05 E                                                  * P
F          0. E                                                 * PA
F          0. E                                                 * QPPP
F           6 E                                                 * MATID
F      419.08 E                                                 * TW
*
*
* COMPONENT NO. 45
* HOT LEG ECC FILL LOOP 4
*
FILL           45        45        HOT-LEG-ECC LOOP 4
*   JUN1       IFTY       IOFF                           C 2
     45          8         0
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```
*     IFTR      IFSV      NFTB      NFSV      NFRF     C 3
      666       100       -6        0         0
*     TWTOLD    RFMX      CONCIN                       C 4
      0.        1.E10     0.
*     DXIN      VOLIN     ALPIN     VLIN      TLIN     C 5
      3.3       .134      0.        0.        303.35
*     PIN       PAIN      FLOWIN    VVIN      TVIN     C 6
      2.60E+05  0         0.        0.        303.35
*     VMSCL     VVSCL                                  C 9
      1         1.
*  TIME (S)   MASS FLOW (KG/S)  *
      0.        0. S
      2.5       500. S
      12.5      500 S
      12.5      500. S
      32.5      400. S
      110.5     300. E
*  *
*  *
*
* COMPONENT NO. 41
*TEE             41        41        BHL SEPARATOR
*     JCELL     NODES     MAT       COST      ICHF     C 2
      5         4         6         1.        1
*     ICONC1    NCELL1    JUN1      JUN2      IPOW1    C 3
      0         11        41        42        0
*     IQPTR1    IQPSV1    NQPTB1    NQPSV1    NQPRF1   C 5
      0         0         0         0         0
*     RADIN1    TH1       HOUTL1    HOUTV1    TOUTL1   C 6
      1.25      .025      0.        0.        300.
*     TOUTV1    PWIN1     PWOFF1    RPWMX1    PWSCL1   C 7
      300.      0         0.        0.        0.
*     QPIN1     QPOFF1    RQPMX1    QPSCL1             C 8
      0.        0         0.        0
*     ICONC2    NCELL2    JUN3      IPOW2              C 9
      0         7         449       0
*     IQPTR2    IQPSV2    NQPTB2    NQPSV2    NQPRF2   C 11
      0         0         0         0
*     RADIN2    TH2       HOUTL2    HOUTV2    TOUTL2   C 12
      1.25      .025      0.        0.        300.
*     TOUTV2    PWIN2     PWOFF2    RPWMX2    PWSCL2   C 13
      300.      0         0.        0.        0.
*     QPIN2     QPOFF2    RQPMX2    QPSCL2             C 14
      0.        0.        0.        0.
* PRIMARY *
      .9556     0.2814    0.202     0.424     0.188  *  DX
R 2   0.710     0.605     0.200     0.346     0.791 E*  DX
      2.597     1.330     0.9477    0.367     0.223  *  VOL
R 2   0.7356    0.644     0.946     1.6365    2.734 E*  VOL
      .44179    4.5584    4.7298 R 2  0.866 R 4  1.511 *  FA
R 2   4.7298    0.44179 E                            *  FA
R 3   .0        0.3621 R 4  0.0     0.E30 F   0.0 E*  FRIC
R 3   0.        .9053 F   0. E                       * RVFRIC
      .766 F    1.00 E                               *  GRAV
      0.75 R 2  2.300 R 2  .1583 R 4  0.2091 F  0.75 E*  FA
F     0 E                                            *  ICFLG
F     1 E                                            *  NFF
F     0. E                                           *  ALP
F     0. E                                           *  VL
F     0. E                                           *  VV
F     419.08 E                                       *  TL
F     419.08 E                                       *  TV
F     2.60E+05 E                                     *  P
F     0. E                                           *  PA
F     0. E                                           *  QPPP
F     6 E                                            *  MATID
F     419.08 E                                       *  TW
* SECONDARY *
R 2   0.710     0.188     0.424     0.900     1.850  *  DX
      1.474 E                                        *  DX
R 2   2.359     0.701     1.755     0.0283    0.0580 *  VOL
      0.2892 E                                       *  VOL
R 3   3.323 R 2  4.138 R 2  0.0314  .1963 E          *  FA
F     0 E                                            *  FRIC
F     0. E                                           * RVFRIC
R 5   -1.0      -.223     -.443     -1.0 E           *  GRAV
R 4   0.318 R 3  0.200    .40 E                      *  HD
F     0 E                                            *  ICFLG
F     1 E                                            *  NFF
R 4   1.        1.0  F    1.0 E                      *  ALP
F     0. E                                           *  VL
F     0. E                                           *  VV
R 4   419.08 F  308.15 E                             *  TL
R 4   419.08 F  308.15 E                             *  TV
F     2.60E+05 E                                     *  P
F     0. E                                           *  PA
F     0. E                                           *  QPPP
F     6 E                                            *  MATID
R 08  419.08 R20 308.15 E                            *  TW
* COMPONENT NO. 449
*FILL            449       449       BHL SEPARATOR DRAIN
*     JUN1      IFTY      IOFF                         C 2
      449       8         1
*     IFTR      IFSV      NFTB      NFSV      NFRF     C 3
      666       100       -2        0         0
*     TWTOLD    RFMX      CONCIN                       C 4
      0.        20.0      0.
```

```
*     DXIN        VOLIN       ALPIN       VLIN        TLIN      C 5
   1.4740     0.28920       0.          0.        308.15
*     PIN         PAIN        FLOWIN      VVIN        TVIN      C 6
  2.60E+05       0.           0.          0.       308.15
*     VMSCL       VVSCL                               C 9
      1.          1.
 *   TIME (S)    MASS FLOW (KG/S)    *
      0.          0. S
      5.        100. E
*
*
* COMPONENT NO. 42 ********************************************************
*
** BROKEN HOT LEG CROSSOVER PIPE,  **
** VALVE AND CONTAINMENT PIPING    **
*
VALVE          42          42          BHL VALVE
*    NCELLS       NODES       JUN1        JUN2        MAT
      12          0           42          91          6
*    ICHF         ICONC       IVTY        IVPS        NVTB2
      0           0           4           7           0
*    IVTR         IVSV        NVTB1       NVSV        NVRF
     666          100         -2          0           0
*    IVTROV       IVTYOV
      0           0
*    RVMX         RVOV        FMINOV      FMAXOV
     1.E10        0.          0.          1.
*    RADIN        TH          HOUTL       HOUTV       TOUTL
     .375         .005        0.          0.          300.
*    TOUTV        AVLVE       HVLVE       FAVLVE      XPOS
     300.         .44179      .75         0.          0.
*    QP3IN        QP3OFF      RQP3MX      QP3SCL
     1.080        3.825       1.225       5.077       3.148 S*    DX
     4.181        1.4         1.34        8.3        13.585 S*    DX
    13.585        4.33 E                                    *    DX
     0.4771       1.6898      0.5413      2.2429      1.3907 S*   VOL
     1.8471       0.6185      1.7786     11.0168     18.0317 S*   VOL
    18.0317       5.7473 E                                  *    VOL
R 4  0.44179      0.1325 R 2  0.44179 R 6  1.3273 E          *    FA
     0.0          0.02592     0.02515     0.0         0.0555 S*   FRIC
     0.01688      0.0         0.00        0.02023     0.00891 S*  FRIC
     0.0          0.01088     0.0 E                         *    FRIC
     0.0          0.02592     0.02515     0.0         0.25 S*   RVFRIC
     0.01688      0.0         0.00        0.02023     0.00891 S* RVFRIC
     0.0          0.01088     0.0 E                         *   RVFRIC
     1.0          0.2202     -0.2425     -1.0        -1.0 S*    GRAV
    -0.4295       0.0         0.0         0.861       0.3793 S*   GRAV
     0.0         -0.2417     -1.0 E                         *    GRAV
R 7  0.75 R 6     1.3 E                                     *    HD
R 4  0            1           0           1 F         0 E*   ICFLG
F    1 E                                                *    NFF
F    1.0 E                                              *    ALP
F    0.0 E                                              *    VL
F    0.0 E                                              *    VV
R 6  419.08 F     416.15 E                                  *    TL
R 6  419.08 F     416.15 E                                  *    TV
F    2.60E+05 E                                             *    P
F    0.0 E                                              *    PA
*
*    TIME(S)   STEM POS.(-)
      0.          0. S
     4.00         0. E
*
*
* COMPONENT NO. 46
*
VALVE          46          46          BCL PIPE AND VALVE
*    NCELLS       NODES       JUN1        JUN2        MAT
      6           4           47          46          6
*    ICHF         ICONC       IVTY        IVPS        NVTB2
      1           0           4           6           0
*    IVTR         IVSV        NVTB1       NVSV        NVRF
     446          100         20          0           0
*    IQP3TR       IQP3SV      NQP3TB      NQP3SV      NQP3RF
      0           0           0           0           0
*    IVTROV       IVTYOV
      0           0
*    RVMX         RVOV        FMINOV      FMAXOV
     1.E10        0.          0.          1.
*    RADIN        TH          HOUTL       HOUTV       TOUTL
     .375         .005        0.          0.          300.
*    TOUTV        AVLVE       HVLVE       FAVLVE      XPOS
     300.         .44179      .75         0.9753      0.
*    QP3IN        QP3OFF      RQP3MX      QP3SCL
      0.          0.          0.          0.
     0.67 R 2     1.5475 R 2  1.758       1.945 E         *    DX
     0.3611 R 2   0.6837      2.2867      0.7767      0.4418 E*   VOL
     .6362 F      .44179 E                              *    FA
F    0. E                                               *    FRIC
F    0. E                                               *   RVFRIC
F    0. E                                               *    GRAV
     .9 F         .75 E                                 *    HD
R 5  0            1 F         0 E                       *   ICFLG
F    1 E                                                *    NFF
F    1.0 E                                              *    ALP
F    0. E                                               *    VL
F    0. E                                               *    VV
R 5  412.15       412.15 E                              *    TL
R 5  412.15       412.15 E                              *    TV
```

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R 5  2.60E+05       2.60E+05 E                      *      P
F        0. E                                     *  PA
F        0. E                                     *  OPPP
F        6 E                                      *  MATID
R20    412.15 F     412.15 E                          *    TW
*
*        T(S)          VTBL(-)
         0.0          0.9753 S
        22.40         0.9753 S
        23.49         0.9755 S
        24.49         0.9762 S
        99.99         0.9755 S
       150.49         0.9756 S
       200.49         0.9756 S
       250.49         0.9755 S
       269.49         0.9755 S
       270.99         0.9117 S
       272.49         0.7423 S
       273.99         0.5781 S
       275.99         0.3582 S
       277.99         0.1473 S
       279.99         0.03359 S
       281.49         0.01548 S
       282.99         0.007362 S
       283.99         0.006766 S
       284.99         0.006713 S
       299.99         0.006511 F
*
*
* COMPONENT NO. 90 ***************************************************
*
BREAK            90          90      BCL CONTAINMENT BREAK
*       JUN1         ITBY        ISAT        IVDV        IOFF     C 2
         46          1           3           1           0
*       IBTR         IBSV        NBTB        NBSV        NBRF     C 3
         90          100         10          0           0
*       DXIN         VOLIN       ALPIN       TIN         PIN      C 4
         .5          25.         1.          434.00      2.28E+05
*       PAIN         CONCIN      RBMX        POFF        BELV     C 5
         0.          0.          1.E10       2.28E+05    0.
*       PSCL         TLSCL       TVSCL       PASCL       CONSCL   C 6
         1.          1.          1.          1.          1.
*
*        T(S)     P(PA)
         0.00    2.28E+05     S
        20.00    2.28E+05     S
        33.90    2.70E+05     S
        46.70    2.30E+05     S
        50.00    2.55E+05     S
        53.30    2.38E+05     S
        79.00    2.38E+05     S
       120.00    2.98E+05     S
       126.70    2.50E+05     S
       140.00    2.41E+05     E
*
* COMPONENT NO. 91 ***************************************************
*
BREAK            91          91      BHL CONTAINMENT BREAK
*       JUN1         ITBY        ISAT        IVDV        IOFF     C 2
         91          1           3           1           0
*       IBTR         IBSV        NBTB        NBSV        NBRF     C 3
         91          100         61          0           0
*       DXIN         VOLIN       ALPIN       TIN         PIN      C 4
         .5          25.         1.          416.15      2.592E+05
*       PAIN         CONCIN      RBMX        POFF        BELV     C 5
         0.          0           1.E10       2.592E+05   0.
*       PSCL         TLSCL       TVSCL       PASCL       CONSCL   C 6
         1.          1.          1.          1.          1.
*
*        T(S)           P(PA)
         0.0           2.592E+05 S
    4.8010E-01         2.592E+05 S
    5.4801E+00         2.598E+05 S
    1.0480E+01         2.599E+05 S
    1.5480E+01         2.593E+05 S
    2.0480E+01         2.572E+05 S
    2.5480E+01         2.585E+05 S
    3.0480E+01         2.568E+05 S
    3.5480E+01         2.514E+05 S
    4.0480E+01         2.489E+05 S
    4.5480E+01         2.462E+05 S
    5.0480E+01         2.458E+05 S
    5.5480E+01         2.467E+05 S
    6.0480E+01         2.466E+05 S
    6.5480E+01         2.463E+05 S
    7.0480E+01         2.472E+05 S
    7.5480E+01         2.469E+05 S
    8.0480E+01         2.482E+05 S
    8.5480E+01         2.508E+05 S
    9.0480E+01         2.512E+05 S
    9.5480E+01         2.519E+05 S
    1.0048E+02         2.527E+05 S
    1.0548E+02         2.536E+05 S
    1.1048E+02         2.550E+05 S
    1.1548E+02         2.554E+05 S
    1.2048E+02         2.555E+05 S
    1.2548E+02         2.545E+05 S
    1.3048E+02         2.540E+05 S
    1.3548E+02         2.540E+05 S
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1.4048E+02        2.528E+05 S
1.4548E+02        2.529E+05 S
1.5048E+02        2.519E+05 S
1.5548E+02        2.526E+05 S
1.6048E+02        2.530E+05 S
1.6548E+02        2.539E+05 S
1.7048E+02        2.551E+05 S
1.7548E+02        2.560E+05 S
1.8048E+02        2.561E+05 S
1.8548E+02        2.561E+05 S
1.9048E+02        2.565E+05 S
1.9548E+02        2.563E+05 S
2.0048E+02        2.558E+05 S
2.0548E+02        2.554E+05 S
2.1048E+02        2.550E+05 S
2.1548E+02        2.546E+05 S
2.2048E+02        2.546E+05 S
2.2548E+02        2.538E+05 S
2.3048E+02        2.512E+05 S
2.3548E+02        2.519E+05 S
2.4048E+02        2.578E+05 S
2.4548E+02        2.581E+05 S
2.5048E+02        2.529E+05 S
2.5548E+02        2.538E+05 S
2.6048E+02        2.554E+05 S
2.6548E+02        2.560E+05 S
2.7048E+02        2.565E+05 S
2.7548E+02        2.570E+05 S
2.8048E+02        2.572E+05 S
2.8548E+02        2.571E+05 S
2.9048E+02        2.572E+05 S
2.9548E+02        2.573E+05 E
*
*
*ARAYA    THE FOLLOWING COMPONENT DATA WERE ADDED FOR MODELLING THE
*         NITROGEN INJECTION SYSTEM.
*         THE GEOMETRICAL DATA MAY NOT CORRECT BECAUSE OF NO KNOWLEDGE
*         ON DIMENSIONS OF THE SYSTEM.  THIS SHOULD BE CORRECTED AFTER
*         GETTING THE DATA.
*
*         NEW COMPONENT DATA FOR THE NITROGEN INJECTION SYSTEM
*
* COMP. 160 FOR THE COLD LEG ECC PIPE AND N2 INJ. PIPE, LOOP 1, TEE
*
*******    TYPE          NUM          ID     CTITLE
TEE                      160          160 ECC & N2 INJ. PIPES LOOP 1
*      JCELL          NODES          MAT          COST          ICHF
           2              4            6            0.            0
*      ICONC1         NCELL1         JUN1         JUN2          IPOW1
           0              3           16          160             0
*      IQPTR1         IQPSV1         NQPTB1       NQPSV1        NQPRF1
           0              0            0            0             0
*      RADIN1          TH1           HOUTL1       HOUTV1        TOUTL1
   1.1000E-01     1.0000E-02   0.0000E+00   0.0000E+00    3.0000E+02
*      TOUTV1          PWIN1         PWOFF1       RPWMX1        PWSCL1
   3.0000E+02             0.           0.           0.            0.
*      QPIN1          QPOFF1         RQPMX1       QPSCL1
   0.0000E+00     0.0000E+00   0.0000E+00   0.0000E+00
*      ICONC2         NCELL2         JUN3         IPOW2
           0              1          161            0
*      IQPTR2         IQPSV2         NQPTB2       NQPSV2        NQPRF2
           0              0            0            0             0
*      RADIN2          TH2           HOUTL2       HOUTV2        TOUTL2
   1.1000E-01     1.0000E-02   0.0000E+00   0.0000E+00    3.0000E+02
*      TOUTV2          PWIN2         PWOFF2       RPWMX2        PWSCL2
   3.0000E+02             0.           0.           0.            0.
*      QPIN2          QPOFF2         RQPMX2       QPSCL2
   0.0000E+00     0.0000E+00   0.0000E+00   0.0000E+00
*
* DX     * R0  0.5 E
* VOL    * R03 1.7000E-02 E
* FA     * F   3.8010E-02 E
* FRIC   * F   0.0000E+00 E
* RV FRI * F   0.0000E+00 E
* GRAV   * R03 0.0000E+00 R01 -1.0 E
* HD     * F   2.2000E-01E
* ICFLG  * F            0E
* NFF    * F            1E
* ALP    * F   1.0000E+00E
* VL     * F   0.0000E+00E
* VV     * F   0.0000E+00E
* TL     * F   4.1118E+02E
* TV     * F   4.1118E+02E
* P      * F   2.6000E+05E
* PA     * F   0.0000E+00E
* QPPP   * F   0.0000E+00E
* MATID  * F            6E
* TW     * F   4.1118E+02E
*
* DX     *     0.5 E
* VOL    *     1.7000E-02 E
* FA     * F   3.8010E-02E
* FRIC   * F   0.0000E+00 E
* RV FRI * F   0.0000E+00 E
* GRAV   * F   1.0000E+00 E
* HD     * F   2.2000E-01E
* ICFLG  * F            0E
* NFF    * F            1E
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* ALP   *    1.0000E+00E
* VL    * F  0.0000E+00E
* VV    * F  0.0000E+00E
* TL    *    4.1118E+02E
* TV    *    4.1118E+02E
* P     *    2.6000E+05E
* PA    *    0.0000E+00E
* QPPP  * F  0.0000E+00E
* MATID * F          6E
* TW    * F  4.1118E+02E
*
*COMPONENT 161 FOR THE NITROGEN INJECTION FILL, LOOP 1, FILL
*
*******   TYPE        NUM        ID     CTITLE
FILL                  161        161 N2 INJ. FILL LOOP 1
*      JUN1          IFTY         IOFF
        161             8          0
*      IFTR          IFSV         NFTB         NFSV        NFRF
         90           100          6            0           0
*    TWTOLD          RFMX       CONCIN          FLV
  0.0000E+00    1.0000E+10   0.0000E+00   0.0000E+00
*      DXIN         VOLIN        ALPIN         VLIN        TLIN
  5.0000E-01    1.7000E-02   1.0000E+00   0.0000E+00   310.0
*       PIN          PAIN       FLOWIN         VVIN        TVIN
  2.215E+06     2.215E+06    0.0000E+00   0.0000E+00   310.0
*     VMSCL         VVSCL
  1.0000E+00    1.0000E+00
*
*NITROGEN INJECTION MASS FLOW RATE TABLE
*      T(S)         VMTB(KG/S)
        0.0          0.0 S
       38.00         0.0 S
       40.0000       0.340000 S
      120.0000       0.340000 S
      122.5000       0.0      S
        1.E+05       0.0      E
*
* COMP. 260 FOR THE COLD LEG ECC PIPE AND N2 INJ. PIPE, LOOP 2, TEE
*
*******   TYPE        NUM        ID     CTITLE
TEE                   260        260 ECC & N2 INJ. PIPES LOOP 2
*     JCELL         NODES          MAT         COST        ICHF
          2             4          6           0.           0
*    ICONC1        NCELL1         JUN1         JUN2       IPOW1
          0             8         26          260           0
*    IQPTR1        IQPSV1       NQPTB1       NQPSV1      NQPRF1
          0             0          0            0           0
*   RADIN1           TH1       HOUTL1       HOUTV1      TOUTL1
  1.1000E-01    1.0000E-02   0.0000E+00   0.0000E+00   3.0000E+02
*    TOUTV1         PWIN1       PWOFF1       RPWMX1      PWSCL1
  3.0000E+02            0.           0.           0.          0.
*     QPIN1        QPOFF1       RQPMX1       QPSCL1
  0.0000E+00    0.0000E+00   0.0000E+00   0.0000E+00
*    ICONC2        NCELL2         JUN3        IPOW2
          0             1        261            0
*    IQPTR2        IQPSV2       NQPTB2       NQPSV2      NQPRF2
          0             0          0            0           0
*   RADIN2           TH2       HOUTL2       HOUTV2      TOUTL2
  1.1000E-01    1.0000E-02   0.0000E+00   0.0000E+00   3.0000E+02
*     QPIN2        QPOFF2       RQPMX2       QPSCL2
  0.0000E+00    0.0000E+00   0.0000E+00   0.0000E+00
*     QPIN2        QPOFF2       RQPMX2       QPSCL2
  0.0000E+00    0.0000E+00   0.0000E+00   0.0000E+00
*
* DX    * R03 0.5 E
* VOL   * R03 1.7000E-02 E
* FA    * F  3.8010E-02 E
* FRIC  * F  0.0000E+00 E
* RV FRI* F  0.0000E+00 E
* GRAV  * R03 0.0000E+00 R01 -1.0 E
* HD    * F  2.2000E-01E
* ICFLG * F          0E
* NFF   * F          1E
* ALP   * F  1.0000E+00E
* VL    * F  0.0000E+00E
* VV    * F  0.0000E+00E
* TL    * F  4.1415E+02E
* TV    * F  4.1415E+02E
* P     * F  2.6000E+05E
* PA    * F  0.0000E+00E
* QPPP  * F  0.0000E+00E
* MATID * F          6E
* TW    * F  4.1415E+02E
*
* DX    *    0.5 E
* VOL   *    1.7000E-02 E
* FA    * F  3.8010E-02E
* FRIC  * F  0.0000E+00 E
* RV FRI* F  0.0000E+00 E
* GRAV  * F  1.0000E+00 E
* HD    * F  2.2000E-01E
* ICFLG * F          0E
* NFF   * F          1E
* ALP   *    1.0000E+00E
* VL    * F  0.0000E+00E
* VV    * F  0.0000E+00E
* TL    *    4.1415E+02E
* TV    *    4.1415E+02E
* P     *    2.6000E+05E
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* PA    *    0.0000E+00E
* QPPP  * F  0.0000E+00E
* MATID * F          6E
* TW    * F  4.1415E+02E
*
*COMPONENT 261 FOR THE NITROGEN INJECTION FILL, LOOP 2, FILL
*
*******   TYPE         NUM         ID       CTITLE
FILL                   261         261 N2 INJ. FILL LOOP 2
*        JUN1          IFTY        IOFF
          261            8          0
*          TR          IFSV        NFTB        NFSV        NFRF
           90          100           5           0           0
*      TWTOLD          RFMX      CONCIN        FELV
   0.0000E+00    1.0000E+10  0.0000E+00  0.0000E+00
*        DXIN         VOLIN       ALPIN        VLIN        TLIN
   5.0000E-01    1.7000E-02  1.0000E+00  0.0000E+00       310.0
*         PIN          PAIN      FLOWIN        VVIN        TVIN
    2.215E+06     2.215E+06  0.0000E+00  0.0000E+00       310.0
*       VMSCL         VVSCL
   1.0000E+00    1.0000E+00
*
*NITROGEN INJECTION MASS FLOW RATE TABLE
*        T(S)         VMTB(KG/S)
          0.0          0.0 S
        38.00          0.0 S
      40.0000          0.340000 S
     120.0000          0.340000 S
     122.5000          0.0      S
       1.E+05          0.0      E
*
************************
* COMP. 360 FOR THE COLD LEG ECC PIPE AND N2 INJ. PIPE, LOOP 3, TEE
************************
*
*******   TYPE         NUM         ID       CTITLE
TEE                    360         360 ECC & N2 INJ. PIPES LOOP 3
*       JCELL         NODES         MAT        COST        ICHF
            2             4           6          0.           0
*      ICONC1        NCELL1        JUN1        JUN2       IPOW1
            0             3          36         360           0
*      IQPTR1        IQPSV1      NQPTB1      NQPSV1      NQPRF1
            0             0           0           0           0
*      RADIN1           TH1      HOUTL1      HOUTV1      TOUTL1
   1.1000E-01    1.0000E-02  0.0000E+00  0.0000E+00  3.0000E+02
*      TOUTV1         PWIN1      PWOFF1      RPWMX1      PWSCL1
   3.0000E+02            0.          0.          0.          0.
*       QPIN1        QPOFF1      RQPMX1      QPSCL1
   0.0000E+00    0.0000E+00  0.0000E+00  0.0000E+00
*      ICONC2        NCELL2        JUN3       IPOW2
            0             1         361           0
*      IQPTR2        IQPSV2      NQPTB2      NQPSV2      NQPRF2
            0             0           0           0           0
*      RADIN2           TH2      HOUTL2      HOUTV2      TOUTL2
   1.1000E-01    1.0000E-02  0.0000E+00  0.0000E+00  3.0000E+02
*       QPIN2        QPOFF2      RQPMX2      QPSCL2
   0.0000E+00    0.0000E+00  0.0000E+00  0.0000E+00
        QPIN2        QPOFF2      RQPMX2      QPSCL2
   0.0000E+00    0.0000E+00  0.0000E+00  0.0000E+00
*
* DX    * R03 0.5 E
* VOL   * R03 1.7000E-02 E
* FA    * F  3.8010E-02 E
* FRIC  * F  0.0000E+00 E
* RV FRI* F  0.0000E+00 E
* GRAV  * R03 0.0000E+00 R01 -1.0 E
* HD    * F  2.2000E-01E
* ICFLG * F          0E
* NFF   * F          1E
* ALP   * F  1.0000E+00E
* VL    * F  0.0000E+00E
* VV    * F  0.0000E+00E
* TL    * F  4.1678E+02E
* TV    * F  4.1678E+02E
* P     * F  2.6000E+05E
* PA    * F  0.0000E+00E
* QPPP  * F  0.0000E+00E
* MATID * F          6E
* TW    * F  4.1678E+02E
*
* DX    *    0.5 E
* VOL   *    1.7000E-02 E
* FA    * F  3.8010E-02E
* FRIC  * F  0.0000E+00 E
* RV FRI* F  0.0000E+00 E
* GRAV  * F  1.0000E+00 E
* HD    * F  2.2000E-01E
* ICFLG * F          0E
* NFF   * F          1E
* ALP   *    1.0000E+00E
* VL    * F  0.0000E+00E
* VV    * F  0.0000E+00E
* TL    *    4.1678E+02E
* TV    *    4.1678E+02E
* P     *    2.6000E+05E
* PA    *    0.0000E+00E
* QPPP  * F  0.0000E+00E
* MATID * F          6E
* TW    * F  4.1678E+02E
```

```
*
*COMPONENT 361 FOR THE NITROGEN INJECTION FILL, LOOP 3, FILL
*
*******   TYPE          NUM          ID       CTITLE
FILL                    361          361 N2 INJ. FILL LOOP 3
*      JUN1          IFTY          IOFF
       361           6             0
*      IFTR          IFSV          NFTB          NFSV          NFRF
       90            100           6             0             0
*      TWTOLD        RFMX          CONCIN        FELV
  0.0000E+00    1.0000E+10    0.0000E+00    0.0000E+00
*      DXIN          VOLIN         ALPIN         VLIN          TLIN
  5.0000E-01    1.7000E-02    1.0000E+00    3.0000E+00    310.0
*      PIN           PAIN          FLOWIN        VVIN          TVIN
  2.215E+06     2.215E+06     0.0000E+00    0.0000E+00    310.0
*      VMSCL         VVSCL
  1.0000E+00    1.0000E+00
*
*NITROGEN INJECTION MASS FLOW RATE TABLE
*       T(S)          VMTB(KG/S)
        0.0           0.0 S
        38.00         0.0 S
        40.0000       0.340000 S
        120.0000      0.340000 S
        122.5000      0.0      S
        1.E+05        0.0      E
*
**                      8. TIME-STEP DATA                          **
*
*      DTMIN         DTMAX         TEND          TRWFP  *      RELX
  .00001     5.000E-01        22.0
*      EDINT         GFINT         DMPINT        SEDINT        *
      2.0     1.000E-01       5.00       1.00E+00
*
*      DTMIN         DTMAX         TEND          TRWFP  *      RELX
  0.50E-05        0.005          35.0
*      EDINT         GFINT         DMPINT        SEDINT        *
  1.00E+00     1.000E-01        2.00       1.00E+00
*
*      DTMIN         DTMAX         TEND          TRWFP  *      RELX
  0.50E-05        0.010         150.0
*      EDINT         GFINT         DMPINT        SEDINT        *
  1.00E+00     1.000E-01        2.00       1.00E+00
*
  -1.00E+00                                              *
```

APPENDIX D: TRAC-PF1 PREDICTION OF UPTF LOWER PLENUM FILLING RATES

UPTF Test 6 Runs 131, 132, 133, and 136 have been simulated with TRAC code by Dr. Henry J. Stumpf at LANL. The computation times on the CRAY computer varied from 2 to 5 hours. Figures D.1 - D.3 show the predicted lower plenum liquid inventory curves for Tests 132, 133 and 136; no liquid penetration was predicted for Test 131 (W_g = 400 kg/s). The lower plenum fill-up rates were obtained graphically using Figures D.1-D.3. The starting point of the straight line on each graph corresponds to beginning of the lower plenum fill-up and the end point of the line corresponds to the "quasi" steady lower plenum inventory. Table D.1 lists readings from the graphs used for predicting the lower plenum filling rates. The first column is the test number; the second and third columns are the starting time of lower plenum fill-up and the liquid inventory of the lower plenum at that time, respectively; the fourth and fifth columns show the time and the liquid inventory when the "quasi" steady lower plenum liquid inventory was first reached. The last column is the lower plenum fill-up rate. Table D.2 summarizes the experimental and calculational data for the UPTF tests.

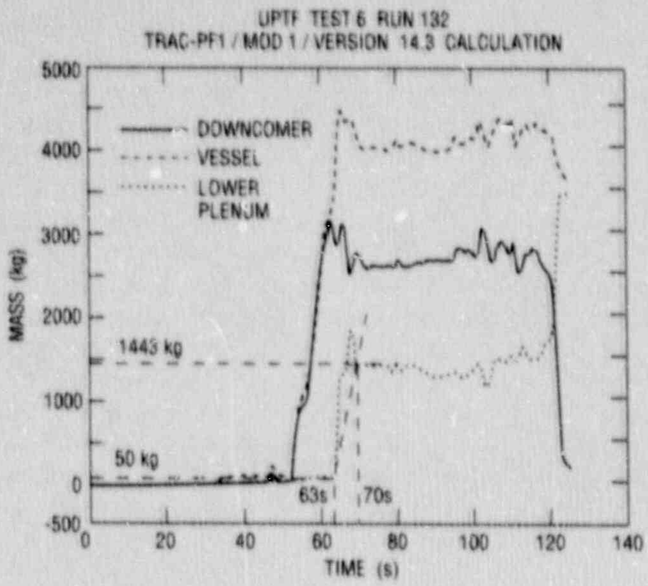

Figure D.1 UPTF Test 6 Run 132, Vessel, Downcomer, Lower Plenum Liquid Masses

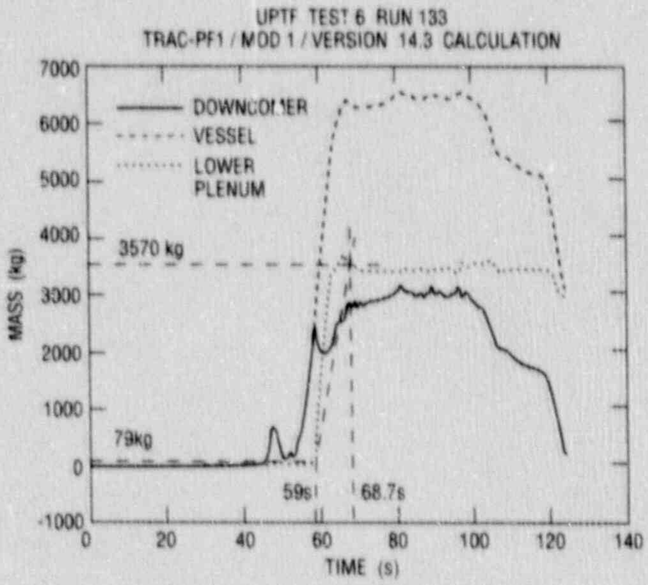

Figure D.2 UPTF Test 6 Run 133, Vessel, Downcomer, Lower Plenum Liquid Masses

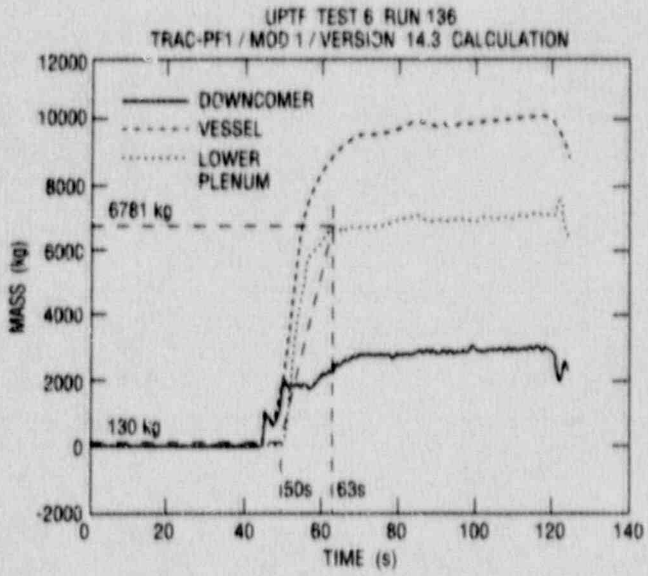

Figure D.3 TRAC-PF1 Prediction, Test 6, Run 136

Table D.1 - Predicted Lower Plenum Water Inventory and Filling Rates, UPTF Test 6

Run	t_1 (s)	$m_{LP,1}$ (kg)	t_2 (s)	$m_{LP,2}$ (kg)	$\dot{m}_{LP}$ (kg/s)
132	63	50	70	1443	199
133	59	79	68.7	3570	360
136	50	130	63	6781	512

Table D.2 - Summary of UPTF Results (Test 6)

	EXPERIMENT					TRAC			
Run	W_g (kg/s)	$\dot{m}_{LP}$ (kg/s)	t_I (s)	t_A (s)	$\tau_{IA,UPTF}$ (s)	$\dot{m}_{LP}$ (kg/s)	t_I (s)	t_A (s)	$t_{IA,UPTF}$ (s)
131	400	419	43	49(54)	6(11)	0	43	∞	∞
132	300	840	43	52	9	199	43	63	20
133	200	699	43	50	7	360	43	59	16
135	440	> 0	43	------	-----	0	43	∞	∞
136	100	644	43	45	2	512	43	50	7

APPENDIX E

Estimate of ECCS Flow in the Presence of Dissolved N_2

E.1 Introduction

The nitrogen (N_2) gas in the system occupies the top portion of the accumulators, and is also dissolved in the coolant in the accumulators. The coolant in the accumulator is in equilibrium with the nitrogen in the gas space. The amount of the dissolved nitrogen (N_2) is only 57.6 kg and about half of it will emerge from the coolant as it flows from the accumulators to the cold legs and the downcomer where the pressure is lower than in the accumulators.

The N_2 in the cold legs and in the downcomer will mix with the steam. This will affect the thermohydraulics of the coolant in two ways. First, N_2 will occupy volume and displace the coolant into the lower parts of the downcomer and, second, N_2 will reduce the interfacial mass transfer process (condensation) by decreasing the rate of interfacial heat transfer.

E.2 Purpose

The objective of the task described in this appendix is to estimate the amount of ECC flow during LBLOCA in a Westinghouse PWR in the presence of N_2. The ECC injection rate depends upon system pressure which is affected by the emerging N_2 from the ECC. Therefore, this task will require estimation of the amount of N_2 emerging from ECC and its effect on the system pressure.

The time to fill the lower plenum depends upon the ECC injection rate. Any delay in filling the lower plenum due to the dissolved N_2 will allow the clad to heat up for the duration of delay and contribute to bias in the predicted PCT.

E.3 Approach

The effect of N_2 on the ECC flow rate is estimated by computing a correction to the system pressure obtained from the nominal TRAC calculation. A separate model predicts the ECC flow rate based on corrected system pressure. The method of estimating the correction to TRAC-predicted system pressure consists of the following steps:

1) Formulate single volume models of the reactor system (excluding accumulators) and of intact and of broken loop accumulators. The system pressure will be evaluated in this step based on the information obtained from the next two steps.

2) Estimate the amount of N_2 emerging in the reactor system from the ECC flow,

3) Estimate the effect of the N_2 on prediction of condensation in the reference NPP calculation with TRAC.

E.3.1 Formulation

The emerging N_2 from the ECC reduces condensation which leads to accumulation of steam in the system. This steam along with N_2 will slow down the rate of system depressurization. Furthermore, unlike in the current reference NPP calculation, where the system pressure was at times below the containment pressure due to condensation leading to the flow from the containment to the system, the system pressure in the presence of N_2 will always be higher than the containment pressure and there will be no flow from the containment to the system.

Three control volumes with liquid and gas spaces are used to model three sections of NPP; the NPP primary side (excluding the accumulators), intact loop accumulators and broken loop accumulator, as shown in Figure E-1. The control volume for the primary side receives ECC from the safety injection system and the accumulators. It is conservatively assumed that all the dissolved N_2 emerges from the ECC before it enters the volume and flows to the gas space. The three intact loop accumulators are represented by a single volume and the broken loop accumulator is represented by another single volume. Special care is taken to model steam generator side break, as the break flow consists of flow from accumulator and from the remaining broken loop. The pipe section at which the accumulator joins the broken loop is designated as junction volume, as shown in Figure E-1.

E.3.1.1 Formulation for Reactor System

It is assumed that the N_2 and steam are in thermal and mechanical equilibrium. Furthermore, the gas space is divided into separate sections for steam and N_2. The phasic densities in each section will be a function of system pressure. The system volume is modelled with phasic mass balances as given here:

$$\frac{dm_\ell}{dt} = W_{i,\ell} - W_{o,\ell} + \dot{m}_{v\ell,N_2} \quad \text{(E-1)}$$

$$\frac{dm_v}{dt} = W_{i,v} - W_{o,v} - \dot{m}_{v\ell,N_2} \quad \text{(E-2)}$$

$$\frac{dm_{N_2}}{dt} = W_{i,N_2} - W_{o,N_2} \quad \text{(E-3)}$$

Where, m_ℓ, m_v, m_{N_2} are masses of liquid, steam and nitrogen, and $\dot{m}_{v\ell,N_2}$ is net condensation rate in the presence of nitrogen at the interface of liquid/vapor regions. The remaining six variables $W_{i,\ell}$, $W_{o,\ell}$, $W_{i,v}$ $W_{o,v}$, W_{i,N_2} W_{o,N_2} represent the mass flow rates at the inlet and outlet for the liquid, steam and N_2, respectively.

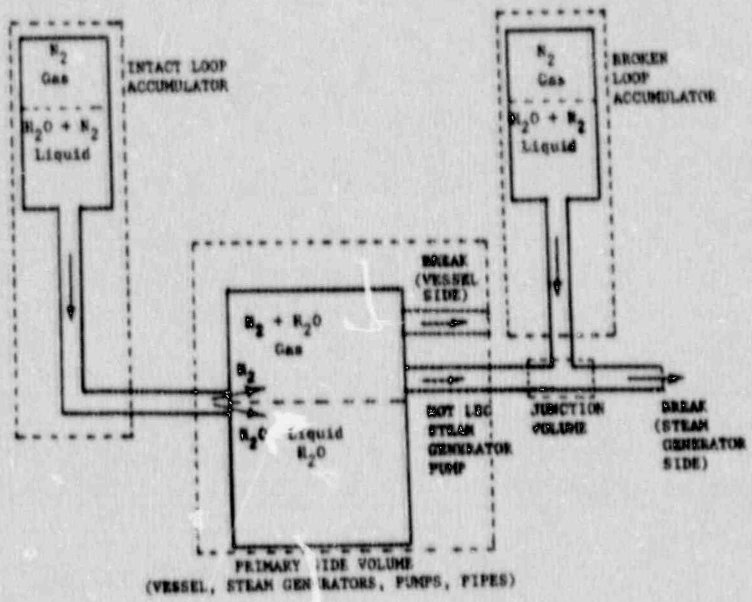

Figure E.1 Schematic of Three Control Volume Representation of NPP (BNL-3-178-90)

The phasic masses are defined as:

$$m_\ell = V_\ell \rho_\ell \quad \text{(E-4)}$$

$$m_v = V_v \rho_v \quad \text{(E-5)}$$

$$m_{N_2} = V_{N_2} \rho_{N_2} \quad \text{(E-6)}$$

The system volume, V, is the sum of phasic volumes, V_ℓ, V_v and V_{N_2}.

$$V = V_\ell + V_v + V_{N_2} \quad \text{(E-7)}$$

We define a system void fraction α and phasic volume fractions α_v and α_{N_2} as:

$$\alpha_v = V_v/V$$

$$\alpha_{N_2} = V_{N_2}/V$$

$$\alpha = \alpha_v + \alpha_{N_2} \quad \text{(E-8)}$$

The nitrogen volume fraction α_{N_2} of the reactor system is expected to be small during the Refill Phase and it is estimated from the nitrogen volume fraction in the downcomer.

$$\alpha_{N_2} = \alpha_{N_2,DC} * V_{DC} \;/V \quad \text{(E-9)}$$

where V_{DC} and V are the downcomer and system volumes, and obtained from the reference NPP calculation. The formulation is based on separate regions of steam, nitrogen and the liquid in equilibrium and so the phasic density can be obtained from the system pressure instead of partial pressures as shown here.

$$\rho_v = \rho_v\ (P) = \frac{m_v}{V_v} = \frac{m_v}{\alpha V} \quad \text{(E-10)}$$

$$\rho_{N_2} = \rho_{N_2}\ (P,T)$$

The fraction of N_2 in the gas space is very small, so the steam partial pressure is close to the system pressure, and the steam and N_2 temperatures are obtained as

$$T = T_{sat}(P)$$

Also,

$$\rho_\ell = \rho_\ell\ (P,u_\ell)$$

We will also need the liquid energy balance as the liquid density is a function of internal energy. The viscious effects and mechanical energy effects (kinetic energy and work due to interface movements) have been neglected.

$$\frac{d(m_\ell u_\ell)}{dt} = W_{i,\ell}\, h_{i,\ell} - W_{o,\ell}\, h_{o,\ell} + \dot{m}_{v\ell,N_2}\, h_v + q_{w\ell} \qquad \text{(E-11)}$$

where u_ℓ, $h_{i\ell}$, $h_{o\ell}$, h_v, $\dot{m}_{v\ell,N_2}$ and $q_{w\ell}$ are the internal energy of the bulk liquid, liquid enthalpies at the inlet and the outlet of the volume, enthalpy of the steam, condensation rate in the presence of N_2 and net wall heat transfer to the liquid phase.

Equations (E-4) to (E-7) and (E-10) to (E-11) are substituted in Equations (E-1) to (E-3) and the derivatives of the volume fractions are eliminated and gas phase expansion ($d\rho_g/dP$) has been approximated by the vapor term as the amount of N_2 is small; the equation for the system pressure is obtained, as given here.

$$\dot{P}_{NPP,N_2}\left\{\frac{1-\alpha}{\rho_\ell}\frac{d\rho_\ell}{dP} + \frac{\alpha}{\rho_v}\frac{d\rho_v}{dP}\right\} = -\frac{1-\alpha}{\rho_\ell m_\ell}\left(\frac{\partial\rho_\ell}{\partial u_\ell}\right)\left\{W_{i,\ell,N_2}(h_{i,\ell}-u_\ell) - W_{o,\ell,N_2}(h_{o,\ell}-u_\ell)\right.$$

$$\left. + \dot{m}_{v\ell,N_2}(h_v-u_\ell) + q_{w\ell}\right\} - \frac{\dot{m}_{v\ell,N_2}}{V}\left(\frac{\rho_\ell-\rho_v}{\rho_\ell\rho_v}\right)$$

$$+ \frac{W_{i,\ell,N_2} - W_{o,\ell N_2}}{V\rho_\ell} + \frac{W_{i,v,N_2} - W_{o,v,N_2}}{V\rho_v}$$

$$+ \frac{W_{i,N_2} - W_{o,N_2}}{V\rho_{N_2}} \qquad \text{(E-12)}$$

This equation represents the system behavior in the presence of N_2 injection into the system. The nominal NPP calculation also accounts for all the effects except N_2 shown in Equation (E-12) during the Refill Phase. There are additional differences in the system behavior due to the N_2 that are not accounted for in the NPP calculation, such as reduced condensation in the downcomer, and no backflow from the containment. In order to estimate the system pressure P_{NPP,N_2}, we will represent the results of the NPP calculations in a form similar to Equation (E-12).

$$\dot{P}_{NPP}\left\{\frac{1-\alpha}{\rho_\ell}\frac{d\rho_\ell}{dP} + \frac{\alpha}{\rho_v}\frac{d\rho_v}{dP}\right\} = -\frac{1-\alpha}{\rho_\ell m_\ell}\left(\frac{\partial\rho_\ell}{\partial u_\ell}\right)\left\{W_{i,\ell}(h_{i,\ell}-u_\ell) - W_{o,\ell}(h_{o,\ell}-u_\ell)\right.$$

$$\left. + \dot{m}_{v\ell}(h_v-u_\ell) + q_{w\ell}\right\} - \frac{\dot{m}_{v\ell}}{V}\left(\frac{\rho_\ell-\rho_v}{\rho_\ell\,\rho_v}\right)$$

$$+ \frac{W_{i,\ell}-W_{o,\ell}}{V\rho_\ell} + \frac{W_{i,v}-W_{o,v}}{V\rho_v} \tag{E-13}$$

Equations (E-12) and (E-13) are combined; the terms in the coefficients of $\dot{P}_{NPP,N_2}$ and $\dot{P}_{NPP}$ representing the compressibility of the liquid are smaller than the terms representing the compressibility of the vapor and are neglected. It is further assumed that the internal energy of the bulk liquid, inlet and outlet and the net wall heat transfer to the liquid phase are the same in two equations. Furthermore, terms representing the differences in the phasic relative velocity have been neglected. The phasic flow rates have been combined to form mixture flow rates. The terms with $\dot{m}_{v\ell}$ have been compared and the first $\dot{m}_{v\ell}$ term containing (h_v-u_ℓ) is two orders of magnitude smaller than the second $\dot{m}_v$ term containing $(\rho_\ell-\rho_v)$ and so the first $\dot{m}_{v\ell}$ term term is neglected.

As we are looking for conservative estimate, it is assumed that no N_2 leaves the system.

$$W_{O,N_2} = 0.0 \tag{E-14}$$

The resulting equation is:

$$\dot{P}_{NPP,N_2} = \dot{P}_{NPP} + \frac{1}{V}\{\frac{W_{i,N_2}}{\rho_{N_2}} + (\frac{W_{i,m}}{\rho_m})_{N_2} - (\frac{W_{i,m}}{\rho_m})$$

$$+ (\frac{W_{o,m}}{\rho_m}) - (\frac{W_{o,m}}{\rho_n})_{N_2} + \frac{(\dot{m}_{v\ell}-\dot{m}_{v\ell,N_2})}{V}[\frac{\rho_\ell-\rho_v}{\rho_\ell\ \rho_v}]\}/(\frac{\alpha}{\rho_v}\frac{d\rho_v}{dP}) \tag{E-15}$$

where $W_{i,m}$ and $W_{o,m}$ are the flow rates of mixture of steam and water going into and out of the volume, and $\dot{m}_{v\ell}$ and $\dot{m}_{v\ell,N_2}$ are condensation rates with and without the presence of N_2. Equation (E-15) indicates that the primary effect of N_2 will be to modify fluid flows at the boundary and the condensation rates.

The condensation term, $\dot{m}_{v\ell}$, in Equation (E-15) is estimated from the results from NPP calculation. The rate of condensation due to subcooled ECC is estimated from ECC flow rate and subcooling. The sensible heat released by the condensate in order to reach DC conditions is neglected in comparison to the latent heat.

$$\dot{m}_{v\ell} = \frac{\dot{m}_{ECC,NPP} \, (T_{DC}-T_A) \, C_p}{h_{fg}} \qquad \text{(E-16)}$$

where $\dot{m}_{ECC,NPP}$, T_{DC}, and T_A are the rate of ECC injection, downcomer and accumulator fluid temperatures.

Steps to evaluate $\dot{m}_{v\ell}$ from the NPP calculations are listed here for any time period from t_1 to t_2 during the Refill Phase (t_I to t_B). The times t_1 and t_2 are times at which the NPP calculation results are available.

$$\Delta m_{CON,NPP} = \Delta m_{ECC,NPP} \frac{C_p}{h_{fg}} \left[\frac{(T_{DC}-T_A)_{t_1} + (T_{DC}-T_A)_{t_2}}{2} \right] \qquad \text{(E-17)}$$

$$\dot{m}_{v\ell} = \frac{\Delta m_{CON,NPP}}{t_2 - t_1} \qquad \text{(E-18)}$$

where $\Delta m_{CON,NPP}$ and $\Delta m_{ECC,NPP}$ are the amounts of steam condensed and ECC injected between t_1 and t_2.

The condensation rate, $\dot{m}_{v\ell,N_2}$ in Equation (E-15) will be less than $\dot{m}_{v\ell}$. For conservative estimate of system pressure, the condensation rate in the presence of N_2 is neglected.

$$\dot{m}_{v\ell,N_2} = 0 \qquad \text{(E-18a)}$$

A procedure of estimating $\dot{m}_{v\ell,N_2}$ is desribed in Section E.3.3. It is shown in Section E.3.4 that condensation reduces by 80% in the presence of N_2 for the conditions expected during the Refill Phase.

The remaining four terms on the right side of Equation (E-15) represent the injection flow rates and break flow rates for NPP with and without including the N_2 effect. The NPP break flow rate and injection rate without N_2 effects were obtained from the reference NPP calculation. The break flow rate for the N_2 case is estimated from the information available from the reference NPP calculation. The pressure difference between the system pressure and break pressure is related to the break flow rate.

$$W_{o,m} = K \sqrt{(P_s - P_B)\rho_m} \qquad \text{(E-19)}$$

K is estimated at times during the Refill Phase at which the reference NPP calculation results are available. The lowest value of K is selected for the conservative estimate of system pressure. The system has two breaks: one on the vessel side and the other on the steam generator side. The flow coefficient K will be different for two sides. The vessel side break flow is:

$$W_{o,m,VE} = K_{VE} \sqrt{(P_v - P_B)\,\rho_m} \qquad \text{(E-20)}$$

where K_{VE}, P_v and P_B are the flow coefficient for the flow path from the vessel to the break, the vessel and break pressures, respectively.

The steam generator side break flow is a combination of flow from the accumulator and from the broken loop.

$$W_{BR,SG} = W_{o,m,SG} + W_{BR,A} \qquad \text{(E-21)}$$

where $W_{BR,SG}$, $W_{o,m,SG}$ and $W_{BR,A}$ are the flow rates at the steam generator side break, and flow rates from the vessel and the accumulator to the junction volume (Figure E-1), respectively. These flows are related to the pressures as follows:

$$W_{BR,SG} = K_{JB} \sqrt{(P_J - P_B)\,\rho_J} \qquad \text{(E-22)}$$

$$W_{o,m,SG} = K_{VJ} \sqrt{(P_V - P_J)\,\rho_v} \qquad \text{(E-23)}$$

$$W_{BR,A} = K_{AJ} \sqrt{(P_A - P_J)\,\rho_\ell} \qquad \text{(E-24)}$$

$$\rho_J = \alpha_J\,\rho_g + (1-\alpha_J)\,\rho_\ell \qquad \text{(E-25)}$$

where K_{JB}, K_{VJ} and K_{AJ} are the flow coefficients for the flow paths from the junction volume to the break, from the vessel and the accumulator to the junction volume. Additionally, P_J, P_B and P_A are the pressures at the junction volume, the break, and in the accumulator, respectively. Furthermore, ρ_J and α_J are the mixture density and void fraction in the junction volume. The flow coefficients in the Equations (E-22) through (E-24) are obtained from the nominal NPP calculation with the TRAC code. The void fraction α_J for the volume is estimated from the volume flow rates to this volume. It is assumed that the flow leaving the junction is homogeneous, the flow coming from the reactor is all steam, and the flow from the accumulator is all liquid.

$$\alpha_J = \frac{(W_{o,m,SG}/\rho_g)}{((W_{o,m,SG}/\rho_g) + (W_{BR,A}/\rho_\ell))} \qquad \text{(E-26)}$$

The solution of Equation (E-15) requires the amount of N_2 injected into the system (W_{i,N_2}), and the procedure of evaluating W_{i,N_2} is described in Section E.3.2.

The ECC flow rate or injection rate (accumulator flows and safety injection) in the presence of N_2 is estimated from the system pressure and a model for the accumulator. The next section, E.3.1.2, describes the accumulator model.

E.3.1.2 Formulation for Accumulator Flows

The rate of accumulator flow is estimated from a model of accumulator and the pipe connecting it to the cold leg. The accumulator has a gas space filled with N_2 and a liquid space filled with subcooled water with dissolved N_2. It has been observed in the reference NPP calculation that the liquid temperature changes by less than 1°K during the Refill Phase, but there has been temperature change in the gas phase of the order of 30°K. Therefore, the nitrogen expansion is not isothermal, and we can assume an adiabatic expansion for the nitrogen. The adiabatic expansion will predict lower accumulator pressure and lower ECC flow rate than the isothermal conditions. The gas space pressure will also be affected by the N_2 which will emerge from the liquid as the accumulator pressure decreases. The system of equations which govern this model is given here:

Mass balances for N_2:

$$\frac{d\,(\rho_{N_2}\, V_{A,N_2})}{dt} = \dot{m}_{N_2} \tag{E-27}$$

where $\dot{m}_{N_2}$ is the rate of nitrogen emerging from the liquid and V_{A,N_2} is the volume of the accumulator occupied by N_2. A mass balance for N_2 in the liquid phase is also needed.

$$\frac{d}{dt}\left(\rho_\ell\, V_{A,\ell}\, X_{N_2}\, \frac{M_{N_2}}{M_{H_2O}}\right) = -\,\dot{m}_{N_2} \tag{E-28}$$

where M_{N_2} and M_{H_2O} are the molecular weights of nitrogen and water, and X is the solubility (mole of N_2 in a mole of solution) of N_2 in water. X_{N_2} is related to the accumulator pressure P_A, through Henry's law,

$$X_{N_2} = P_A/H \tag{E-29}$$

where H is Henry's constant.

The N_2 will follow an adiabatic expansion:

$$P_A\, \rho_{N_2}^{-\gamma} = \text{constant} = K \tag{E-30}$$

It is also assumed that N_2 behaves as perfect gas:

$$P_A\, V_{A,N_2} = n\, R\, T_A \tag{E-31}$$

As the accumulator volume is fixed, there is an additional constraint on the V_{A,N_2}:

$$V_A = V_{A,N_2} + V_{A,\ell} \tag{E-32}$$

In addition to the N_2 balance equations, mass and momentum balances are also needed for the liquid phase (water):

$$\frac{dV_{A,\ell}}{dt} = - Q_\ell \tag{E-33}$$

$$\rho_\ell = K_A \sqrt{(P_A - P_S)\rho_\ell} \tag{E-34}$$

where Q_ℓ is the volume flow rate from the accumulator, P_A and P_S are the pressures in the accumulator and the rest of the NPP system.

After combining Equations (E-27) to (E-34), an equation for dP_A/dt is obtained.

$$\frac{dP_A}{dt} = \frac{Q_\ell \left[\frac{\rho_\ell}{H} \frac{M_{N_2}}{M_{H_2O}} \frac{P_A}{\rho_g} - 1\right]}{\left[\frac{V_{A,\ell} M_{N_2} \rho_\ell}{H \, M_{H_2O} \, \rho_g} + \frac{V_{A,g}}{\gamma P_A}\right]} \tag{E-35}$$

It should be noted that for PWR application, the terms containing H in the above equation are three orders of magnitude smaller than the terms they are added to, implying that the effect of N_2 dissolution on the accumulator pressure is small and could be neglected.

The flow coefficient K_A is obtained from the reference NPP calculation. The accumulator pressure is obtained from Equation (E-35). The liquid flow rate in Equation (E-35) is related to $W_{i,m}$ in Equation (E-15).

$$W_{i,m} = W_{SI} + \dot{m}_A \tag{E-36}$$

$$\dot{m}_A = Q_\ell \rho_\ell \tag{E-37}$$

where $\dot{m}_A$ and W_{SI} are the accumulator and safety injection flow rates.

E.3.2 Estimate of Rate of N_2 Dissolution in the Reactor System

It is assumed that the N_2 and steam are in equilibrium with the water. As the fluid particle moves from the accumulator to the cold leg, the N_2 solubility decreases and this difference in the solubility leads to the emergence of N_2 in the cold legs.

The amount of N_2 emerging from ECC into the cold leg can be estimated as follows:

$$W_{i,N_2} = \dot{m}_A \left(c_{N_2,A} - c_{N_2,CL}\right) \tag{E-38}$$

where $c_{N_2,A}$ and $c_{N_2,CL}$ are the concentration of N_2 in the water in the accumulator and the cold leg. The other variables appearing in the above equation are defined below.

$\dot{m}_A$ Rate of ECC injection into cold legs from accumulators,

W_{i,N_2} Rate of N_2 emerging into cold legs,

c_{N_2} Concentration of N_2 in solution; kg of N_2 per kg of the solution.

The concentration of N_2 in the solution is related to the solubility as follows,

$$c_{N_2} = \frac{X_{N_2}}{1-X_{N_2}} \frac{M_{N_2}}{M_{H_2O}} = X_{N_2} \frac{M_{N_2}}{M_{H_2O}} \quad \text{for} \quad X_{N_2} << 1 \tag{E-39}$$

The solubility of N_2 in the water varies with the pressure and temperature. The partial pressure of N_2 in the gas phase is related to the solubility by Henry's law:

$$P_{N_2} = H\, X_{N_2} \tag{E-40}$$

where P_{N_2} is the partial pressure of N_2 in the gas phase, X_{N_2} is the solubility of N_2 in water (moles of N_2 per mole of solution) and H is Henry's constant. Henry's constant, H, is listed in Table E-1 (Chemical Engineering Handbook, Perry & Chilton, Pages 3-98). H is not very sensitive to the partial pressure of N_2 but does vary with the temperature.

The partial pressure of N_2 in Equation (E-40) is computed as follows:

$$P_{N_2} = P_{NPP} - P_{sat,H_2O} \tag{E-41}$$

where P_{NPP} is the fluid pressure obtained from the NPP calculation and P_{sat,H_2O} is the saturation pressure for water corresponding to the water temperature in the NPP calculation.

The average rate of N_2 injection (W_{i,N_2}) into the reactor system during any time period t_1 to t_2 in the Refill Phase of the accident is computed from Δm_{N_2} (the amount of N_2 emerged during this period) as follows:

$$W_{i,N_2} = \frac{\Delta m_{N_2}}{t_2-t_1} \tag{E-42}$$

Δm_{N_2} is estimated by integrating Equation (E-38) after substituting Equation (E-39).

TABLE E-1

N_2 Solubilities (Chemical Engineering Handbook, Perry & Chilton)
(Tables 3-139 and 3-140)

T, °C	0	5	10	15	20	25	30	35
10^{-4} x H	5.29	5.97	6.68	7.38	8.04	8.65	9.24	9.85

t, °C	40	45	50	60	70	80	90	100
10^{-4} x H	10.4	10.9	11.3	12.0	12.5	12.6	12.6	12.6

Partial Pressure of N_2, mm, Hg	10^{-4} x H	
	19.4°C	24.9°C
900	8.24	9.08
2000	8.32	9.15
3000	8.41	9.25
4000	8.49	9.38
[illegible]00	8.59	9.49
[illegible]0	8.74	9.62
[illegible]00	8.86	9.62
[illegible]100	9.04	
8200		9.91

$$\Delta m_{N_2} = \int_{t_1}^{t_2} \dot{m}_A \, dt \quad \left(\frac{X_{N_2,A,t_1} - X_{N_2,CL,t_1}}{2} + \frac{X_{N_2,A,t_2} - X_{N_2,CL,t_2}}{2} \right) \frac{M_{N_2}}{M_{H_2O}} \qquad \text{(E-43)}$$

$$\Delta m_{N_2} = \Delta m_A \quad \left(\frac{X_{N_2,A,t_1} - X_{N_2,CL,t_1}}{2} + \frac{X_{N_2,A,t_2} - X_{N_2,CL,t_2}}{2} \right) \frac{M_{N_2}}{M_{H_2O}} \qquad \text{(E-44)}$$

Where Δm_A and Δm_{N_2} are the total ECC injected from the accumulators and the total dissolution of N_2 during t_1 to t_2. Δm_A is obtained from the reference NPP calculation.

The N_2 injection rate W_{i,N_2} Equation (E-42) is needed in Equation (E-15). The rate of N_2 dissolution is based on ECC flow rate from the reference NPP calculation and will be an overestimation as the ECC flow is expected to be lower in the presence of N_2.

E.3.3 Estimation of Condensation in the Presence of N_2

During the Refill Phase, the steam is close to saturation while the ECC is subcooled. The condensation rate will be dominated by the interfacial heat transfer on the liquid side.

$$\dot{m}_{v\ell,N_2} = \text{[illegible]} \, (CHMOD) \, q_{i\ell}/h_{fg} \qquad \text{(E-45)}$$

where K_{con}, CHMOD, $q_{i\ell}$ and h_{fg} are the constant of proportionality, a multiplier to account for N_2 effect, interfacial heat transfer in the absence of N_2 and the heat of vaporization. The multiplier CHMOD is obtained from the correlation described in TRAC-PF1/MOD1 Correlation and Models document [Liles, 1988, Page 4-26].

$$CHMOD = 0.168 \left[\frac{\alpha(\rho_v - \rho_{N_2})}{(1-\alpha)\rho_\ell \rho_{N_2}} \right]^2 \qquad \text{(E-46)}$$

where

α	Gas void fraction ($\alpha_v + \alpha_{N_2}$)
ρ_v	Gas density
ρ_{N_2}	Density of nitrogen at its partial pressure, P_{N_2}

The gas volume fraction α and the density of N_2 at its partial pressure are evaluated as follows:

$$\alpha = \alpha_v \left(\frac{1}{1 - n_{N_2}} \right) \qquad \text{(E-47)}$$

$$\rho_{N_2} = \rho_{N_2}(P_{N_2})$$

$$P_{N_2} = P_{NPP}\, n_{N_2} \qquad \text{(E-48)}$$

where n_{N_2} is the mole fraction of N_2 in the gas mixture and α_v is the vapor volume fraction in the downcomer as obtained from the reference NPP calculation results.

An estimate of n_{N_2}, mole fraction of N_2 in the gas space of the downcomer at a given time has been made from the information obtained from the reference NPP calculation. The net steam flow into the downcomer during a time period (t_1 to t_2) is computed from Figure E-2, which was plotted from the information obtained from the reference NPP calculation. The assumption in this procedure is that during the period of interest, all the steam flow from the lower plenum to the downcomer and all the N_2 emerging from the ECC, mixes with the existing gas phase in the downcomer and the part of this mixture (vapor + N_2) leaves through the break. It is further assumed that steam and N_2 densities are constant.

$$n_{N_2}(t_2) = \frac{V_{N_2,DC,t_1} + V_{N_2,i,t_1,t_2}}{V_{g,DC,t_1} + V_{N_2,i,t_1,t_2} + V_{H_2O,i,t_1,t_2}} \qquad \text{(E-49)}$$

n_{N_2} in the above equation is the mole fraction of N_2 in the gas mixture as the volume per kg-mole for each gas is the same at the same temperature and pressure conditions.

The other variables used in Equation (E-49) are defined below:

V_{N_2,DC,t_1}	Volume of DC occupied by N_2 at t_1 at system pressure
V_{g,DC,t_1}	Gas space volume in DC at t_1 at system pressure
V_{N_2,i,t_1,t_2}	Total volume of N_2 emerged during t_1 and t_2 at system pressure
V_{H_2O,i,t_1,t_2}	Total volume of steam injected from LP during t_1 to t_2 at system pressure
n_{N_2}	Mole fraction of N_2 in the DC gas space
V_{g,DC,t_1}	$V_{H_2O,DC,t_1} + V_{N_2,DC,t_1} = V_{H_2O,DC,t}\left(\frac{1}{1-n_{N_2}(t_1)}\right)$

where

V_{H_2O,DC,t_1}	Volume of DC occupied by steam at t_1 at system pressure, obtained from NPP calculation

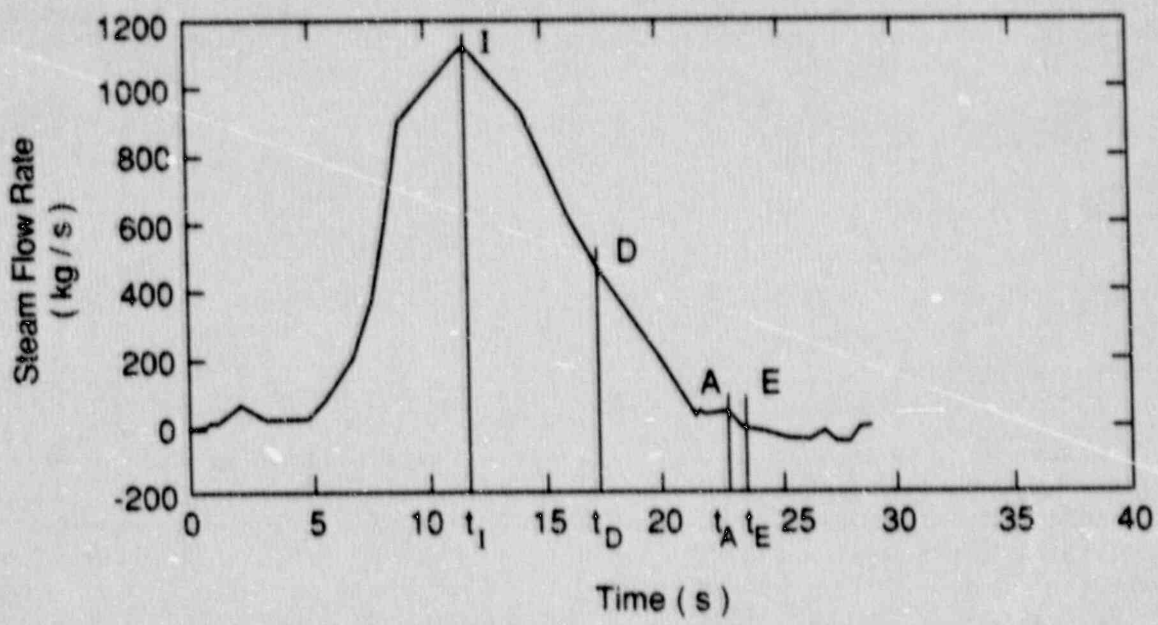

Figure E.2 Predicted Steam Flow Rate from Lower Plenum to the Downcomer

E.4 Results

The model described in Section E.3 requires the results of a nominal NPP calculation. Some of the values used in the estimate are listed in Table E-2. Columns 1 through 8 list the number, time of the transient, downcomer pressure, vessel and steam generator side break flow rates, and the liquid temperatures in the downcomer and in the accumulator, and average void fraction for the vessel, respectively. The Equations (E-15) and (E-35) have been integrated by Euler's method.

The flow coefficients K_{VE}, K_{JB}, K_{VJ} and K_{AJ} in Equations (E-20), (E-22), (E-23) and (E-24) are estimated from the nominal NPP calculation results during the Refill Phase. The values of these coefficients varied during the Refill Phase and conservative values - ones which will lead to smaller loss of the inventory and larger system pressure - were selected.

$$K_{VE} = 0.32 \text{ m}^2 \qquad \text{(E-50)}$$

$$K_{JB} = 0.41 \text{ m}^2 \qquad \text{(E-51)}$$

$$K_{VJ} = 0.22 \text{ m}^2 \qquad \text{(E-52)}$$

$$K_{AJ} = 0.02 \text{ m}^2 \qquad \text{(E-53)}$$

The rate of condensation $\dot{m}_{v\ell}$ is computed by substituting downcomer liquid temperature, accumulator liquid temperature, integrated safety injection rate and integrated accumulator flows (originated from the loss of accumulator inventory) obtained from the nominal NPP calculation, into Equations (E-17) and (E-18). These values are summarized in Table E-3. In this table, Columns 1 through 6 list the time periods, integrated ECC flow consisting of safety injection and accumulator flows for the three intact loops, latent heat of vaporization, net condensation, and rates of condensation and ECC injection.

The rate of N_2 dissolution is obtained by substituting the NPP conditions obtained from the nominal NPP calculation in the Equation (E-44). These values are shown in Table E-4. The first column in this table shows the time of the transient. The next five columns (2 through 6) show the accumulator conditions: pressure, liquid temperature, saturation pressure, Henry's constant and solubility of nitrogen in the liquid, respectively. Similarly, the last five columns (7 through 11) represent the fluid conditions in the cold legs: pressure, liquid temperature, saturation pressure, Henry's constant and nitrogen solubility in the liquid. The fluid conditions listed in Table 4, along with the equations in Section E.3.2, are used to compute the rate of dissolution of N_2. The rate of N_2 emergence has been computed for six intervals. The void fraction in the downcomer will change slightly and is computed from Equation (E-47). Table E-5 summarizes the results. There are ten columns: the time of the transient, net accumulator flow, net emergence of N_2, net steam supplied to the downcomer, steam volume in the downcomer, densities of the steam and the nitrogen, mole fraction of nitrogen in the gas space, new void fraction in the presence of N_2, and the rate of N_2 dissolution.

TABLE E-2

LBLOCA Flow Parameters from TRAC Calculation

No.	Time Sec	$P_{DC,NPP}$ bar	$W_{o,m,v}$ kg/s	$W_{o,m,sg}$ kg/s	T_{DC} K	T_A K	$\sum \Delta \dot{m}_A$ kg	$\sum \Delta m_{SI}$ kg	$\sum \Delta m_{ECC}$ kg
1	11.5					305	0.0		
2	12.1	34.5	3612	1127	515	305	780	76	860
3	18.1	7.35	3599	74.6	394	305	15360	544	15900
4	22.9	3.15	-5.0	295.8	362	305	28980	1686	30670
5	23.8	3.29	-43.6	58.5	354	305	31530	1960	33490
6	26.1	3.07	-84	-14.0	348	305	37290	2646	39940
7	29.5	2.72	-113	-788.2	355	305	45300	3771	49070
8	33.5	2.91	-66.7	5.50	348	305	53670	5130	58800
9	37.6	3.04	-42.9	-676.3	352.4	305	61920	5540	68560
10	39.6	3.54	35.9	81.6	342	305	65550	7365	72920

$$\sum \Delta \dot{m}_A = \sum \int_{11.5}^{t} \dot{m}_A \, dt$$

$$\sum \Delta \dot{m}_{SI} = \sum \int_{11.5}^{t} \dot{m}_{SI} \, dt$$

$$\sum \dot{m}_{ECC} = \sum \dot{m}_{ACC} + \sum \dot{m}_{SI}$$

TABLE E-3

Estimated Condensation Rates in the Nominal NPP Calculation

Time Period s	$\Delta m_{ECC}(t_1-t_2)$ kg	h_{fg} KJ/kg	$\Delta m_{v\ell}$ kg	$\Delta \dot{m}_{v\ell}$ kg/s	$\dot{m}_{ECC}$ kg/s
12.1-18.1	15040	1955.5	1376	229	2480
18.1-22.9	14770	2154	500	104	3110
22.9-26.1	9270	2154	216	67	2900
26.1-29.5	9130	2154	197	58	2685
29.5-33.5	9730	2154	210	53	2430
33.5-37.6	9760	2154	205	50	2380

TABLE E-4

Estimates of N_2 Solubility

TIME SEC	ACCUMULATOR					COLD LEG				
	P bar	T_K	P_{sat,H_2O} bar	H* atm	X_{N2}	P bar	T_K	P_{sat,H_2O} bar	H atm	X_{N2}
12.1	41.2	305.5	0.047	9.55×10^{4}	4.3×10^{-4}	34.7	484.5	19.5	12.6×10^{4}	1.2×10^{-4}
18.1	27.33	305.5	0.047	9.55×10^{4}	2.8×10^{-4}	7.27	336.3		12.2×10^{4}	5.9×10^{-5}
22.9	21.25	305.4	0.047	9.55×10^{4}	2.2×10^{-4}	3.33	324.6	0.13	11.4×10^{4}	2.8×10^{-5}
23.8	20.37	305.4	0.047	9.55×10^{4}	2.1×10^{-4}	3.20	319.3	0.10	11.0×10^{4}	2.8×10^{-5}
26.1	18.48	305.4	0.047	9.55×10^{4}	1.9×10^{-4}	2.73	314		10.4×10^{4}	2.6×10^{-5}
29.5	16.5	305.3	0.047	9.55×10^{4}	1.7×10^{-4}	2.6	322.6		11.2×10^{4}	2.3×10^{-5}
33.53	15.08	305.2	0.047	9.55×10^{4}	1.6×10^{-4}	1.66	332	0.19	12×10^{4}	1.2×10^{-5}
37.6	13.6	305.1	0.047	9.55×10^{4}	1.4×10^{-4}	2.85	321	0.11	11.2×10^{4}	2.5×10^{-5}
39.6	13.05	305.1	0.047	9.55×10^{4}	1.4×10^{-4}	3.49	330.2	0.17	11.8×10^{4}	2.8×10^{-5}

* P = HX Henry's Law

TABLE E-5

Estimated Volume Fraction and Rate of Dissolution of N_2

TIME SEC	Δm_A** kg	Δm_{N_2} kg	Δm_{steam} kg	$V_{v,DC}$** m^3	ρ^*_{steam} kg/m^3	$\rho^*_{N_2}$ kg/m^3	$n_{N_2,DC}$	α_g	W_{i,N_2} kg/s
11.5	------	-----	------	-----	17.4	27.1	0.0	0.97	-----
12.1	787	0.25	667.5	25.66	17.4	27.1	0.00014	0.97	0.42
22.9	28,980	12.2	5057.5	16.0	1.57	2.44	0.0017	0.60	1.1
23.8	31,530	13.1	5070	14.83	1.57	2.44	0.016	0.57	1.0
33.5	53,670	19.4	5070	10.22	1.5	2.33	0.163	0.46	0.65
39.6	65,550	22.2	5070	2.0	2.16	3.36	0.22	0.097	0.46

$\Delta m_A = \int_{11.5}^{t} m_A \, dt$ = Total ECC Injection, Accumulators Only

$\Delta m_{N_2} = \int_{11.5}^{t} m_{N_2} \, dt$ = Total N_2 Emerged

$\Delta m_{steam} = \int_{11.5}^{t} m_{steam} \, dt$ = Total steam flow into DC from LP

$n_{N_{2,DC}}$ = mole fraction = Vol N_2/(Vol N_2 + Vol Steam)

V_{DC} = 26.48 m^3

$$W_{i,N_2} = \frac{\Delta M_{N_2}(t_2) - \Delta M_{N_2}(t_1)}{t_2 - t_1}$$

* Densities are obtained at the system pressure
** Obtained from NPP calculation

The effect of N_2 on the condensation rate is computed from Equation (E-46). The multiplier CHMOD is computed for the following conditions:

$P = 3.0$ bar, $n_{N_2} = 0.001$, $P_{steam} \sim 2.997$ bar, $P_{N_2} = 0.003$ bar

$\rho_v - \rho_{N_2} = \rho_{steam} = 1.65\ kg/m^3$,

$\rho_l \sim 1000\ kg/m^3$

$\rho_{N_2} \sim 0.00257\ kg/m^3$,

$CHMOD = 0.17\ [\frac{\alpha}{1-\alpha}]^{0.1}$

$CHMOD = 0.14\ ,\ \alpha = 0.1$

$CHMOD = 0.21\ ,\ \alpha = .9$

and at $P = 3.0$, $n_{N_2} = 0.01$, $P_{steam} \sim 2.7$ bar, $P_{N_2} \sim 0.3$ bar

$\rho_{steam} \sim 1.496\ kg/m^3$

$\rho_\ell \sim 1000\ kg/m^3$

$\rho_{N_2} \sim 0.034\ kg/m^3$

$CHMOD = 0.128\ [\frac{\alpha}{1-\alpha}]^{0.1}$

$CHMOD = 0.1,\ \alpha = 0.9$

$CHMOD = 0.16,\ \alpha = 0.9$

The above calculations indicate that there will be a large reduction in the condensation rate (~80%). For the purpose of a conservative estimate of the N_2 effect, it is assumed that there will be no condensation in the presence of N_2.

$$\dot{m}_{v\ell,N_2} = 0.0 \quad \text{(E-52)}$$

The Equations (E-15) and (E-35) are integrated by a first order Euler's method and the predicted system pressure is shown in Figure E-3. The system pressure in the presence of N_2 is higher. Figure E-4 compares the total ECC flows in the NPP calculation with the ECC flow predicted by the bounding calculation. As expeted, the ECC flows in the presence of N_2 are smaller. The results are summarized in Table E-6. The first column in this table is time, Columns 2 and 3 show the system pressures from the TRAC calculation and from the bounding calculation, and the last two columns are the total ECC flow in the intact loops as obtained from the nominal NPP calculation (TRAC) and from the bounding calculation. These ECC flow rates are used in Chapter 4 to estimate the bias in the time period of the Refill Phase and in the PCT.

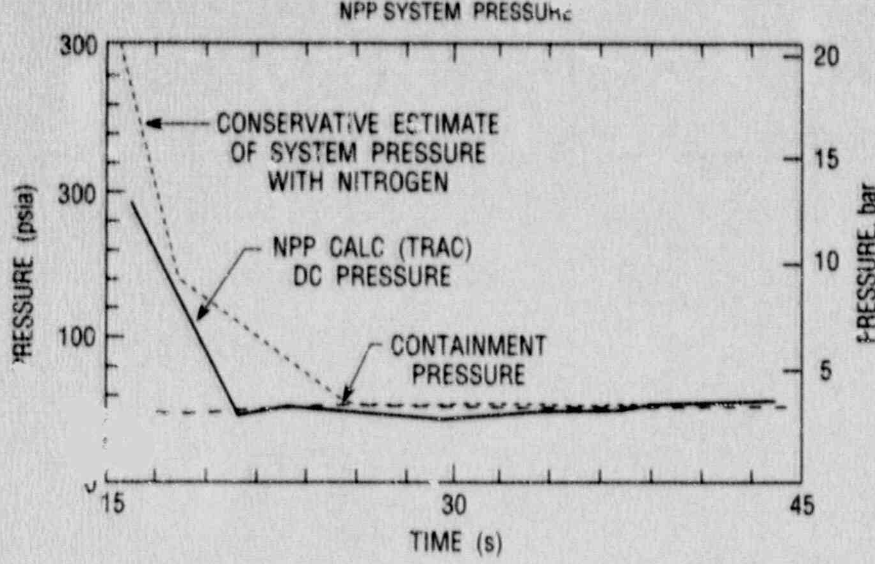

Figure E.3 System Pressure during Refill Period

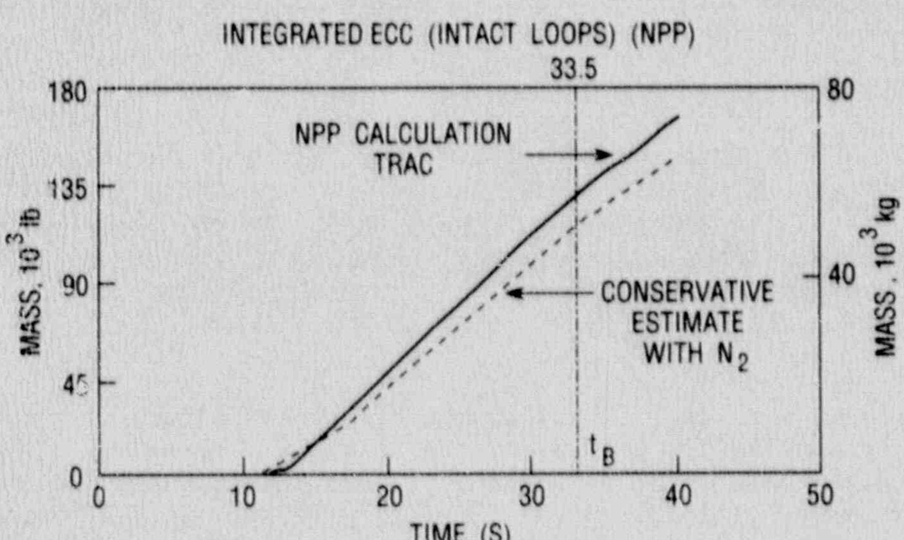

Figure E.4 Predi^tions of Integrated ECC Injection

TABLE E-6

Integrated ECC with and without N_2

Time	P_{NPP_1} bar	P_{NPP,N_2} bar	Δm_{ECC} kg	$\Delta m_{ECC,N_2}$ kg
12.1	34.5	34.5	860	860
18.1	17.35	11.23	15,900	12,145
22.9	3.28	7.29	30,670	23,843
23.8	3.07	6.38	33,490	[illegible]
26.1	3.07	4.61	39,940	31,773
29.5	2.72	3.51	49,070	40,100
33.5	2.92	3.61	58,800	49,310
37.6	3.04	3.28	68,560	58,610

$$R_{ECC} = \frac{\Delta m_{ECC}\ (33.5s) - \Delta m_{ECC}\ (t_D)}{\Delta m_{ECC,N_2}\ (33.5\ s) - \Delta m_{ECC}\ (t_D)}$$

$$\Delta m_{ECC} = \int_{11.5}^{t} \mathring{m}_{ECC}\ dt$$

P_{NPP} = System Pressure

NOMENCLATURE FOR APPENDIX E

C	Concentration, kg per kg of solution
CHMOD	Multiplier for N_2 effect on condensation
h	Enthalpy
h_{fg}	Latent heat of vaporization
H	Henry's constant
K	Flow coefficient
$\dot{m}_{v\ell}$	Rate of condensation
m	Mass
M	Molecular weight
n	Mole fraction
P	Pressure
$q_{w\ell}$	Reactor power
Q	Volume flow rate
R_{ECC}	Ratio of the amounts of ECC delivered with no N_2 and with N_2
t	Time
T	Temperature
V	Volume
W	Mass flow rate
X	Solubility, mole per mole of solution

Greek

α	Volume fraction
ρ	Density
γ	Ratio of specific heats

Subscripts

A	Accumulator
B	Break
BR	Break
CL	Cold Leg
CON	Condensation
DC	Downcomer
ECC	Emergency Core Coolant
H_2O	Water
i	Inlet
J	Junction Volume (Figure E-1)
ℓ	Liquid
N_2	Nitrogen
NPP	Nuclear Power Plant
O	Outlet
S	System
SG	Steam Generator
SI	Safety Injection
v	Vapor
V	Vessel

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER (Assigned by NRC. Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG/CR-5254
BNL/NUREG-52168

2. TITLE AND SUBTITLE

Bias in Peak Clad Temperature Predictions Due to Uncertainties in Modeling of ECC Bypass and Dissolved Non-Condensable Gas Phenomena

3. DATE REPORT PUBLISHED

MONTH	YEAR
September	1990

4. FIN OR GRANT NUMBER

A3952

5. AUTHOR(S)

U. S. Rohatgi, L. Y. Neymotin, J. Jo and W. Wulff

6. TYPE OF REPORT

7. PERIOD COVERED (Inclusive Dates)

8. PERFORMING ORGANIZATION – NAME AND ADDRESS (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)

Brookhaven National Laboratory
Upton, NY 11973

9. SPONSORING ORGANIZATION – NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Division of Systems Research
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

The U.S. Nuclear Regulatory Commission (USNRC), its contractors and consultants have developed a methodology for evaluating Code Scaling, Applicability and Uncertainty (CSAU). The CSAU method has been demonstrated by applying it to the TRAC-PF1/MOD1, Version 14.3 code and its analysis of a Large Break Loss of Coolant Accident (LBLOCA) for a Westinghouse four-loop plant. In applying the methodology, the accident course is divided into three different phases, namely: Blowdown, Refill and Reflood. There are two distinct peak clad temperatures (PCT), one in the Blowdown Phase and one in the Reflood Phase. The Reflood Phase PCT is affected by the phenomena related to Emergency Core Cooling System (ECCS) in the downcomer and lower plenum of the reactor vessel.

This report describes a general method for estimating the biases in the Reflood Phase PCT from systematic errors (biases) associated with the modelling of the ECCS and dissolved nitrogen, and the application of this method. The bias in the Reflood Phase PCT due to the uncertainty in the existing code models for ECCS related phenomena is -19°K (-34°F). The bias in the PCT due to the lack of modelling of dissolved N_2 in the code is estimated to be 9.9°K (17.8°F). The code prediction for PCT is conservative if the bias is negative, and nonconservative if the bias is positive. The bias estimated here is based on full scale data from the Upper Plenum Test facility and is unaffected by the scale distortions

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

Reactor Accidents--Mathematical Models; PWR Type Reactors--Reactor Accidents; PWR Type Reactors--Reactor Safety; Loss of Coolant--T Codes; PWR Type Reactors--Loss of Coolant; Blowdown; Cladding; Computerized Simulation; ECCS; Parametric Analysis; Test Facility; Heat Transfer; Computer Codes

13. AVAILABILITY STATEMENT

Unlimited

14. SECURITY CLASSIFICATION

(This Page) Unclassified

(This Report) Unclassified

15. NUMBER OF PAGES

16. PRICE

NRC FORM 335 (2-89)

THIS DOCUMENT WAS PRINTED USING RECYCLED PAPER.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

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