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CONFIRMATORY ANALYSIS:
ANO-2 Design Basis Accident Containment Response

Prepared for

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1. INTRODUCTION

Entergy Operations, Inc., the licensee for Arkansas Nuclear One, Unit 2 (ANO-2), has requested US Nuclear Regulatory Commission (NRC) approval of a license amendment associated with the ANO-2 Replacement Steam Generator Project (Entergy 1999). The amendment addresses the containment's post-accident response resulting from the new steam generators that will be installed beginning with operating Cycle 15. The pivotal element of the license amendment request is an increase in the containment design pressure from 54 to 59 psig. The licensee has determined the increased containment design pressure to be an unreviewed safety question (USQ) in compliance with 10 CFR 50.59, which requires NRC review and approval before implementation.

The licensee submitted structural response analyses that support the higher containment design pressure. The licensee also updated the calculations of peak containment pressure during established design-basis events that demonstrate the peak pressures to be lower than the revised design pressure of the containment. These calculations were performed with computer programs that have been approved by the NRC. However, because of the importance to safety of an intact containment following an accident and because the results of a computer calculation depend to a large extent on the detailed modeling and assumptions used in the it, independent confirmatory calculations were performed to verify the licensee's conclusions. The confirmatory calculations are described here.

After the calculations described in the main body of this report were completed, the licensee submitted a supplement to their amendment request (Entergy 2000). The supplement described corrections to two assumptions in computer model input. Other changes in plant input and modeling assumptions also were made to "offset the effects of these corrections." Additional confirmatory calculations were performed to examine these changes, which are described in Appendix B.

1.1. Background

Corrosion-related phenomena have degraded the ANO-2 heat-transfer capability and therefore the net thermal power generated by plant to the extent that the licensee has decided to replace the original steam generators with new ones. The replacement steam generators have larger primary and secondary inventories than the original steam generators. From a safety analysis perspective, the larger coolant inventories represent an increase in the stored energy available for release to the containment during a design-basis loss of coolant accident (LOCA). In addition, the licensee plans to increase the power level of ANO-2 from 2815 MWt to 3026 MWt.

These changes in plant characteristics result in an increase in the containment pressure associated with the postulated accidents that are part of the ANO-2 licensing basis, with peak pressures exceeding the current design pressure for several scenarios. In particular, peak pressure for the design-basis events that determine the bounding structural loads on the containment were identified in the amendment request to be 57.7 psig. The licensee rounded this value to 58 psig for defining the peak containment accident pressure (1 psi below the new design pressure of 59 psig).

1.2. Objective and Scope of Confirmatory Analysis

The objective of the analysis described here is to provide independent calculations of the peak pressure and temperature inside the ANO-2 containment associated with design-basis LOCA and main steam line break (MSLB) accident scenarios. Differences in results from those submitted by the licensee, if any, are identified and explained.

2. APPROACH

Calculations of containment response to design-basis accident (DBA) scenarios were performed using the MELCOR 1.8.4 computer code. MELCOR provides a robust framework for calculating nonequilibrium thermodynamic behavior in the containment and heat transfer to bounding structures, including the effects of engineered safeguard systems. Further, MELCOR provides the requisite flexibility to examine the effects of alternative assumptions and modeling uncertainties on calculated results. The convenience afforded by MELCOR for this purpose is the primary reason for using it in lieu of the CONTAIN computer code (Murata 1997). Recent comparative analysis performed by Sandia National Laboratories has shown that the two codes generate sufficiently similar results for the current objectives (Gauntt 1999). Potential deficiencies in containment wall condensation modeling identified by the MELCOR peer review are mitigated by the fact that wall heat-transfer coefficients were specified through user input in the current analysis (Boyack 1992). A listing of the ANO-2 MELCOR model is given in Appendix A.

2.1. Containment Geometry and Structures

The free volume within the ANO-2 containment is represented by a single thermodynamic control volume. Treatment of the entire containment free volume as a single (iso-thermal, uniformly mixed) control volume is consistent with the vendor analysis. More detailed subcompartment analysis was not practical because geometric information needed to subdivide the containment volume was absent. The containment sump is not represented as a distinct thermodynamic control volume. Water that falls to the containment floor from operation of containment sprays or drains from films on structure surfaces collects in the sump. Alternatively, in the LOCA simulations, water is sourced directly to the sump during the reflood/post-reflood periods, which accounts for discharge from the reactor coolant system (RCS). In all cases, a nonequilibrium thermodynamic solution to the control volume conservation equations allows the sump water to have a different temperature from the atmosphere. Mass transfer between the sump water and the containment atmosphere (i.e., evaporation or condensation) is modeled. For the LOCA simulations, the volume of the reactor vessel and other RCS internals is not represented in the model, which is consistent with the conservative assumptions applied in the licensee analysis.

A total of 20 one-dimensional heat structures was defined to model the effects of heat transfer between the containment atmosphere and surfaces such as the containment walls, floors, and equipment. These structures directly mimic those described in Table 6.2-8D of the licensee submittal. Heat transfer between these surfaces and the atmosphere or sump water was modeled using specified values for surface coefficients. Values for surface coefficients were derived from guidance provided in NUREG-0800. Surface coefficients were treated as an uncertain parameter in the current analysis, and the effects of alternative, credible values are examined in the results described in Sec. 3.

2.2. Engineered Safety Features

Containment heat removal by the operation of containment air coolers and containment sprays was modeled based on information provided in the licensee submittal. Air cooler performance was modeled by a simple tabular function of heat removal rate as a function of inlet (containment atmosphere) temperature. Performance data were taken from Table 6.2-8I in the licensee submittal. Heat removal rate is also a weak function of service water (SW) temperature. This effect was not modeled explicitly in the current analysis, and the effects of changing SW temperature were examined through sensitivity analysis (see Sec. 3). One of two trains of containment air coolers was assumed to operate in the LOCA and MSLB analyses.

Containment spray operation was modeled using the Spray Package in MELCOR. Spray flow rates in the injection mode and recirculation modes were modeled as defined in Tables 6.2-8F and 6.2-9A of the licensee submittal (i.e., 1875 gal./min and 2000 gal./min, respectively). In the LOCA simulations, switch-over of suction from the refueling water tank (RWT) to the containment sump was specified to occur at the time derived from the licensee analysis (2707.62 s). An independent calculation of time to switchover was not possible because of the absence of information regarding the depletion of the RWT inventory by emergency coolant system (ECS) operation. The change in spray droplet size accompanying the increase in flow rate from injection to recirculation spray was modeled as specified in the submittal. One of two trains of containment spray was assumed to operate in the LOCA and MSLB analyses.

Actuation of either system was modeled explicitly, including the appropriate containment pressure signals and delay times.

2.3. Mass/Energy Sources

Mass and energy sources to the containment were developed from data provided in the licensee submittal. In the current analysis, mass and energy sources associated with the discharge of steam and/or water to the containment were defined in terms of integral quantities (i.e., cumulative mass or energy as a function of time). These quantities were taken directly from Tables 6.2-8B and 6.2-9B in the licensee submittal for the LOCA and MSLB scenarios, respectively.

Two additional sources of energy to the containment atmosphere are represented in the LOCA analysis. One is the release of sensible heat from RCS structures. Three elements of the energy source were defined.

- Residual energy associated with the pressurizer
- Residual stored energy associated with the RCS loop and the steam generator
- Residual energy associated with the reactor vessel upper head and its miscellaneous hardware

The total quantities of energy involved are given in Table 6.2-8B of the licensee submittal, but neither the rates nor the time periods over which these energies are released are described. In the baseline analysis described in Sec. 3, it is assumed that these quantities of energy are added to the containment atmosphere at an even rate over a period of 1 h.[1] A sensitivity calculation was performed to examine the extent to which the results might change if more rapid energy release rates are assumed.

The second additional source of energy to the containment atmosphere in the LOCA simulations is decay heat. The energy source associated with decay heat was specified as the product of the rated core power and a normalized decay heat curve developed from Branch Technical Position ASB 9-2 (shown in Fig. 6.2-11 of the licensee submittal). Two values of rated core power were examined here, the current power level of 2815 MWt and the proposed up-rate level of 3026 MWt. In either case, long-term containment response was calculated assuming that the decay heat corresponding to 102% of rated power is added directly to the containment atmosphere.

Sources of mass and energy to the containment from each of these sources (with the single exception of decay heat) are shown in Fig. 2.1 in the form of cumulative quantities. The sources are more diverse in the LOCA scenario than in the MSLB scenario, but the total amount of mass/energy imparted to the atmosphere is very similar in both cases.

[1]The time at which energy release begins differs among the three sources as described in Sec. 6.2.1.1.3.1.1.1 of the licensee submittal.

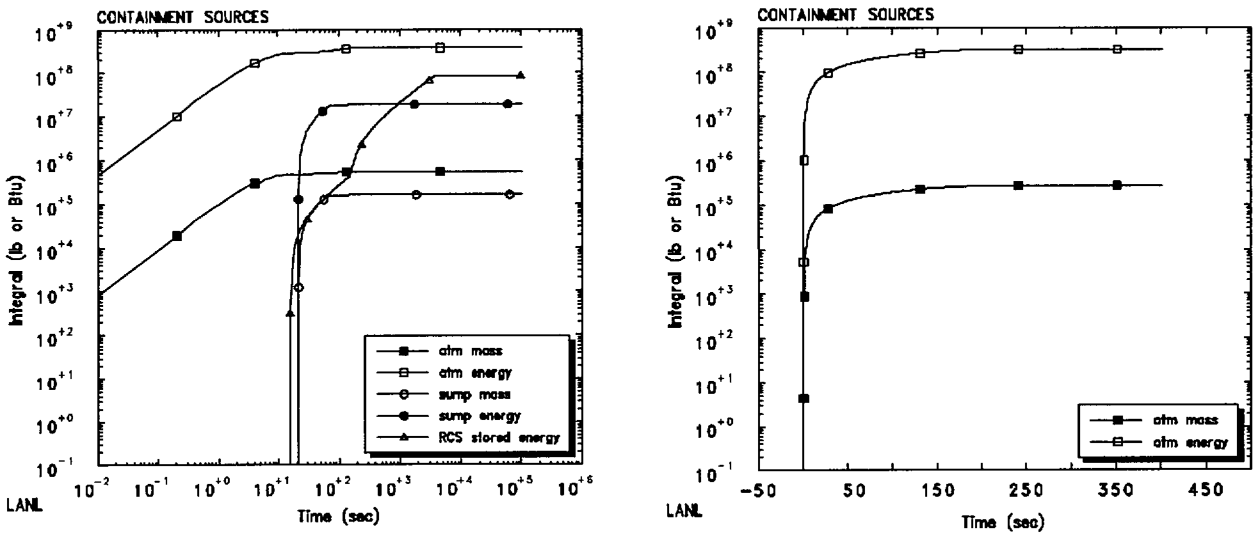

Fig. 2.1. Cumulative Mass/Energy Source to Containment (LOCA on the Left, MSLB on the Right).

2.4 Other Boundary Conditions

The current ANO-2 technical specifications allow containment leakage up to 0.1% of the containment volume per day. However, the containment was assumed to be leak tight in the current analysis. A sensitivity calculation was performed to examine the effect of leakage on containment peak pressure.

3. RESULTS OF CONFIRMATORY ANALYSIS

The results of the confirmatory analysis of the LOCA are described in Sec. 3.1. The results of calculations for the DBA MSLB are described in Sec. 3.2.

3.1. Large-Break Loss-of-Coolant Accident

The limiting conditions for the large-break LOCA in terms of emergency safety feature (ESF) availability and operating conditions were evaluated and defined in the licensee submittal (e.g., the number of available trains of ESF systems). These conditions were adopted for our analyses without change. For the limited DBA, a baseline calculation was established that applies the general modeling guidelines outlined in the Standard Review Plan (SRP). These guidelines also were followed in the licensee analysis. Several additional calculations were performed to evaluate the extent to which peak containment pressure is sensitive to model input concerning key boundary conditions and modeling assumptions.

A description of the modeling assumptions used in the baseline calculations and subsequent sensitivity calculations is given in Sec. 3.1.1. Key results from the baseline calculation are described in Sec. 3.1.2, and the results of the sensitivity calculations are described in Sec. 3.1.3. A summary of all the calculated results is given in Sec. 3.1.4.

3.1.1. Modeling Variables

The parameters that were varied in these calculations are summarized in Table 3.1 and discussed below.

Rated Power. The licensee plans to submit a separate amendment request addressing a power up-rate from the current value of 2815 MW_t to 3026 MW_t. Nevertheless, the analyses supporting the current amendment request were based on an assumption that the up-rate will occur. The decay heat level used in the confirmatory calculations also was based on a rated power of 3026 MW_t. A sensitivity calculation was performed with the rated power reduced to the currently approved level to approximate the effect of this change on containment pressure[2].

Table 3.1. Variables in the LOCA Calculations.

Variable	*SRP Baseline*	*Sens1*	*Sens2*	*Sens3*	*Sens4*	*Sens5*	*Sens6*	*Sens7*	*Sens8*
Rated Power (MW)	3026	3026	2815	3026	3026	3026	3026	3026	3026
Service Water Temp (°F)	110	120	110	110	110	110	120	120	120
RCS Sensible Heat Addition Time (min)	60	60	60	10	60	60	60	60	60
Heat Structure Film	Yes	Yes	Yes	Yes	No	Yes	No	No	No
Structure Surface Coefficient	Tagami & Uchida	Tagami & Uchida	Tagami & Uchida	Tagami & Uchida	Tagami & Uchida	Tagami decays to 5.0*	Tagami decays to 5.0	Tagami decays to 5.0	Tagami decays to 5.0
Steel/Concrete Gap Conductance*	100.	100.	100.	100.	100.	100.	100,000	100.	100.
Containment Leakage (vol-%/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

[2]This approach does not account for differences in energy stored in reactor fuel.

* $Btu/h\text{-}ft^2\text{-}°F$

Service Water Temperature. In the licensee analysis, containment heat removal through the air coolers was calculated using a model that accounts for time-dependent changes in SW temperature and therefore cooler performance. The results of their analysis indicate that SW temperature increases linearly from an initial value of ~100°F to ~120°F over a period of 1 day (refer to Fig. 6.2-8B in the submittal). This time period is very long in comparison to the period of interest to the present analysis. Consequently, a simpler, conservative approach was taken. In the confirmatory calculations; the SW temperature was assumed to remain constant. In the baseline calculation, SW temperature was assumed to be 110°F (i.e., the average value calculated in the licensee's analysis). Sensitivity calculations also were performed assuming a constant SW temperature of 120°F.

RCS Sensible Heat Addition. As described above, the time period over which stored energy in the RCS and steam generator structures is released to the containment atmosphere is not specified in the submittal. A 1-h release period was assumed in the baseline calculation. A sensitivity calculation was performed assuming a 10-min release period.

Heat Structure Films. In the COPATTA analysis performed by the licensee, condensate on containment structures is transferred to the sump immediately upon formation. The effects of film development and drainage were not taken into account. In the baseline confirmatory calculation, condensate films were allowed to develop and gradually drain to the sump as allowed in the default MELCOR models. However, the effects of film conductance on structure heat transfer were examined in sensitivity calculations in which the maximum film thickness was set to 10^{-6} mm (i.e., no film).

Heat Structure Surface Coefficient. Specific guidelines are not provided in the SRP for modeling condensing heat transfer on containment structures to calculate peak (maximum) containment pressure. However, a correlation by Tagami for the blowdown period of a LOCA and data by Uchida for the reflood and post-reflood periods are recognized standards for this purpose. These coefficients were used in the baseline confirmatory analysis as follows.

- Blowdown period (0–14.9 s): A linear ramp from an initial value of 8 $Btu/h\text{-}ft^2\text{-}°F$ to a maximum value defined by the Tagami correlation.

$$h_{Tagami} = 72.5\ (Q/V\ t_p)^{0.62} \tag{1}$$

where

h_{max} = maximum blowdown coefficient
Q = primary coolant energy (Btu) (3.00E8 Btu including residual energy stored in the pressurizer)
V = net free containment volume (ft^3) (1.778E6 ft^3)
t_p = time interval to end of blowdown (s) (14.9 s)

- Reflood and post-reflood (14.9 s onward): An exponential transition to the Uchida correlation as follows.

$$h_{longterm} = h_{Uchida} + (h_{Tagami} - h_{Uchida})\exp\{-0.025(t-t_p)\} \tag{2}$$

where h_{Uchida} = a function of the air-to-steam mass ratio in the containment atmosphere.[3]

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[3]Data for the Uchida coefficients are taken directly from Branch Technical Position CSB 6-1 (Rev. 2).

Time-dependent values for the atmosphere air-steam mass ratio and the Uchida surface coefficient are calculated as part of the MELCOR model for the baseline LOCA calculation as shown in Fig. 3.1. A peak value of approx. 325 Btu/h-ft^2-°F (~1850 W/m^2-K) results from this approach.

The blended Tagami/Uchida coefficients are used in several of the calculations listed in Table 3.1. However, an alternate conservative approach also was taken; namely, the time-dependent values from the Uchida correlation in Eq. (2) were replaced by a single, long-term asymptotic value of 5 Btu/h-ft^2-°F (~28 W/m^2-K). The resulting alternative transition from the Tagami peak value also is shown in Fig. 3.1. These values are used in several of the sensitivity calculations.

Steel/Concrete Gap Conductance. An argument is posed in the licensee submittal and is examined in one sensitivity calculation. The DBA calculation results presented in the submittal assume that an air gap of 0.01 ft (0.12 in.) separates the steel containment liner from the outer concrete shell. This gap is assumed to have an average conductance of 100 Btu/h-ft^2-°F. This value also was used in most of the confirmatory calculations. However, a value of 100,000 Btu/h-ft^2-°F was used in a sensitivity calculation to represent near-perfect contact between the steel liner and concrete wall. This calculation was performed to confirm the statement made in the submittal that "by introducing an interface conductance of 100 Btu/hr-ft^2-°F on the lined concrete heat sinks instead of assuming perfect contact, the peak containment pressure increases less than one per cent."[4]

Containment Leakage. The final parameter examined in the sensitivity calculations was containment leak rate. All calculations except one assumed that the containment pressure boundary is leak tight. The

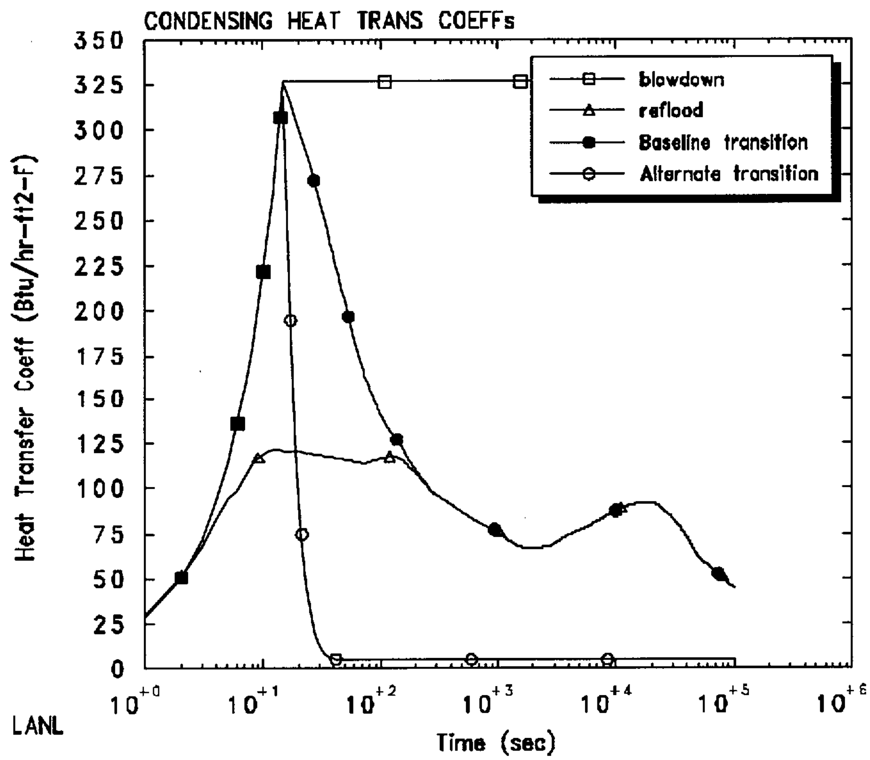

Fig. 3.1. Structure Heat-Transfer Coefficients (LOCA Calculations).

[4]Statement in Entergy report Sec. 6.2.1.1.3.1.2.1 (1999).

effects of the maximum allowable leak rate[5] on the calculated peak pressure were examined in a sensitivity calculation.

3.1.2. Baseline Results

The times of key events obtained from the baseline LOCA calculation are compared with the licensee results in Table 3.2. The prompt increase in containment pressure associated with RCS blowdown results in containment air cooler and containment spray actuation signals within 1 s of the pipe break. ESF operation begins 52 s after the containment pressure high (CPH) actuation signal for the air coolers, and 53.6 s after the containment pressure high-high (CPHH) signal for containment sprays[6].

As indicated in Fig. 3.2, differences in calculated containment pressure signature following RCS blowdown lead to differences in the predicted peak pressure and the time at which it occurs. The qualitative trends in baseline confirmatory calculation and the licensee result are similar, but several quantitative details differ. The peak pressure immediately following RCS blowdown is approximately 5 psi higher in the MELCOR baseline calculation than the COPATTA result. More importantly, the subsequent rise in containment pressure resulting from mass/energy addition during reactor vessel reflood and from the residual energy released from RCS structures (refer to Fig. 2.1) is much smaller in the baseline calculation than in the licensee calculation. The peak pressures predicted in the two calculations are 57.7 psig (COPATTA) and 53.3 psig (MELCOR baseline). Potential causes for this difference are examined in the sensitivity calculations described in Sec. 3.1.2.

The containment temperature responses in the two calculations are compared in Fig. 3.3. Temperature signatures are shown for the containment atmosphere as well as for water in the sump. Again, the qualitative trends are very similar. Differences in the quantitative results, particularly peak temperature, are not as noteworthy as those for containment pressure. The peak temperature calculated in the MELCOR baseline analysis is 278.6 °F compared with 291°F in the licensee analysis.

Table 3.2. Calculated Time of Key Events (Baseline LOCA).

Event	Time (s) Licensee Calculations	Time (s) Baseline Confirmatory Calculation
Pipe rupture, mass/energy release to containment begins	0.0	0.0
CPH signal received—containment air cooler actuation set point	0.5	0.46
CPHH signal received— containment spray set point	1.0	0.90
End of blowdown period	14.9	14.9
Containment air coolers begin operation	52.5	52.5
Containment sprays begin operation	54.6	54.5
Containment reaches peak temperature	54.6	3616.
Containment reaches peak pressure	149.0	13.0
Switchover to spray recirculation	2707.62	2707.62
End of analysis	2.60×10^6	1.0×10^6

[5]The hole allowing 0.1% volume/day leakage is sized assuming that the containment is pressurized with air to the proposed new design pressure (59 psig).
[6]The delay times are specified in the submittal.

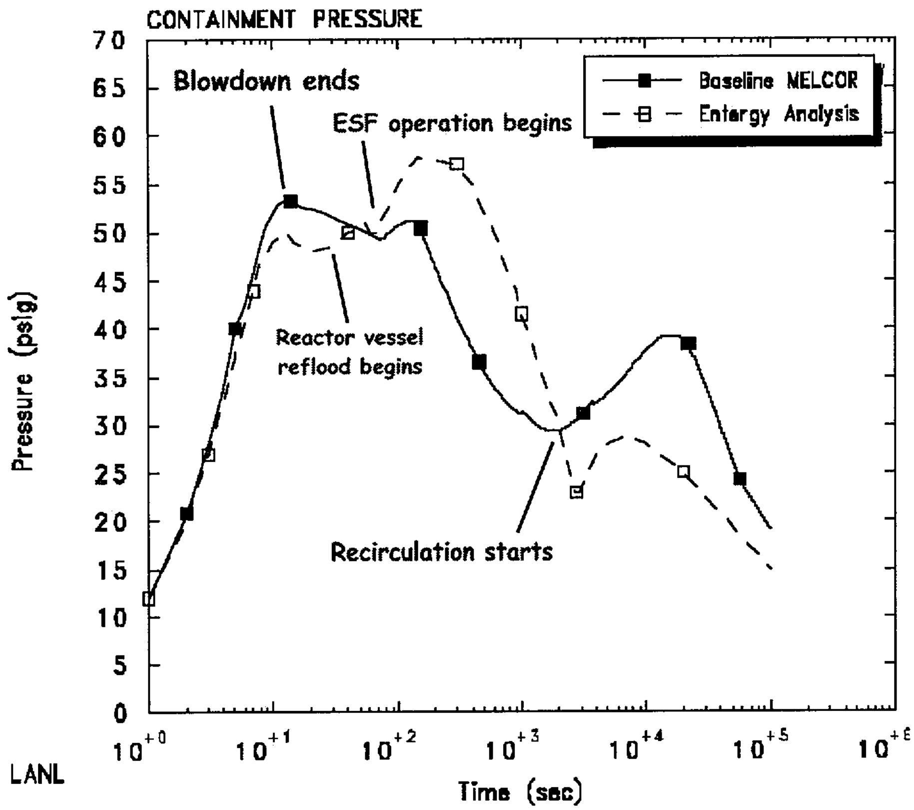

Fig. 3.2. Containment Pressure (LOCA Baseline Calculation).

3.1.3. Sensitivity to Key Modeling Parameters

The modeling variables examined in the sensitivity calculations were described in Sec. 3.1.1. The results of the sensitivity calculations are described below.

Sensitivity cases 3, 4, and 5 (see Table 2.1) examined the modeling parameters that influence peak containment pressure following reactor vessel reflood, in particular, the following.

1. A faster rate at which residual stored energy in the RCS is assumed to be released
2. Neglecting the development and drainage of condensate films on heat structures
3. Reduced post-reflood structure heat-transfer coefficients

The containment pressure signatures generated in these three sensitivity calculations are compared with the MELCOR baseline and licensee results in Fig. 3.4.

The pressure signature for the case in which liquid films on the containment structures are neglected (i.e., condensate is transported to the sump immediately as it forms) is nearly identical to that for the baseline calculation. Changes in the other two parameters result in a noticeable change in the pressure history.

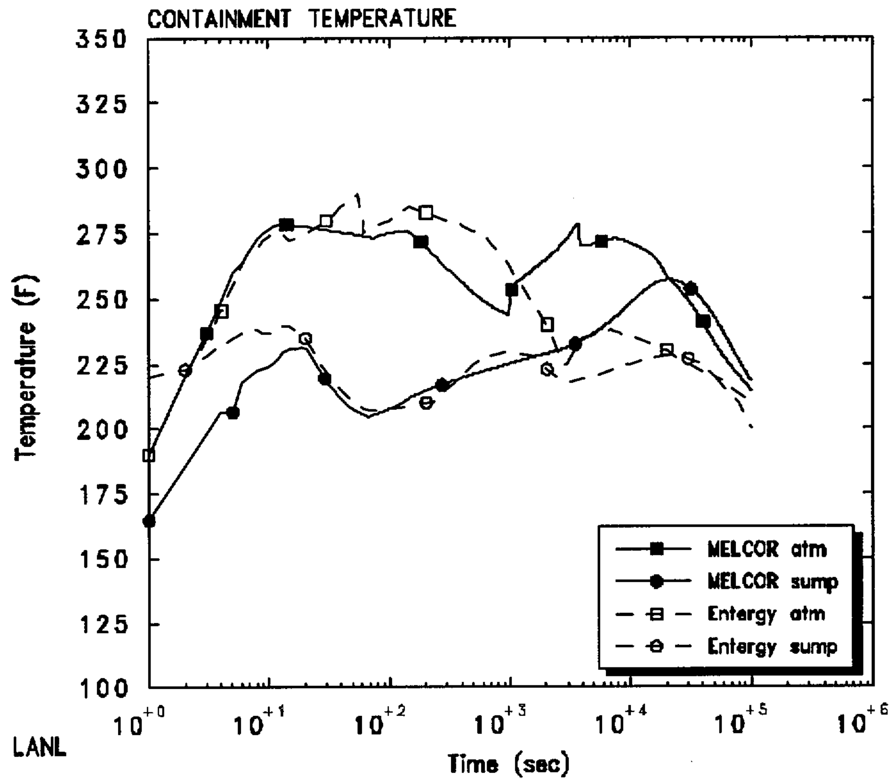

Fig. 3.3. Containment Temperature (LOCA Baseline Calculation).

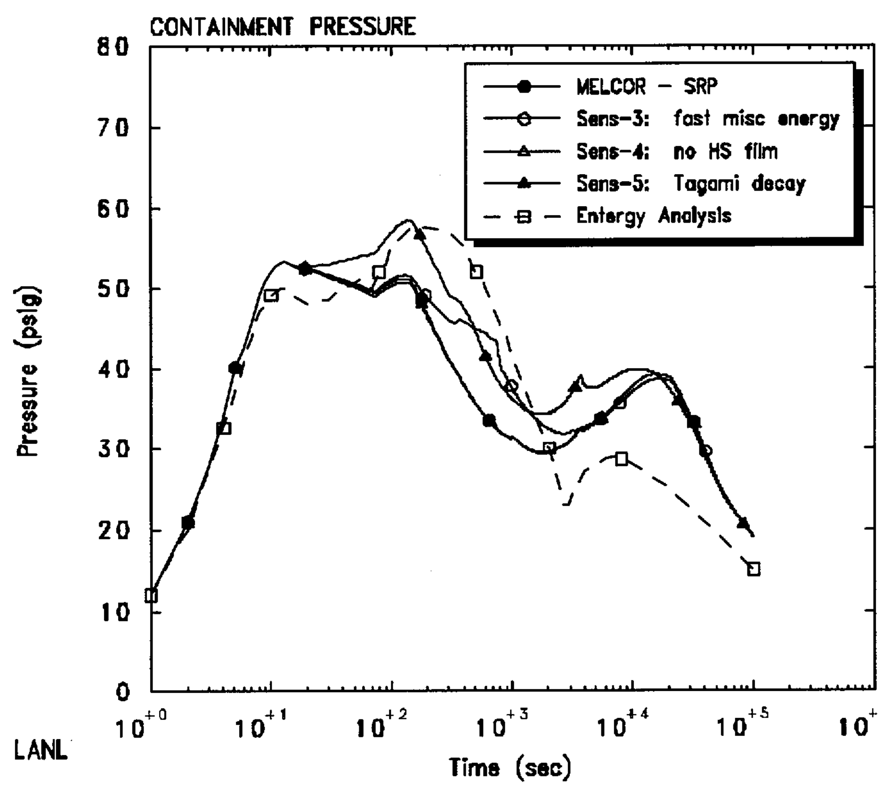

Fig. 3.4. Containment Pressure (Sensitivity Cases 3, 4, and 5).

Accelerating the release of residual RCS energy is not shown to increase the peak pressure, but it slows the subsequent rate at which the containment depressurizes. Reducing the post-reflood containment structure surface coefficients generates a noticeable increase in peak pressure. The peak pressure for sensitivity case 5 is 58.4 psig, approximately 0.7 psi higher than the licensee result.

Sensitivity cases 3 and 5 also change the calculated peak containment temperature. As shown in Fig. 3.5, a sharp increase in temperature occurs in the two sensitivity calculations; this is caused by an imbalance between energy addition rates to the containment atmosphere and heat removal rates by ESF operation and structure surface heat transfer.

Sensitivity cases 1 and 2 examined modeling parameters that influence containment response in the intermediate period following switchover to spray recirculation, in particular, the following.

1. Degrading containment air cooler performance by assuming higher service water temperature
2. Reducing decay heat by assuming a reduced (i.e., the current) core rated power

The results from these cases are shown in Fig. 3.6. Neither case significantly alters the calculated containment pressure signature before switchover to spray recirculation, but the secondary peak in pressure that occurs roughly 5 h (18,000 s) into the accident is reduced slightly at lower decay heat levels and is increased slightly with degraded air cooler performance.

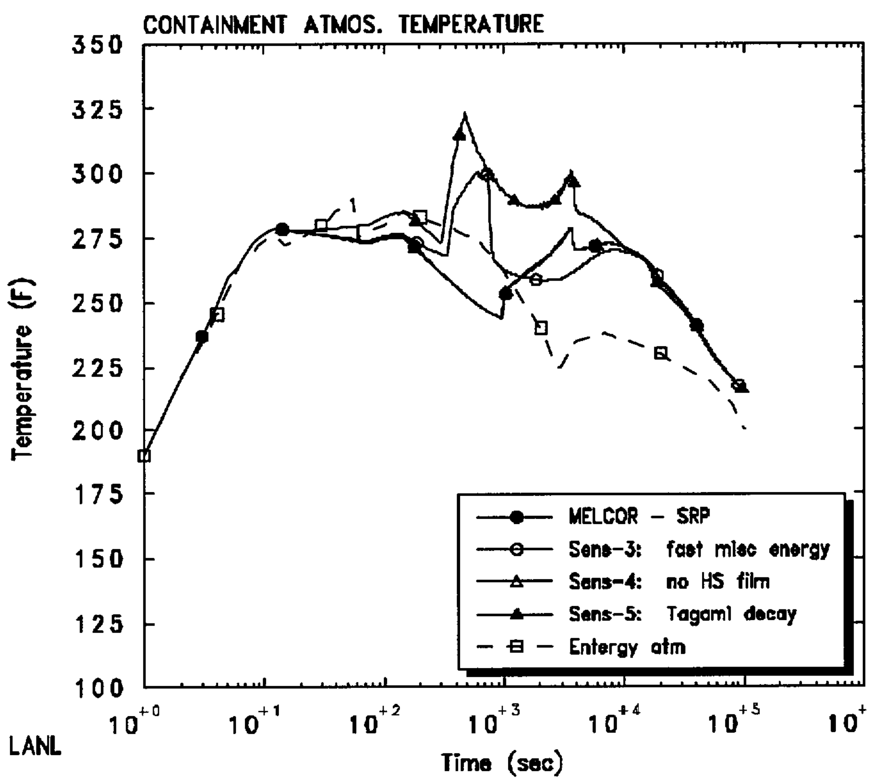

Fig. 3.5 Containment Temperature (Sensitivity Cases 3, 4, and 5).

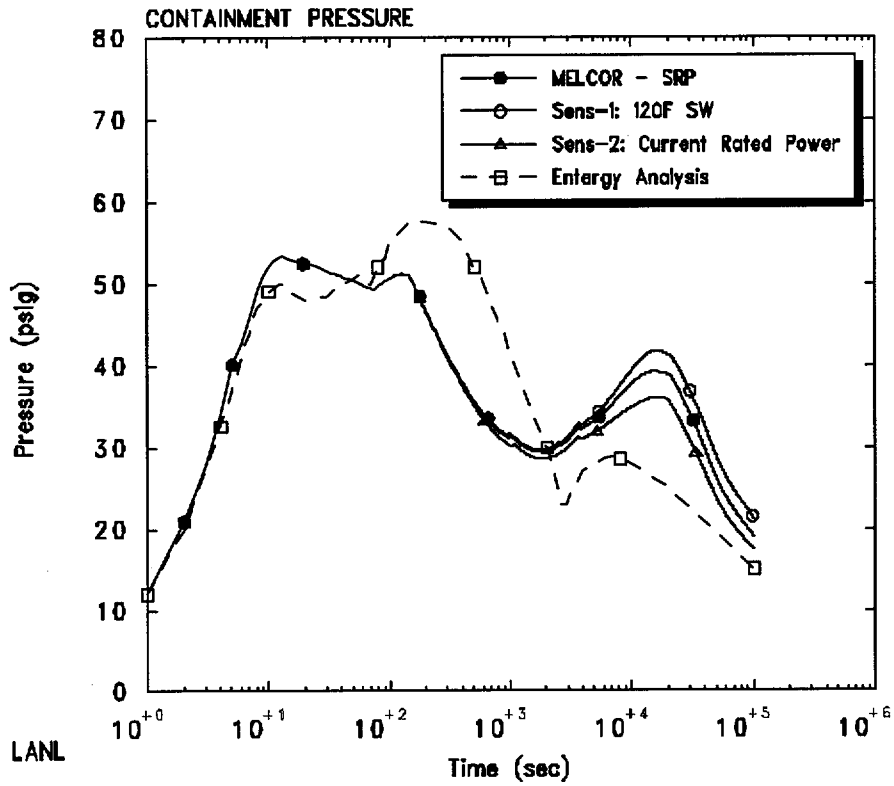

Fig. 3.6. Containment Pressure (Sensitivity Cases 1 and 2).

From these sensitivity calculations (and the results of sensitivity case 7),[7] bounding modeling assumptions were identified within the general SRP guidance. In particular, using the "alternate transition" to the Uchida correlation generated a bounding value for peak containment pressure and temperature. Assumptions regarding the other parameters were found to be of secondary importance. The range of containment pressure and temperature signatures generated by the alternative modeling assumptions examined here is summarized in Figs. 3.7 and 3.8, respectively.

As discussed in Sec. 3.1.1, two final sensitivity calculations were performed to measure the effect of containment leakage and perfect contact between the containment liner and concrete wall. The results of these calculations are shown in comparison with the bounding case in Fig. 3.9. Accounting for containment leakage (at a maximum rate corresponding to the Technical Specification limit of 0.1%/day is shown to have no effect on the containment pressure signature. On the other hand, perfect contact between the liner and the concrete wall reduces the peak pressure by approximately 4%, a larger margin than that mentioned in the submittal.

3.1.4. Summary of Loss-of-Coolant Accident Results

The results of the containment response analysis for the ANO-2 LOCA are summarized in Table 3.3. Peak pressures are shown to span a range of ±4% and peak temperatures span a range of ±7% of the mean values on this table.

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[7]The calculated peak pressure from sensitivity case 7 is 58.2 psig; the peak temperature is 324°F.

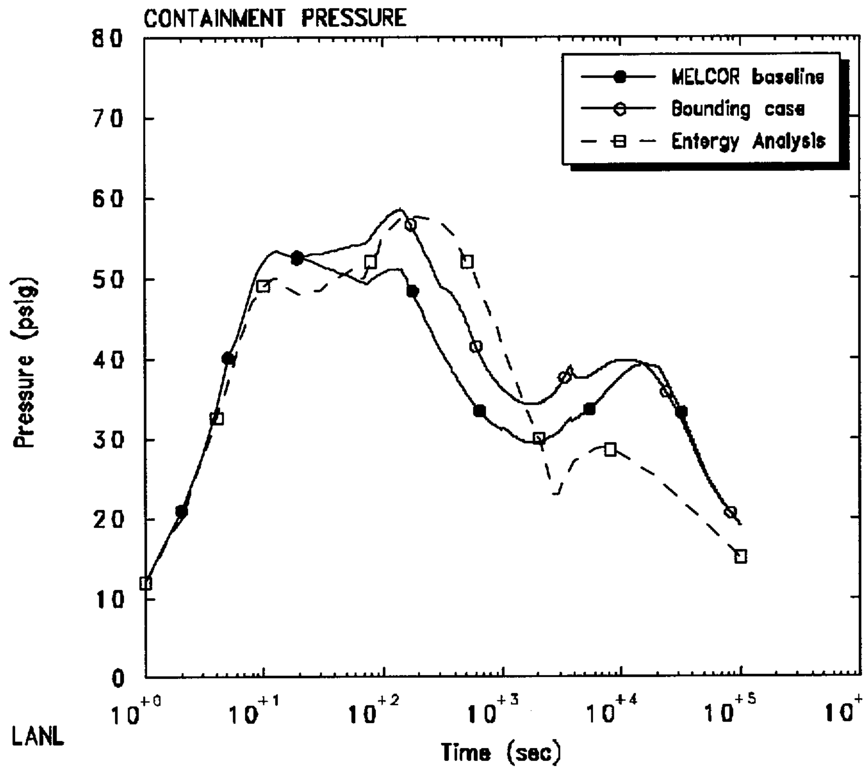

Fig. 3.7. Range of Containment Pressure Signatures in the Confirmatory Analysis.

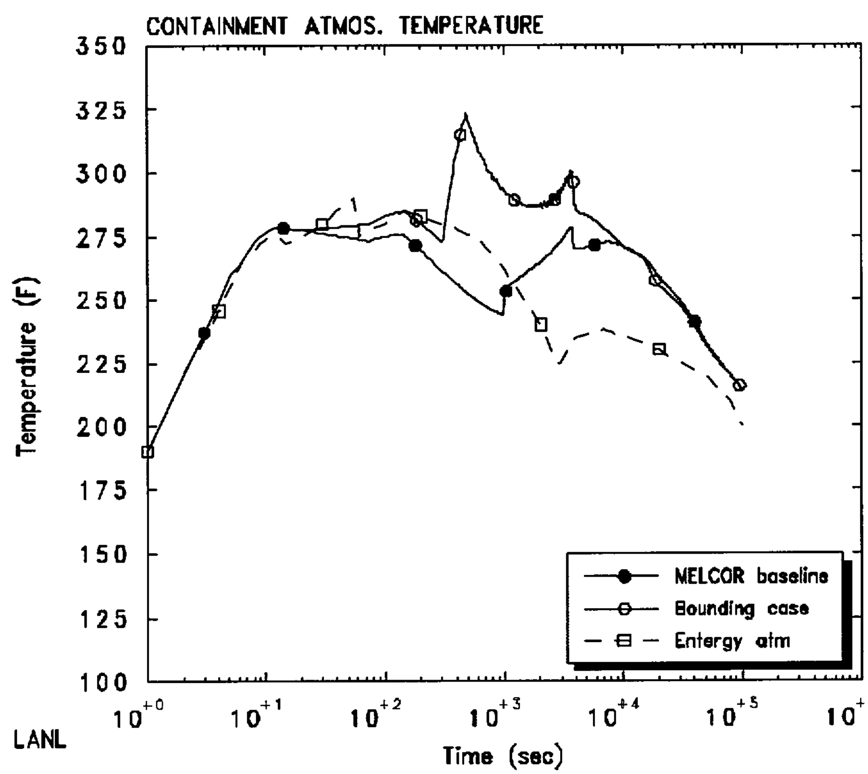

Fig. 3.8. Range of Containment Temperature Signatures in the Confirmatory Analysis.

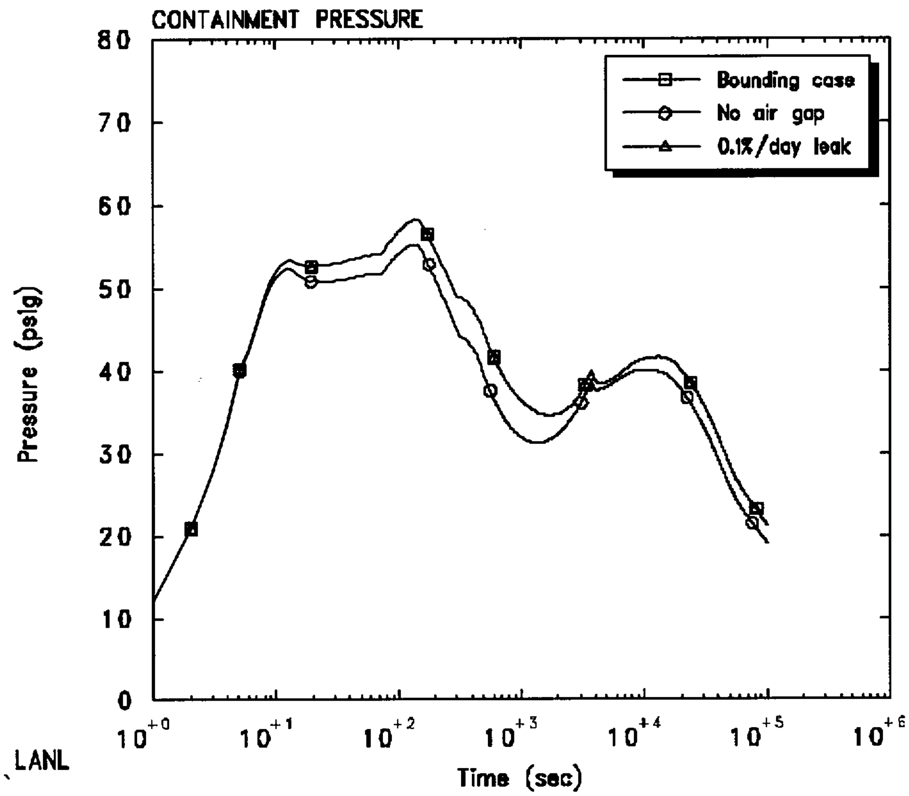

Fig. 3.9. Reduction in Containment Pressure from Bounding Case Resulting from Design Basis Leakage and Perfect Contact Between Steel Liner and Concrete Wall.

Table 3.3. Summary of Key Results: LOCA.

Variable	*SRP Baseline*	*Sens1*	*Sens2*	*Sens3*	*Sens4*	*Sens5*	*Sens6*	*Sens7*	*Sens8*
Peak Containment Pressure (psig)	53.3	53.3	53.3	53.3	53.3	58.4	55.2	58.2	58.2
Time at which Peak Occurs (s)	13.0	13.0	13.0	13.0	13.0	148.5	133.4	148.5	148.5
Peak Containment Temperature (°F)	278.6	280.5	278.6	300.6	278.8	323.1	311.0	324.2	324.2
Time at which Peak Occurs (s)	3616.	3616.	13.0	615.5	3616.	480.5	445.5	468.5	468.5

Alternatively, the peak pressure and temperature resulting from the confirmatory analysis can be characterized as follows.

	Confirmatory Analysis	**Licensee Analysis**
Peak Pressure (psig)	55.9 ± 2.5	57.7
Peak Temperature (°F)	301.4 ± 22.8	291

3.2 Main Steam Line Break

The confirmatory MSLB analysis is simpler than the LOCA analysis in several ways. The sources of mass and energy to the containment were limited to the discharge of secondary coolant from the faulted steam generator. Energy transferred from the RCS across the faulted steam generator tubes was assumed to be accounted for properly in the licensee's SGNIII and RELAP5 analyses.[8] Heat transfer to the containment heat structure was addressed directly through data correlated by Uchida; transitions from one family of surface coefficients to another were not needed. Finally, the RCS inventory is not depleted during an MSLB. Consequently, ECS operation is not required and sufficient RWT inventory is available to operate the containment sprays in injection mode throughout the time period of interest to this analysis.

One effect of these simplifications from the LOCA analysis is fewer parameters to examine through sensitivity calculations. Lessons learned from the LOCA calculations described in Sec. 3.1 also narrowed the list of candidate parameters to examine for the MSLB analysis.

3.2.1. Modeling Variables

The baseline modeling approach for the MSLB analysis was the same as that described in Sec. 3.1.1 for the baseline LOCA calculation with one exception. Heat transfer to containment structures is modeling data by Uchida as tabulated in Branch Technical Position CSB 6-1 (Rev. 2). Sensitivity calculations were performed to examine the effects of two variables, thickness of condensate film on structure surfaces and structure surface coefficients. The baseline calculation is described in Sec. 3.2.2; the sensitivity results are described in Sec. 3.2.3.

3.2.2. Baseline Results

The calculated times of key events in the MSLB sequence are compared with licensee results in Table 3.4. The times at which containment air cooler and spray actuation is initiated are in good agreement. However, the times at which peak pressure and temperatures occur differ for reasons described below.

The calculated containment pressure response for the baseline MSLB analysis is shown in comparison with the licensee result in Fig. 3.10. As in the baseline LOCA calculation, the qualitative pressure

Table 3.4. Calculated Time of Key events (Baseline MSLB).

Event	Time (s) Licensee Calculations	Time (s) Baseline Confirmatory Calculation
MSLB at 0% power, mass/energy release to containment begins	0.0	0.0
CPH signal received—containment air cooler actuation set point	3.2	3.2
CPHH signal received—containment spray set point	7.0	7.3
Containment air coolers begin operation	33.2	33.2
Containment spray begins operation	45.6	45.9
Containment reaches peak temperature	45.6	20.3
Containment reaches peak pressure	196.6	178.1
End of analysis	400.0	400.0

[8]A described in Sec. 6.2.1.1.3.2.1 of the submittal.

signatures are similar, but important quantitative differences are evident. First, the peak pressure in the MELCOR baseline calculation is significantly lower than the licensee result (50.0 vs 57.7 psig). The knee in the ascending pressure history is less evident in the MELCOR result than in the COPATTA result and occurs at a different time. The reasons for the difference in peak pressure are examined in the next section. The knee in the ascending pressure history occurs when superheat in the containment atmosphere is eliminated through operation of ESF systems. However, as indicated in Fig. 3.11, the amount of atmosphere superheat reflected in the MELCOR baseline calculation is ~120°F less than that in the COPATTA calculation. Consequently, the atmosphere returns to saturation conditions sooner in the MELCOR calculation; the knee is smaller and occurs earlier.

Altering the modeling assumptions associated with structure heat transfer as described below can eliminate these differences in results.

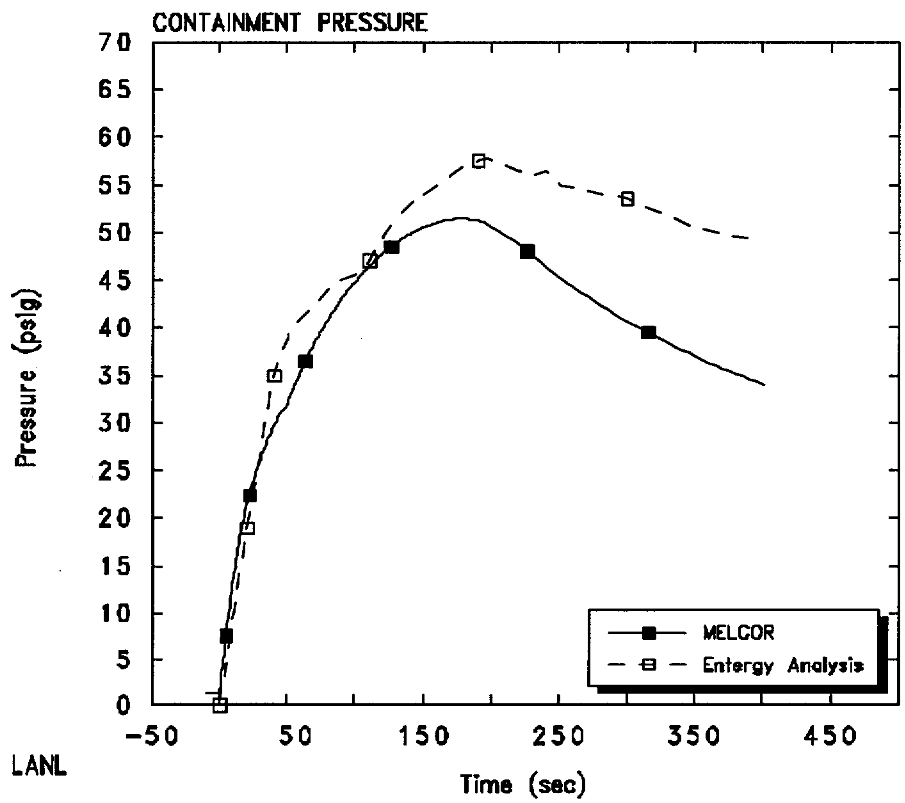

Fig. 3.10. Containment Pressure (MSLB Baseline Calculation).

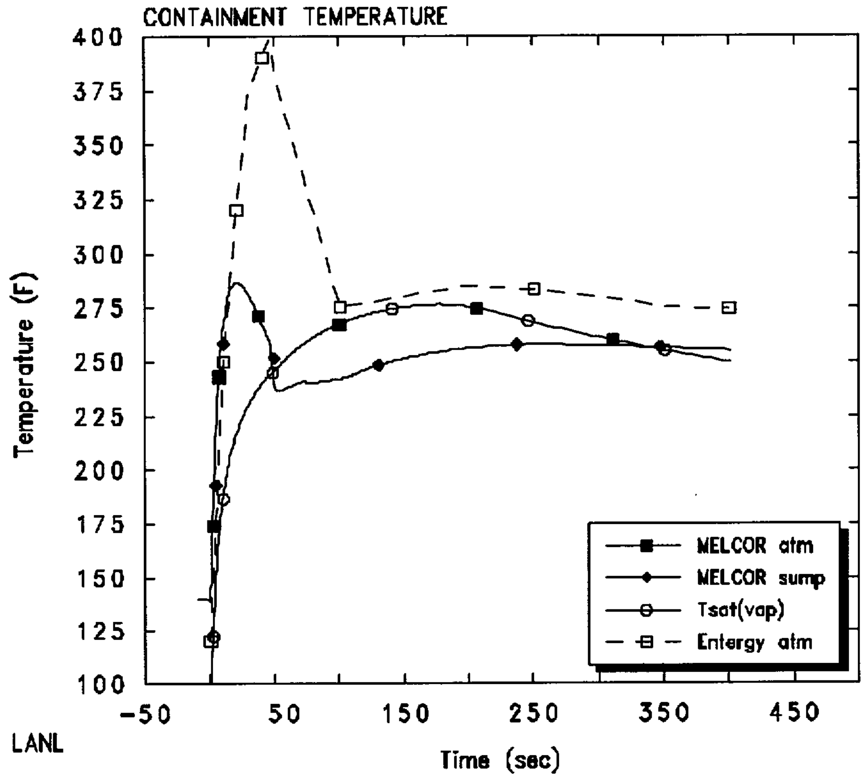

Fig. 3.11 Containment Temperatures (MSLB Baseline Calculation).

3.2.3. Sensitivity to Key Modeling Parameters

Two sensitivity calculations were performed to identify possible explanations for the differences in results described above. In the first sensitivity case, the thickness of liquid films on containment structures was set to 10^{-6} mm, effectively forcing condensate to be transported to the sump immediately upon formation. As described in Sec. 3.1.1, this nonstandard approach to containment modeling in MELCOR was taken to mimic a similar assumption made in the licensee's COPATTA analysis. The second case examined the effect of reduced structure surface heat-transfer coefficients. The basic formulation of the Uchida correlation was not changed in this sensitivity case. However, the magnitude of the resulting surface coefficients was decreased arbitrarily by a factor of 10.

The resulting containment pressure signatures are shown in comparison with the baseline result and the licensee's result in Fig. 3.12. Ignoring the presence of condensate films on containment structures is shown to have no effect on the baseline results. However, the results of the second sensitivity case show excellent agreement with the licensee analysis. A similar improvement in the calculated atmosphere temperature response is shown in Fig. 3.13.

3.2.4. Summary of Main Steam Line Break Results

The calculated results for the MSLB analysis are summarized in Table 3.5. The baseline results that result from the application of the SRP modeling assumptions (particularly values for surface heat-transfer coefficients) are shown to be approximately 16% lower than those presented in the ANO-2 license amendment request. A peak pressure consistent with the licensee analysis can be obtained by electing the conservative modeling approach of reducing the Uchida heat-transfer coefficients by a factor of 10.

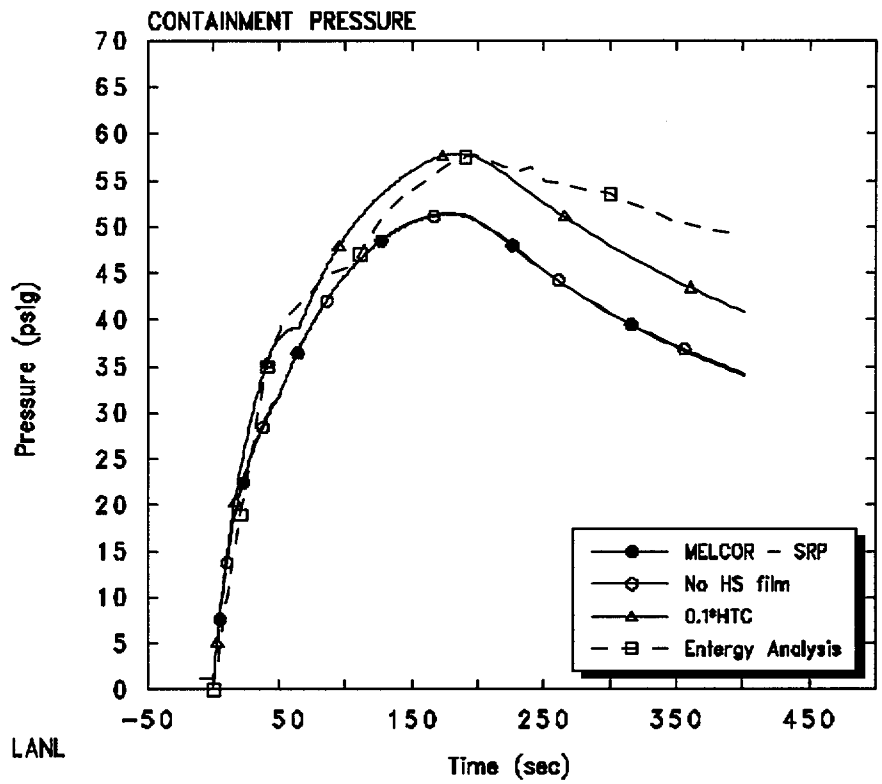

Fig. 3.12 Containment Pressure (MSLB Sensitivity Calculations).

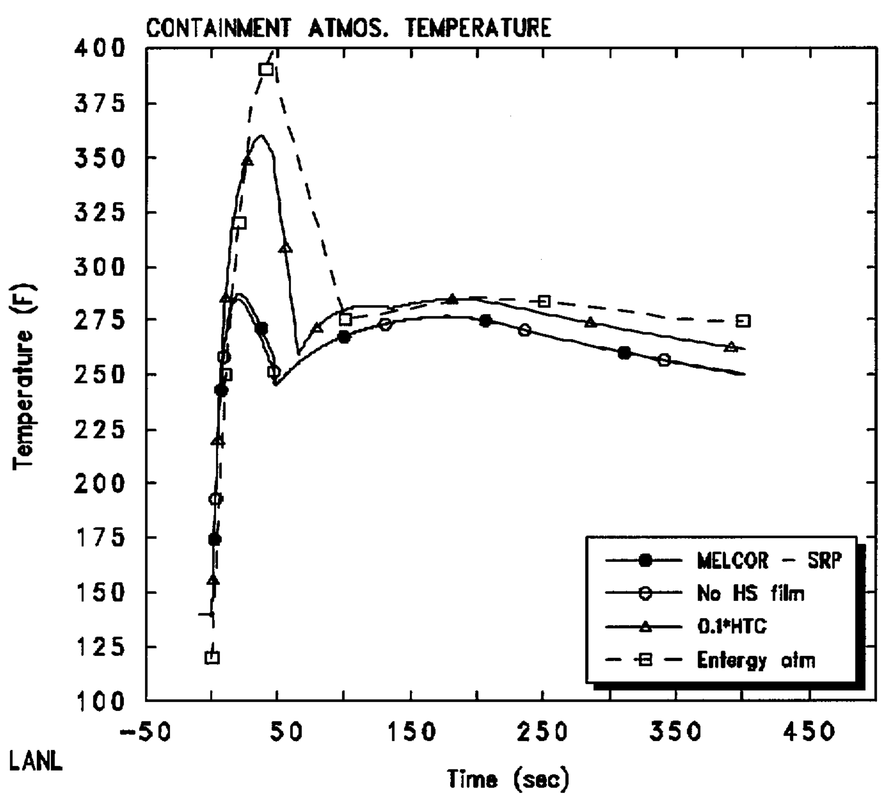

Fig. 3.13 Containment Temperatures (MSLB Sensitivity Calculations).

Table 3.5. Summary of Key Results: MSLB.

Variable	*SRP Baseline*	*Sens1*	*Sens2*	*Licensee Results*
Peak Containment Pressure (psig)	51.4	51.3	57.8	57.7
Time at which Peak Occurs (sec)	178.1	178.1	186.1	196.6
Peak Containment Temperature (F)	286.4	283.8	360.0	398.
Time at which Peak Occurs (sec)	20.3	19.4	37.0	45.6

4. DISCUSSION OF RESULTS

Confirmatory calculations of containment response to two DBA events in ANO-2 were performed using modeling assumptions consistent with guidance outlined in the SRP. In both cases, the confirmatory analysis generated peak containment pressures and temperatures lower than those presented by the licensee in their license amendment request. The difference in peak pressures is roughly 5% for the large LOCA scenario and is considerably larger for the MSLB scenario (~16%). Several sensitivity calculations were performed to identify plausible reasons for these differences. Among the parameters that were varied in these calculations, containment structure heat-transfer coefficients clearly stand out as having the single largest influence on results.[9] In the analysis of both DBA events, calculations of peak pressures consistent with those presented by the licensee could be replicated by applying surface coefficients significantly lower than those suggested in the SRP.

Although differences in results can be eliminated through more conservative modeling of surface heat transfer, this does not necessarily identify the root cause of the differences in the results. Alternative explanations may be possible but can only be investigated effectively through a cooperative effort with the licensee.

5. CONCLUSIONS

The licensee analysis of DBAs in the ANO-2 containment was performed in two sequential steps: (1) generate mass/energy sources to the containment resulting from a postulated DBA and (2) calculate the resulting containment thermodynamic response. The confirmatory analysis described here focused exclusively on the second step.

The confirmatory analysis of containment response clearly indicates that the peak containment pressure and temperature during a design-basis LOCA or MSLB event are no greater than the proposed containment design pressure of 59 psig.

REFERENCES

Boyack 1992 — B. E. Boyack et al., "MELCOR Peer Review," Los Alamos National Laboratory report LA-12240 (March 1992).

Entergy 1999 — Proposed License Amendment (No. 16) to License No. NPF-6, Entergy Operations, Inc., Arkansas Nuclear One, Unit Two, Docket 50-368, an Attachment to 2CAN119903 (November 3, 1999).

Entergy 2000 — Supplement to Proposed Technical Specification Change Request Supporting the ANO-2 Containment Building Design Pressure Increase to 59 Psig, 2CAN060014 (June 29, 2000).

Gauntt 2000 — R. O. Gauntt et al., "MELCOR/CONTAIN Parity Assessment Report," Sandia National Laboratories, Modeling & Analysis Department, report (January 24, 2000).

[9] It is important to note that variations in the tabulated mass and energy sources to the containment presented in the license amendment request were not examined.

Murata 1997 K. K. Murata et al., "Code Manual for CONTAIN 2.0: A Computer Code for Nuclear Reactor Containment Analysis," US Nuclear Regulatory Commission/Sandia National Laboratories report NUREG/CR-6533, SAND97-17359 (June 1997).

APPENDIX A

MELCOR Input Data

ANO-2 Design-Basis Accident Containment Response Analysis

July 2000

```
********************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  MELCOR CALCULATION CONTROL INPUT
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
********************************************************************
*
*eor* MELGEN
*
TITLE 'ANO-2  1-CELL CONTAINMENT'
*
OUTPUTFILE   ANO-2.GOU
DIAGFILE     ANO-2.GDI
RESTARTFILE  ANO-2.RST
*
NCG001   O2  4
NCG002   N2  5
*
TSTART    -10.
*
CRTOUT
*
**************** GEOMETRIC DATA ********************
r*i*f  geom.dat
*
**************** MATERIAL PROPS ********************
r*i*f  MP.dat
*
************** MASS/ENERGY SOURCE ******************
** Sources as integral quantities (via TF)
r*i*f DEDLSint.dat
**r*i*f MSLBint.dat
r*i*f decay-ht.dat
*
*************** SPRAY OPERATION ********************
r*i*f  SPRAY.dat
*
*************** FAN COOLER OPERATION ***************
r*i*f  FAN.dat
*
**** LICENSEE HEAT TRANSFER COEFFICIENTS ***********
r*i*f  HTC.dat
**  ALSO:  need to activate sensitivity coefficients in
**         MELCOR input below to zero out pool surface
**         heat transfer
****************************************************
******  TRACK PEAK VALUES
*
** Peak Pressure
cf50100   new-gt-old   L-GT     2  1.0  0.0   * TRUE if p .gt. old max
cf50101   .TRUE.
cf50110   1.4504E-4 -14.7 CVH-P.100          * current pressure (psig)
cf50111   1.0  0.0        cfvalu.502         * previous peak
*
cf50200   Peak-P       L-A-IFTE 3  1.0  0.0   * Peak containment pressure
cf50210   1.0  0.0        cfvalu.501          * if new .gt. old
cf50211   1.4504E-4 -14.7 CVH-P.100           * then peak is current value (psig)
cf50212   1.0  0.0        cfvalu.502          * else peak is old value
*
cf50300   Time-at-Peak L-A-IFTE 3  1.0  0.0   * Time peak pressure occurs
cf50310   1.0  0.0        cfvalu.501          * if new .gt. old
cf50311   1.0  0.0        TIME                * record time of peak
cf50312   1.0  0.0        cfvalu.503          * else time unchanged
*
** Peak Temperature
cf50400   new-gt-old   L-GT     2  1.0  0.0   * TRUE if p .gt. old max
cf50401   .TRUE.
```

```
cf50410   1.8 -460.       CVH-TVAP.100        * current temperature (F)
cf50411   1.0  0.0        cfvalu.505          * previous peak
*
cf50500   Peak-T      L-A-IFTE 3  1.0  0.0    * Peak containment atm temperature
cf50510   1.0  0.0        cfvalu.504          * if new .gt. old
cf50511   1.8 -460.       CVH-TVAP.100        * then peak is current value (F)
cf50512   1.0  0.0        cfvalu.505          * else peak is old value
*
cf50600   Time-at-Peak L-A-IFTE 3  1.0  0.0   * Time peak temp occurs
cf50610   1.0  0.0        cfvalu.504          * if new .gt. old
cf50611   1.0  0.0        TIME                * record time of peak
cf50612   1.0  0.0        cfvalu.506          * else time unchanged
*
.
************************************************************
*                       TIME ADVANCEMENT                   *
************************************************************
*eor* MELCOR
*
TITLE 'ANO-2  1-CELL CONTAINMENT'
CRTOUT
OUTPUTFILE    ANO-2.OUT
DIAGFILE      ANO-2.DIA
RESTARTFILE   ANO-2.RST
MESSAGEFILE   ANO-2.MES
PLOTFILE      ANO-2.PTF
*
CPULEFT       20.0
CPULIM         1.00E+06
RESTART       -1
TEND       100000.       * LOCA
*TEND         400.       * MSLB
*
*        TIME  DTMAX     DTMIN     DTEDT   DTPLT    DTRST
TIME1   -10.0   0.1   1.00E-08     10.0     0.1   3600.0
TIME2    -1.0   0.001 1.00E-08      5.0     0.1   3600.0
TIME3     1.0   0.001 1.00E-08     15.0     0.5   3600.0
TIME4    15.0   0.01  1.00E-08    600.0     1.0   3600.0
TIME5   150.0   0.1   1.00E-08    600.0     2.0   3600.0
TIME6   200.0   1.0   1.00E-08   3600.0     5.0   3600.0
TIME7  2000.0   2.0   1.00E-08  36000.0    10.0  36000.0
TIME8 10000.0   5.0   1.00E-08  36000.0    60.0  36000.0
**
** Sensitivity coefficients to zero out pool (sump) surface heat transfer
** (for cases where NUREG-0800 HTC values are being used)
**
SC00001   4407  0.0  2    * reset 4407(2) to 0.0
SC00002   4407  0.0  3    * reset 4407(3) to 0.0
SC00003   4407  0.0  4    * reset 4407(5) to 0.0
SC00004   4407  0.0  5    * reset 4407(6) to 0.0
SC00005   4407  0.0  7    * reset 4407(9) to 0.0
*
** Heat Structure maximum liquid film thickness
*SC00007   4251   1.E-9  2    * change default value of 0.0005 m
.
```

```
**********************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  Geometric configuration data
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
**********************************************************************
*
**************** CONTROL VOLUMES *******************
CVTYPE01  'contain'
CVTYPE08  'RWT'
CVTYPE09  'environ'
*
CV10000   'containment'   2   1   1   * Non-Equilibrium thermo
CV10001   0   0
CV100A0   3
CV100B1   0.0          0.0
CV100B2   52.2732 43848.6             * cylinder free vol
CV100B3   63.5508 50347.3             * total free volume (1.778E6 ft^3 [Table 6.2-
7])
CV100A1   VPOL         0.0
CV100A2   PVOL   110315.2             * 16.0 psia [Table 6.2-8F]
*CV100A2   PVOL   508139.4             * new design pressure: 59 psig
CV100A3   TATM       333.3            * 140 F
CV100A4   RHUM         0.             * [Table 6.2-8F]
CV100A5   MLFR.4       0.21
CV100A6   MLFR.5       0.79
*
CV99900   'environment'   2   1   9
CV99901   0   -1
CV999A0   3
CV999B1   0.0          0.0
CV999B2   100.        10.0
CV999A1   VPOL         0.0
CV999A2   PVOL   101352.1             * 14.7 psia
CV999A3   TATM       305.5            * 90 F  [Table 6.2-8F]
CV999A4   RHUM         0.0            *       [Table 6.2-8F]
CV999A5   MLFR.4       0.21
CV999A6   MLFR.5       0.79
*
**************** FLOW PATHS *******************
*
FL99900   'leakage'  100   999   1.   1.
*FL99901   0.881E-5   1.0   1.0         * 0.1% vol/day @ design pres.
FL99901   0.881E-5   1.0   0.0          * Open fraction = 0.0 DBA leakage [Table 6.2-
8F]
FL99902   3    0    0    0
FL99903   0.0   0.0  1.0   1.0
FL99904   0.    0.
FL999S0   0.881E-5   1.0   0.00164
*
**************** HEAT STRUCTURES **************
**                [Table 6.2-8D]
*
HS10001000   12   1   0               * 12 nodes / rectangular geom
HS10001001   'Type B wall-dome'
HS10001002   0.0       1.0            * base at basemat / vertical
HS10001100   -1   1   0.0             * specify node locations (ref=0.0)
HS10001101   0.0001524  4             * 0.0005 ft
HS10001102   0.0065024  7             * +0.0208333 ft
HS10001103   0.0095504  9             * +0.01 ft
HS10001104   1.1525504 12             * +3.75 ft
HS10001200   -1                       * specify region mat'ls
HS10001201   'TYPE-B COATING'    3
HS10001202   'CARBON STEEL'      6
HS10001203   'AIR'               8
HS10001204   'CONCRETE'         11
HS10001300   0   -1
HS10001400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10001500   5208.    10.      63.5   * 56,059 ft^2 / assume L=10m
HS10001600   1   999   EXT   1.  1.   * Convective bndry to CV999
HS10001700   5208.    10.      63.5   * ignore curvature
*
HS10002000   12   1   0               * 12 nodes / rectangular geom
HS10002001   'Type C wall'
HS10002002   0.0     1.0              * base on basemat / vertical
HS10002100   -1   1   0.0             * specify node locations (ref=0.0)
HS10002101   0.0002286  4             * 0.00075 ft
HS10002102   0.0065786  7             * +0.0208333 ft
HS10002103   0.0096266  9             * +0.01 ft
HS10002104   1.1526266 12             * +3.75 ft
HS10002200   -1                       * specify region mat'ls
HS10002201   'TYPE-B COATING'    3
HS10002202   'CARBON STEEL'      6
HS10002203   'AIR'               8
HS10002204   'CONCRETE'         11
HS10002300   0   -1
HS10002400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10002500   1861.    10.    52.27    * 20,035 ft^2 / assume L=10m
HS10002600   1   999   EXT   1.  1.   * Convective bndry to CV999
HS10002700   1861.    10.    52.27    * ignore curvature
*
HS10003000   10   1   0               * 10 nodes / rectangular geom
HS10003001   'Refueling Canal'
HS10003002   25.0     1.0             * base at mid-level / vertical
HS10003100   -1   1   0.0             * specify node locations (ref=0.0)
HS10003101   0.0063500  4             * +0.0208333 ft
HS10003102   0.0093980  7             * +0.01 ft
HS10003103   1.1523980 10             * +3.75 ft
HS10003200   -1                       * specify region mat'ls
HS10003201   'STAINLESS STEEL'   3
HS10003202   'AIR'               6
HS10003203   'CONCRETE'          9
HS10003300   0   -1
HS10003400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10003500   1672.    1.    10.       * 18,000 ft^2 / assume L=1m
HS10003600   0  -100   EXT   1.  1.   * Insulated bndy
*
HS10004000   7   1   0                * 7 nodes / rectangular geom
HS10004001   'Thick Steel'
HS10004002   10.0     1.0             * base off basemat / vertical
HS10004100   -1   1   0.0             * specify node locations (ref=0.0)
HS10004101   0.0001524  4             * 0.0005 ft
HS10004102   0.0065024  7             * +0.0208333 ft
HS10004200   -1                       * specify region mat'ls
HS10004201   'TYPE-C COATING'    3
HS10004202   'CARBON STEEL'      6
HS10004300   0   -1
HS10004400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10004500   3235.    1.    1.        * 34,824 ft^2 / assume L=1m
HS10004600   0  -100   EXT   1.  1.   * Insulated bndy
*
HS10005000   7   1   0                * 7 nodes / rectangular geom
HS10005001   'Thin Steel'
HS10005002   10.0     1.0             * base off basemat / vertical
HS10005100   -1   1   0.0             * specify node locations (ref=0.0)
HS10005101   0.00015240 4             * 0.0005 ft
HS10005102   0.00253365 7             * +0.0078125 ft
HS10005200   -1                       * specify region mat'ls
HS10005201   'TYPE-C COATING'    3
HS10005202   'CARBON STEEL'      6
HS10005300   0   -1
HS10005400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10005500   4153.    1.    1.        * 44700 ft^2 / assume L=1m
HS10005600   0  -100   EXT   1.  1.   * Insulated bndy
*
```

```
HS10006000   7   1   0              * 7 nodes / rectangular geom
HS10006001   'Elevated Floors'
HS10006002   25.0     0.0           * base at mid-height / horizontal
HS10006100   -1   1   0.0           * specify node locations (ref=0.0)
HS10006101   0.0032513  4           * 0.010667 ft
HS10006102   0.337312   7           * +1.096 ft
HS10006200   -1                     * specify region mat'ls
HS10006201   'TYPE-C COATING'    3
HS10006202   'CONCRETE'          6
HS10006300   0   -1
HS10006400   0  -100   EXT   1.  1.  * Insulated bndy
HS10006600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10006700   1068.     1.    1.      * 11,500 ft^2 / assume L=1m
*
HS10007000   7   1   0              * 7 nodes / rectangular geom
HS10007001   'Base slab-sump'
HS10007002   0.0      0.0           * base at basemat / horizontal
HS10007100   -1   1   0.0           * specify node locations (ref=0.0)
HS10007101   0.0032513  4           * 0.010667 ft
HS10007102   0.46045    7           * +1.5 ft
HS10007200   -1                     * specify region mat'ls
HS10007201   'TYPE-C COATING'    3
HS10007202   'CONCRETE'          6
HS10007300   0   -1
HS10007400   0  -100   EXT   1.  1.  * Insulated bndy
HS10007600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10007700   864.0     1.    1.      * 9,300 ft^2 / assum L=1m
*
HS10008000   4   1   0              * 4 nodes / rectangular geom
HS10008001   'Unlined Walls'
HS10008002   10.0     1.0           * base off basemat / vertical
HS10008100   -1   1   0.0           * specify node locations (ref=0.0)
HS10008101   0.6096     4           * 2.0 ft
HS10008200   -1                     * specify region mat'ls
HS10008201   'CONCRETE'          3
HS10008300   0   -1
HS10008400   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10008500   3956.     1.    1.      * 42,584 ft^2 / assume L=1m
HS10008600   0  -100   EXT   1.  1.  * Insulated bndy
*
HS10009000   7   1   0              * 7 nodes / rectangular geom
HS10009001   'Uninsulated Walls'
HS10009002   10.0     1.0           * base off basemat / vertical
HS10009100   -1   1   0.0           * specify node locations (ref=0.0)
HS10009101   0.0016635  4           * 0.005458 ft
HS10009102   0.6112635  7           * +2.0 ft
HS10009200   -1                     * specify region mat'ls
HS10009201   'TYPE-C COATING'    3
HS10009202   'CONCRETE'          6
HS10009300   0   -1
HS10009400   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10009500   1218.5    1.    1.      * 13,116 ft^2 / assume L=1m
HS10009600   0  -100   EXT   1.  1.  * Insulated bndy
*
HS10010000   7   1   0              * 7 nodes / rectangular geom
HS10010001   'Polar Crane Rail'
HS10010002   26.0     0.0           * base at springline / horizontal
HS10010100   -1   1   0.0           * specify node locations (ref=0.0)
HS10010101   0.0001524  4           * 0.0005 ft
HS10010102   0.0192024  7           * +0.0625 ft
HS10010200   -1                     * specify region mat'ls
HS10010201   'TYPE-D COATING'    3
HS10010202   'CARBON STEEL'      6
HS10010300   0   -1
HS10010400   0  -100   EXT   1.  1.  * Insulated bndy
HS10010600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10010700   793.8     1.    1.      * 8,542 ft^2 / assume L=1m
*
```

```
HS10011000   7   1   0              * 7 nodes / rectangular geom
HS10011001   'Trolley Steel'
HS10011002   10.0     0.0           * base off basemat / horizontal
HS10011100   -1   1   0.0           * specify node locations (ref=0.0)
HS10011101   0.0002804  4           * 0.00092 ft
HS10011102   0.0050596  7           * +0.01568 ft
HS10011200   -1                     * specify region mat'ls
HS10011201   'TYPE-D COATING'    3
HS10011202   'CARBON STEEL'      6
HS10011300   0   -1
HS10011400   0  -100   EXT   1.  1.  * Insulated bndy
HS10011600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10011700   3750.6    1.    1.      * 40,371 ft^2 / assume L=1m
*
HS10012000   7   1   0              * 7 nodes / rectangular geom
HS10012001   'Box Girders'
HS10012002   10.0     1.0           * base off basemat / vertical
HS10012100   -1   1   0.0           * specify node locations (ref=0.0)
HS10012101   0.0002804  4           * 0.00092 ft
HS10012102   0.0098054  7           * +0.03125 ft
HS10012200   -1                     * specify region mat'ls
HS10012201   'TYPE-D COATING'    3
HS10012202   'CARBON STEEL'      6
HS10012300   0   -1
HS10012400   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10012500   557.8     1.    1.      * 6,020 ft^2 / assume L=1m
HS10012600   0  -100   EXT   1.  1.  * Insulated bndy
*
HS10013000   4   1   0              * 4 nodes / rectangular geom
HS10013001   'Elevator'
HS10013002   10.0     1.0           * base off basemat / vertical
HS10013100   -1   1   0.0           * specify node locations (ref=0.0)
HS10013101   0.0008129  4           * 0.002667 ft
HS10013200   -1                     * specify region mat'ls
HS10013201   'CARBON STEEL'      3
HS10013300   0   -1
HS10013400   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10013500   660.5     1.    1.      * 7,110 ft^2 / assume L=1m
HS10013600   0  -100   EXT   1.  1.  * Insulated bndy
*
HS10014000   7   1   0              * 7 nodes / rectangular geom
HS10014001   'MS Piping'
HS10014002   10.0     0.0           * base off basemat / horizontal
HS10014100   -1   1   0.0           * specify node locations (ref=0.0)
HS10014101   0.0001524  4           * 0.0005 ft
HS10014102   0.0016026  7           * +0.05208 ft
HS10014200   -1                     * specify region mat'ls
HS10014201   'TYPE-C COATING'    3
HS10014202   'CARBON STEEL'      6
HS10014300   0   -1
HS10014400   0  -100   EXT   1.  1.  * Insulated bndy
HS10014600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10014700   427.4     1.    1.      * 4,600 ft^2 / assume L=1m
*
HS10015000   4   1   0              * 4 nodes / rectangular geom
HS10015001   'Spray-Hdr + H2-Rec'
HS10015002   10.0     0.0           * base off basemat / horizontal
HS10015100   -1   1   0.0           * specify node locations (ref=0.0)
HS10015101   0.003048   4           * 0.01 ft
HS10015200   -1                     * specify region mat'ls
HS10015201   'STAINLESS STEEL'   3
HS10015300   0   -1
HS10015400   0  -100   EXT   1.  1.  * Insulated bndy
HS10015600   1   100   EXT   1.  1.  * Convective bndry to CV100
HS10015700   195.2     1.    1.      * 2,101 ft^2 / assume L=1m
*
HS10016000   4   1   0              * 4 nodes / rectangular geom
HS10016001   'Cable Trays'
```

```
HS10016002   10.0     0.0             * base off basemat / horizontal
HS10016100   -1   1   0.0             * specify node locations (ref=0.0)
HS10016101   0.001054   4             * 0.003458 ft
HS10016200   -1                       * specify region mat'ls
HS10016201   'CARBON STEEL'      3
HS10016300   0   -1
HS10016400   0  -100   EXT   1.  1.   * Insulated bndy
HS10016600   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10016700   1079.5    1.    1.       * 11,620 ft^2 / assume L=1m
*
HS10017000   4   1   0                * 4 nodes / rectangular geom
HS10017001   'Conduit'
HS10017002   10.0     0.0             * base off basemat / horizontal
HS10017100   -1   1   0.0             * specify node locations (ref=0.0)
HS10017101   0.0031826  4             * 0.0104417 ft
HS10017200   -1                       * specify region mat'ls
HS10017201   'CONDUIT'           3
HS10017300   0   -1
HS10017400   0  -100   EXT   1.  1.   * Insulated bndy
HS10017600   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10017700   421.9     1.    1.       * 4,541 ft^2 / assume L=1m
*
HS10018000   4   1   0                * 4 nodes / rectangular geom
HS10018001   'Refueling Apparatus'
HS10018002   10.0     0.0             * base off basemat / horizontal
HS10018100   -1   1   0.0             * specify node locations (ref=0.0)
HS10018101   0.009525   4             * 0.03125 ft
HS10018200   -1                       * specify region mat'ls
HS10018201   'STAINLESS STEEL'   3
HS10018300   0   -1
HS10018400   0  -100   EXT   1.  1.   * Insulated bndy
HS10018600   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10018700   192.8     1.    1.       * 2,075 ft^2 / assume L=1m
*
HS10019000   4   1   0                * 4 nodes / rectangular geom
HS10019001   'HVAC ducts'
HS10019002   10.0     0.0             * base off basemat / horizontal
HS10019100   -1   1   0.0             * specify node locations (ref=0.0)
HS10019101   0.0020472  4             * 0.0067167 ft
HS10019200   -1                       * specify region mat'ls
HS10019201   'CARBON STEEL'      3
HS10019300   0   -1
HS10019400   0  -100   EXT   1.  1.   * Insulated bndy
HS10019600   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10019700   2108.     1.    1.       * 22,690 ft^2 / assume L=1m
*
HS10020000   7   1   0                * 7 nodes / rectangular geom
HS10020001   'SITs'
HS10020002   10.0     1.0             * base off basemat / vertical
HS10020100   -1   1   0.0             * specify node locations (ref=0.0)
HS10020101   0.0001524  4             * 0.0005 ft
HS10020102   0.0467563  7             * +0.1529 ft
HS10020200   -1                       * specify region mat'ls
HS10020201   'TYPE-C COATING'    3
HS10020202   'CARBON STEEL'      6
HS10020300   0   -1
HS10020400   1   100   EXT   1.  1.   * Convective bndry to CV100
HS10020500   352.7     1.    1.       * 3,796 ft^2 / assume L=1m
HS10020600   0  -100   EXT   1.  1.   * Insulated bndy
*
.
```

```
*******************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  Decay heat addition
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*******************************************************************
*
*  Long-term decay heat addition [curve based on Figure 6.2-11]
*
*******
*
cv100c7    ae       352     3                      * cf352 for energy source rate
for atm (W)
*
*
cf35000   FAN-CLR-RATE   TAB-FUN  1  3026.E+06  0.0   * 3026E6 MW (new rated power)
*cf35000   FAN-CLR-RATE   TAB-FUN  1  2815.E+06  0.0   * 2815E6 MW (current rated
power)
*
cf35003   350
cf35010   1.0      0.0      TIME                   * f(time)
*
tf35000   'DECAY HEAT  '  21  1.0     0.0          * fraction of full power
tf35010     -1.0E6     0.0
tf35011      0.0       0.0
tf35012      1.0       0.065
tf35013      3.0       0.060
tf35014     10.0       0.050
tf35015     40.0       0.040
tf35016    100.0       0.035
tf35017    150.0       0.031
tf35018    170.0       0.037
tf35019    400.0       0.030
tf35020   1000.0       0.025
tf35021   2000.0       0.020
tf35022   3000.0       0.017
tf35023   4000.0       0.016
tf35024  10000.0       0.012
tf35025  20000.0       0.0094
tf35026  30000.0       0.0085
tf35027  40000.0       0.0076
tf35028  50000.0       0.0070
tf35029 100000.0       0.006
tf35030 300000.0       0.004
*
cf35100   long-term    L-GT       2  1.0  0.0
cf35110   1.0  0.0       TIME
cf35111   0.0  152.51    TIME                 * start of long term cooldown
*
cf35200   lower-bound  L-A-IFTE   3  1.02  0.0  * 102% power
cf35210   1.0  0.0       cfvalu.351           *  if long-term cooldown starts
cf35211   1.0  0.0       cfvalu.350           *    add decay heat to containment
cf35212   0.0  0.0       time                 *  otherwise wait
*

.
```

```
*******************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  ANO-2 Material Properties for Heat Structures
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*******************************************************************
*
*  Add properties for the following materials
*        1.  TYPE-B COATING
*        2.  TYPE-C COATING
*        3.  TYPE-D COATING
*        4.  AIR (as a 'structure')
*        5.  CARBON STEEL
*        6.  CONDUIT
*
**********  Heat capacity (rho*Cp) and
**********  Conductivity from [Table 6.2-8E]
* Densities derived separately (to convert rho*Cp to units req'd by MELCOR
*
*           MATERIAL 1 IS TYPE-B COATING
*
MPMAT00100     'TYPE-B COATING'
MPMAT00101     RHO  1
MPMAT00102     CPS  2
MPMAT00103     THC  3
*
* Density
TF00100  'RHO B-COATING'  1  1.00  0.0   * representative values for coating
TF00110  300.0   2100.                    * spec. grav.:  1.7 - 2.5 [CDI report]
*                                         * assume mean value of 2.1 (~130 lb/ft^3)
*
* Specific Heat
TF00200  'CPS B-COATING'  1  1.00  0.0
TF00210  300.0  0.9581                    * 30 Btu/ft^3-F / rho
*                                         * (2012.0 kW/m^3-K) / rho
*
* Conductivity
TF00300  'THC B-COATING'  1  1.00  0.0
TF00310  300.0  1.55889                   * 0.9 Btu/hr-ft-F
*
*           MATERIAL 2 IS TYPE-C COATING
*
MPMAT00200     'TYPE-C COATING'
MPMAT00201     RHO  4
MPMAT00202     CPS  5
MPMAT00203     THC  6
*
* Density
TF00400  'RHO C-COATING'  1  1.00  0.0   * same as above
TF00410  300.0   2100.
*
* Specific Heat
TF00500  'CPS C-COATING'  1  1.00  0.0
TF00510  300.0  0.9587                    * 33 Btu/ft^3-F / rho
*                                         * (2013.2 kW/m^3-K) / rho
* Conductivity
TF00600  'THC C-COATING'  1  1.00  0.0
TF00610  300.0  0.17321                   * 0.1 Btu/hr-ft-F
*
*           MATERIAL 3 IS TYPE-D COATING
*
MPMAT00300     'TYPE-D COATING'
MPMAT00301     RHO  7MPMAT00302     CPS  8
MPMAT00303     THC  9
*
* Density
TF00700  'RHO D-COATING'  1  1.00  0.0   * same as above
TF00710  300.0   2100.
*
* Specific Heat
TF00800  'CPS D-COATING'  1  1.00  0.0
TF00810  300.0  0.9581                    * 30 Btu/ft^3-F / rho
*                                         * (2012.0 kW/m^3-K) / rho
* Conductivity
TF00900  'THC D-COATING'  1  1.00  0.0
TF00910  300.0  12.81754                  * 7.4 Btu/hr-ft-F
*
*           MATERIAL 4 IS AIR
*
MPMAT00400     'AIR'
MPMAT00401     RHO 10
MPMAT00402     CPS 11
MPMAT00403     THC 12
*
* Density
TF01000  'RHO AIR'  1  1.00  0.0         * same as above
TF01010  300.0   1.23
*
* Specific Heat
TF01100  'CPS AIR'  1  1.00  0.0
TF01110  300.0  0.92683                   * 0.017 Btu/ft^3-F / rho
*                                         * (1.140 kW/m^3-K) / rho
* Conductivity
TF01200  'THC AIR'  1  1.00  0.0
TF01210  300.0  1.7321                    * 1.0 Btu/hr-ft-F
*
*           MATERIAL 5 IS CARBON STEEL
*
MPMAT00500     'CARBON STEEL'
MPMAT00501     RHO 13
MPMAT00502     CPS 14
MPMAT00503     THC 15
*
* Density
TF01300  'RHO CS'  1  1.00  0.0          * same as above
TF01310  300.0   7850.                    * representative value from Mark's Hdbk
*
* Specific Heat
TF01400  'CPS CS'  1  1.00  0.0
TF01410  300.0  0.4613                    * 54. Btu/ft^3-F / rho
*                                         * (3621.2 kW/m^3-K) / rho
* Conductivity
TF01500  'THC CS'  1  1.00  0.0
TF01510  300.0  43.3                      * 25. Btu/hr-ft-F
*
*           MATERIAL 6 IS CONDUIT
*
MPMAT00600     'CONDUIT'
MPMAT00601     RHO 16
MPMAT00602     CPS 17
MPMAT00603     THC 18
*
* Density
TF01600  'RHO CONDUIT'  1  1.00  0.0     * same as above
TF01610  300.0   7850.                    * representative CS value from Mark's Hdbk
*
* Specific Heat
TF01700  'CPS CONDUIT'  1  1.00  0.0
TF01710  300.0  0.3588                    * 42. Btu/ft^3-F / rho
*                                         * (2816.5 kW/m^3-K) / rho
* Conductivity
TF01800  'THC CONDUIT'  1  1.00  0.0
TF01810  300.0  107.4                     * 62. Btu/hr-ft-F
*
.
```

```
*******************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  Containment Spray Operation
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*******************************************************************
*
*  Sprays actuate on cont-p high-high (25.7 psia), delay time of 53.6 sec
*     [Table 6.2-8F]
*
*******
* trip logic
*
cf20000   CPHH-sig     L-GT      2  1.0  0.0
cf20005   latch
cf20006   2    'CPHH signal'
cf20010   1.0       0.0  cvh-p.100
cf20011   0.0  177193.8  time                      * 25.7 psia
*
cf20100   spr-sig-time TRIP      1  1.0  0.0
cf20110   1.0       0.0  cfvalu.200
*
cf20200   inj-spray-on L-GT      2  1.0  0.0
cf20206   2    'Containment Spray Starts (1-pump)'
cf20210   1.0       0.0  cfvalu.201
cf20211   0.0      53.6  time                      * LOCA delay time=53.6 sec
*cf20211   0.0      38.6  time                      * MSLB delay time=38.6 sec
*
cf20300   rec-spray-on L-GT      2  1.0  0.0
cf20306   2    'Switchover to Cont. Spray Recirc'
cf20310   1.0       0.0    time
cf20311   0.0     2708.    time                    * LOCA switchover time
*cf20311   0.0       1.0E10 time                    * MSLB switchover time
*
cf20400   not-recirc   L-NOT    1  1.0  0.0
cf20410   1.0       0.0    cfvalu.203
*
cf20500   inj-true     L-AND    2  1.0  0.0
cf20510   1.0       0.0    cfvalu.202
cf20511   1.0       0.0    cfvalu.204
*
cf20600   inj-true     L-L-IFTE 3  1.0  0.0
cf20601   .false.
cf20610   1.0       0.0    cfvalu.205              * If injection should be on
cf20611   1.0       0.0    cfvalu.290              *  CF is true
cf20612   1.0       0.0    cfvalu.291              * Else CF is false
*
*******
cf21000   RWT-invent    divide  2  264.173 0.0    * convert m^3 to gal
cf21010   1.0  0.0      cvh-rhop.901             * pool density
cf21011   1.0  0.0      cvh-mass.1.901           * pool mass
*
cf22000   Spray-temp    L-A-IFTE 3  1.0     0.0
cf22010   1.0  0.0      cfvalu.203               * If sprays switchover
cf22011   1.0  0.0      cvh-tliq.100             *       spray temp = sump temp
cf22012   1.0  0.0      cvh-tliq.901             * else: spray temp = RWT temp
*
cf23000   Spray-flow    L-A-IFTE 3  1.0     0.0
cf23010   1.0  0.0      cfvalu.203               * If sprays switchover
cf23011   0.0  0.1262   time                     *       spray flow = 2000
gpm/pump
cf23012   0.0  0.1183   time                     * else: spray flow = 1875
gpm/pump
*
*******
cf29000   always-T     L-GT     2  1.0  0.0
cf29010   0.0       1.0    time
cf29011   0.0       0.0    time
*
cf29100   always-F     L-GT     2  1.0  0.0
cf29110   0.0       0.0    time
cf29111   0.0       1.0    time
*
*******
* Spray-01 (injection) performance specs
*
SPRSR0100  SPRY-INJ  100  31.7 206  901  1  0.  52.  * spray into CV100
*                                                     * 104 ft ave fall height [Sec.
6.2.3.2.1]
*                                                     * trip on/off with cf204
*                                                     * source from CV901
*                                                     * injection spray stops if RWT
is depleted
SPRSR0101  322.22    0.1262   220  230                * 120F / 2000 gpm per pump
[Table 6.2-8]
*                                                     * spray temp (K) defined by
cf220
*                                                     * spray flow (m^3/s) defined by
cf230
SPRSR0102  0.000925  1.0                              * 925 micron drop size during
inj. mode
*
*******
* Spray-02 (recirculation) performance specs
*
SPRSR0200  SPRY-REC  100  31.7 203  100  1  0.  52.  * spray into CV100
*                                                     * 104 ft ave fall height [Sec.
6.2.3.2.1]
*                                                     * trip on w/ cf203
*                                                     * source from CV100
*                                                     * injection spray stops if sump
is depleted
SPRSR0201  322.22    0.1183   220  230                * (120F) / 1875 gpm per pump
[Table 6.2-8]
*                                                     * spray temp (K) defined by
cf220
*                                                     * spray flow (m^3/s) defined by
cf230
SPRSR0202  0.000880  1.0                              * 880 micron during recirc
*
*******
SPRSUMP0   100                                        * sump in CV100 for both
*
*******
cv90100    'RWT'   2   1   8
cv90101    0       0
cv901A0    3
cv901B1    0.0         0.0
cv901B2    52.2     1514.16   * total tank vol 53,472 ft^3 (400,000 gal)  [Table 6.2-
8]
cv901A1    VPOL     1453.59   * max coolant inventory 384,000 gal [Table 6.2-8A]
cv901A2    PVOL   101352.1    * 14.7 psia [Table 6.2-8]
cv901A3    TATM      322.2    * 120 F     [Table 6.2-8A]
cv901A4    MLFR.4      0.21
cv901A5    MLFR.5      0.79
*
.
```

```
*******************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  Containment Fan Cooler Operation
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*******************************************************************
*
*  Fan Coolers actuate on cont-p high (20.7 psia), delay time of 52 sec
*     [Table 6.2-8F]
*
*******
* trip logic
*
cf30000   CPH-sig      L-GT      2  1.0  0.0
cf30005   latch
cf30006   2    'CPH signal'
cf30010   1.0  0.0       cvh-p.100
cf30011   0.0  142720.3  time                    * 20.7 psia
*
cf30100   fan-sig-time TRIP      1  1.0  0.0
cf30110   1.0  0.0       cfvalu.300
*
cf30200   fan-clr-on   L-GT      2  1.0  0.0
cf30206   2    'Fan Coolers Starts (2/4 fans)'
cf30210   1.0  0.0       cfvalu.301
cf30211   0.0 52.0       time                    * LOCA delay time=52.0 sec
*cf30211   0.0 30.0       time                   * MSLB delay time=30.0 sec
*
*******
* heat removal per train
*
cv100c6    ae       310     3                    * cf310 for energy source rate for
atm (W)
*
cf30400   test-TSAT    L-GT        2  1.0  0.0
cf30410   1.0  0.0       CVH-TSAT(A).100
cf30411   0.0  308.34    TIME                    * 95F
*
cf30500   lower-bound  L-A-IFTE    3  1.0  0.0   * set lower bound to Tsat to cover
cf30510   1.0  0.0       cfvalu.304              *  initial (zero steam) conditions
cf30511   1.0  0.0       cvh-tsat(a).100
cf30512   0.0  308.33    time
*
cf30600   FAN-CLR-RATE   TAB-FUN   1  2.0  0.0   * Mult=2.0
*                                                * (1 'group' consisting of 2
fans)[sec. 9.4.5.3]
cf30603   306
cf30610   1.8      -460.    CVH-TSAT(A).100      * convert to deg-F for table look-
up
*                                                *  reference t(sat) at P(steam)
*
tf30600   'FAN-CLR-RATE'   6  0.293   0.0        * convert output from Btu/hr to W
* table in deg-F & Btu/hr
* negative values for heat removal
*
*tf30610     95.       0.0                        * constant 95F service water
*tf30611    105.      -1.35E6
*tf30612    150.      -1.05E7
*tf30613    180.      -2.01E7
*tf30614    230.      -4.21E7
*tf30615    286.      -6.98E7
*
tf30610    110.       0.0                        * constant 110F service water
tf30611    120.      -1.62E6
tf30612    150.      -7.96E6
tf30613    180.      -1.71E7
tf30614    230.      -3.80E7
tf30615    286.      -6.47E7
*
*tf30610    120.       0.0                        * constant 120F service water
*tf30611    130.      -1.78E6
*tf30612    150.      -6.15E6
*tf30613    180.      -1.49E7
*tf30614    230.      -3.51E7
*tf30615    286.      -6.12E7
*
cf31000   fan-clr-rate L-A-IFTE    3  1.0  0.0   *
cf31010   1.0  0.0       cfvalu.302              *
cf31011   1.0  0.0       cfvalu.306
cf31012   0.0  0.0       time
*
.
```

```
*******************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  Heat transfer coefficient used in licensee analysis
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*******************************************************************
*
allowreplace
*
**  sump liquid to containment atm
**  (set to zero via sensitivity coeff in melCOR input
*
**  sump and floor to sump liquid
tf90200   'HTC-2' 1  5.68   0.0   * convert Btu/hr-ft2-F to W/m^2-K
tf90210    0.0    0.4             * 0.4 Btu/hr-ft^2-F
*
**  heat sink surfaces exposed to outside air
tf90300   'HTC-3' 1  5.68   0.0   * convert Btu/hr-ft2-F to W/m^2-K
tf90310    0.0    2.0             * 2.0 Btu/hr-ft^2-F
*
* Heat structures affected by change:
HS10001600   4903   999   EXT   1.  1.  * Convective bndry to CV999
HS10002600   4903   999   EXT   1.  1.  * Convective bndry to CV999
HS10007600   4902   100   EXT   1.  1.  * Convective bndry to CV100
*
**  wall condensation
**  (per NUREG-0800, 6.2.1.5)
**
**  BLOWDOWN (Tagami)
**  linear increase from 8 Btu/hr-ft2-F to h(max)
**  between t=0 and end of blowdown.
**
**  h(Tagami) = 72.5*(Q/Vt)^0.62
**          where Q    = integrated energy release to containment (Btu)
**                V    = net free containment volume (ft3)
**                t(p) = time interval to end of blowdown (sec)
**
**                       V    = 1.778E+06 ft3
**          for DBA LOCA:  Q    = 2.885E+08 Btu    blowdown atm energy
**                            = 3.000E+08        (including prz stored energy)
**                       t(p) = 14.90 sec        end of blowdown
**  h(Tagami) = 318.636 Btu/hr-ft2-F
**            = 326.456  (including prz stored energy)
**
cf90000    time>0  L-GT     2  1.0  0.0    * TRUE if blowdown has begun
cf90010    1.0      0.0     TIME           *  (steam mass.ne.zero)
cf90011    0.0      1.0     TIME
*
cf90100    ramp    DIVIDE   2  1.0  0.0
cf90102    3        0.0     1.0            * min / max
cf90110    0.0     14.9     TIME           *
cf90111    1.0      0.0     TIME           * t/t(p)
*
cf90200    H-blow  EQUALS   1  1.0  0.0    * Blowdown HTC (Btu/hr-ft2-F)
cf90202    3        8.0     326.456        * min / max (blowdown only)
cf90210    318.456  8.0     cfvalu.901     * linear ramp from 8 to h(max)
*
cf90300    M-air   ADD      2  1.0  0.0    * add mass of O2+N2
cf90310    1.0      0.0     CVH-MASS.4.100
cf90311    1.0      0.0     CVH-MASS.5.100
*
cf90400    steam  L-A-IFTE  3  1.0  0.0
cf90401    0.0
cf90410    1.0      0.0     cfvalu.900     * If blowdown has started
cf90411    1.0      0.0     CVH-MASS.3.100 *  evaluate real mass ratio
cf90412    0.0      1.0E-6  TIME           * else define small, non-zero steam mass
*
```

```
cf90500    Fix-MR  EQUALS   1  1.0  0.0    * Define Uchida (long-term HTC = 5.0)
cf90510    0.0     35.0     TIME
*
*cf90500    M-ratio DIVIDE   2  1.0  0.0     * mass air/mass steam
*cf90501    50.
*cf90502    3        0.1     50.             * min / max
*cf90510    1.0      0.0     cfvalu.904      * mass of steam in containment
*cf90511    1.0      0.0     cfvalu.903      * mass of air in containment
*
cf90600    H-stag TAB-FUN   1  1.0  0.0    * long-term post-blowdown (Uchida)
cf90603    906                             * use tf906
cf90610    1.0      0.0     cfvalu.905     * indep variable is M-ratio (cf905)
*
tf90600    Uchida   15         1.0  0.0    * Uchida data
*         M-ratio  HTC
tf90610     0.1  280.0
tf90611     0.5  140.0
tf90612     0.8   98.0
tf90613     1.3   63.0
tf90614     1.8   46.0
tf90615     2.3   37.0
tf90616     3.0   29.0
tf90617     4.0   24.0
tf90618     5.0   21.0
tf90619     7.0   17.0
tf90620    10.    14.0
tf90621    14.    10.0
tf90622    18.     9.0
tf90623    20.     8.0
tf90624    50.     2.0
*
cf90700    save     MIN     2  1.0  0.0    * prevent overflow of CF909
cf90710    1.0      0.0     TIME
cf90711    0.0    300.0     TIME
*
cf90800    expon   EQUALS   1  1.0  0.0    * delta-t [dt]
cf90810    1.0    -14.90    cfvalu.907
*
cf90900    e-term  EXP      1  1.0  0.0
cf90910   -0.025    0.0     cfvalu.908     * exp(-0.025*dt)
*
cf91000    h-diff  ADD      2  1.0  0.0
cf91010    1.0      0.0     cfvalu.902     * h(max)
cf91011   -1.0      0.0     cfvalu.906     *      - h(stag)
*
cf91100    adder  MULTIPLY  2  1.0  0.0
cf91110    1.0      0.0     cfvalu.910     * (h(max)-h(stag))
cf91111    1.0      0.0     cfvalu.909     *                  *exp(-0.025*dt)
*
cf91200    h-long  ADD      2  1.0  0.0
cf91210    1.0      0.0     cfvalu.906     * h(stag)+
cf91211    1.0      0.0     cfvalu.911     *        (h(max)-h(stag))*exp(-0.025*dt)
*
cf91300    Uchida  max      2  1.0  0.0    * ensure postive value
cf91310    1.0      0.0     cfvalu.912
cf91311    0.0      0.0     time
*
cf91500    time    L-GT     2  1.0  0.0    * True if blowdown is over
cf91510    1.0      0.0     TIME
cf91511    0.0     14.90    TIME
*
cf91600    alt-decay MULTIPLY  2  1.0  0.0 * simple decay of Tagami h(max)
cf91610    1.0      0.0     cfvalu.902
cf91611    1.0      0.0     cfvalu.909
*
cf92000    HTC   L-A-IFTE   3  5.68 0.0    * convert Btu/hr-ft2-F to W/m2-K
cf92001    0.0
cf92010    1.0      0.0     cfvalu.915     * If blowdown is over
```

```
cf92011    1.0      0.0     cfvalu.913     *   transition to Uchida (LOCA)
cf92012    1.0      0.0     cfvalu.902     * else ramp to Tagami peak (LOCA)
*cf92011    1.0      0.0     cfvalu.902     *   stay at Tagami peak (LOCA)
*cf92011    1.0      0.0     cfvalu.906     *    use Uchida (MSLB)
*cf92012    1.0      0.0     cfvalu.906     * else use Uchida (MSLB)
*
*  Replace default HTC to CF920
HS10001400 6920  100   EXT   1.  1.
HS10002400 6920  100   EXT   1.  1.
HS10003400 6920  100   EXT   1.  1.
HS10004400 6920  100   EXT   1.  1.
HS10005400 6920  100   EXT   1.  1.
HS10006600 6920  100   EXT   1.  1.
HS10008400 6920  100   EXT   1.  1.
HS10009400 6920  100   EXT   1.  1.
HS10010600 6920  100   EXT   1.  1.
HS10011600 6920  100   EXT   1.  1.
HS10012400 6920  100   EXT   1.  1.
HS10013400 6920  100   EXT   1.  1.
HS10014600 6920  100   EXT   1.  1.
HS10015600 6920  100   EXT   1.  1.
HS10016600 6920  100   EXT   1.  1.
HS10017600 6920  100   EXT   1.  1.
HS10018600 6920  100   EXT   1.  1.
HS10019600 6920  100   EXT   1.  1.
HS10020400 6920  100   EXT   1.  1.
.
```

```
*********************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  CONTAINMENT SOURCE TABLES
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*********************************************************************
*
*  DEDLS mass/energy source as integral quantities  [Table 6.2-8B]
*
*          src-type iestyp  iesflg
cv100c1    mass.3   110     1            * cf110 for integral mass source for atm
cv100c2    ae       120     1            * cf120 for integral energy source for atm
cv100c3    mass.1   130     1            * cf130 for integral mass source for pool
cv100c4    pe       140     1            * cf140 for integral energy source for pool
cv100c5    ae       160     1            * cf150 for misc stored energy sources
*
*******
* atmosphere mass
*******
cf10100    BLODWN-MASS-A  TAB-FUN   1  1.0  0.0
cf10103    101
cf10110    1.0     0.0    TIME
*
cf10200    REFLD-MASS-A   TAB-FUN   1  1.0  0.0
cf10203    102
cf10210    1.0     0.0    TIME
*
tf10100    'BLODWN-MASS-A'  50  0.4536   0.0    * convert lbm to kg
tf10110      -1.0       0.0
tf10111       0.0       0.0
tf10112       0.01      7.950E2
tf10113       0.02      1.536E3
tf10114       0.03      2.276E3
tf10115       0.04      3.027E3
tf10116       0.05      3.787E3
tf10117       0.06      4.546E3
tf10118       0.07      5.300E3
tf10119       0.08      6.053E3
tf10120       0.09      6.796E3
tf10121       0.10      7.675E3
tf10122       0.15      1.314E4
tf10123       0.20      1.868E4
tf10124       0.25      2.419E4
tf10125       0.30      2.969E4
tf10126       0.35      3.512E4
tf10127       0.40      4.048E4
tf10128       0.45      4.581E4
tf10129       0.50      5.111E4
tf10130       0.60      6.153E4
tf10131     · 0.70      7.185E4
tf10132       0.80      8.193E4
tf10133       0.90      9.167E4
tf10134       1.00      1.013E5
tf10135       1.5       1.456E5
tf10136       2.0       1.844E5
tf10137       2.5       2.188E5
tf10138       3.0       2.486E5
tf10139       3.5       2.755E5
tf10140       4.0       2.999E5
tf10141       5.0       3.147E5
tf10142       6.0       3.763E5
tf10143       7.0       4.028E5
tf10144       8.0       4.213E5
tf10145       9.0       4.314E5
tf10146      10.0       4.388E5
tf10147      11.0       4.501E5
tf10148      12.0       4.620E5
tf10149      13.0       4.712E5
tf10150      14.0       4.763E5
tf10151      14.1       4.766E5
tf10152      14.2       4.769E5
tf10153      14.3       4.772E5
tf10154      14.4       4.774E5
tf10155      14.5       4.776E5
tf10156      14.6       4.777E5
tf10157      14.7       4.778E5
tf10158      14.8       4.779E5
tf10159      14.9       4.779E5
*
tf10200   'REFLD-MASS-A'  52   0.4536   0.0    * convert lbm to kg
tf10210      0.0       0.0
tf10211     14.91      0.0
tf10212     15.00      1.253E1
tf10213     19.00      1.866E3
tf10214     20.80      3.442E3
tf10215     20.81      3.446E3
tf10216     22.90      4.396E3
tf10217     26.80      6.171E3
tf10218     30.70      7.945E3
tf10219     34.60      9.711E3
tf10220     38.50      1.147E4
tf10221     42.40      1.321E4
tf10222     46.40      1.498E4
tf10223     50.30      1.669E4
tf10224     54.20      1.838E4
tf10225     58.10      2.005E4
tf10226     62.00      2.171E4
tf10227     65.90      2.335E4
tf10228     69.80      2.498E4
tf10229     73.59      2.654E4
tf10230     73.60      2.654E4
tf10231     78.60      3.052E4
tf10232     83.60      3.425E4
tf10233     88.60      3.774E4
tf10234     93.60      4.109E4
tf10235     98.60      4.426E4
tf10236    103.50      4.723E4
tf10237    108.50      5.016E4
tf10238    113.50      5.299E4
tf10239    118.50      5.573E4
tf10240    123.50      5.834E4
tf10241    128.40      6.079E4
tf10242    133.40      6.319E4
tf10243    138.40      6.545E4
tf10244    143.40      6.760E4
tf10245    148.30      6.960E4
tf10246    148.40      6.964E4
tf10247    148.50      6.969E4
tf10248    148.60      6.971E4
tf10249    148.70      6.974E4
tf10250    148.80      6.975E4
tf10251    148.90      6.976E4
tf10252    149.30      6.977E4
tf10253    149.60      6.978E4
tf10254    149.90      6.980E4
tf10255    150.20      6.981E4
tf10256    150.60      6.982E4
tf10257    151.00      6.984E4
tf10258    151.50      6.986E4
tf10259    152.00      6.988E4
tf10260    152.50      6.990E4
tf10261    152.51      6.990E4
*
cf11000   ATM-MASS-SRC   ADD       2  1.0  0.0
cf11001   0.0
```

```
cf11010  1.0     0.0    CFVALU.101
cf11011  1.0     0.0    CFVALU.102
*
*******
* atmosphere energy
*******
cf11100  BLODWN-ENRG-A  TAB-FUN  1  1.0  0.0
cf11103  111
cf11110  1.0     0.0    TIME
*
cf11200  REFLD-ENRG-A   TAB-FUN  1  1.0  0.0
cf11203  112
cf11210  1.0     0.0    TIME
*
tf11100  'BLODWN-ENRG-A' 50  1055.    0.0    * convert Btu to J
tf11110    -1.0      0.0
tf11111     0.0      0.0
tf11112     0.01     4.377E5
tf11113     0.02     8.447E5
tf11114     0.03     1.251E6
tf11115     0.04     1.664E6
tf11116     0.05     2.081E6
tf11117     0.06     2.498E6
tf11118     0.07     2.912E6
tf11119     0.08     3.325E6
tf11120     0.09     3.734E6
tf11121     0.10     4.217E6
tf11122     0.15     7.233E6
tf11123     0.20     1.029E7
tf11124     0.25     1.334E7
tf11125     0.30     1.639E7
tf11126     0.35     1.939E7
tf11127     0.40     2.236E7
tf11128     0.45     2.530E7
tf11129     0.50     2.823E7
tf11130     0.60     3.400E7
tf11131     0.70     3.971E7
tf11132     0.80     4.528E7
tf11133     0.90     5.068E7
tf11134     1.00     5.603E7
tf11135     1.5      8.080E7
tf11136     2.0      1.030E8
tf11137     2.5      1.229E8
tf11138     3.0      1.404E8
tf11139     3.5      1.566E8
tf11140     4.0      1.716E8
tf11141     5.0      1.980E8
tf11142     6.0      2.208E8
tf11143     7.0      2.398E8
tf11144     8.0      2.549E8
tf11145     9.0      2.641E8
tf11146    10.0      2.703E8
tf11147    11.0      2.770E8
tf11148    12.0      2.825E8
tf11149    13.0      2.861E8
tf11150    14.0      2.879E8
tf11151    14.1      2.881E8
tf11152    14.2      2.882E8
tf11153    14.3      2.882E8
tf11154    14.4      2.883E8
tf11155    14.5      2.884E8
tf11156    14.6      2.884E8
tf11157    14.7      2.885E8
tf11158    14.8      2.885E8
tf11159    14.9      2.885E8
*
tf11200  'REFLD-ENRG-A'   52   1055.    0.0    * convert Btu to J
tf11210     0.0      0.0
tf11211     14.91      0.0
tf11212     15.0       1.634E4
tf11213     19.0       2.423E6
tf11214     20.80      4.451E6
tf11215     20.81      4.457E6
tf11216     22.90      5.671E6
tf11217     26.80      7.930E6
tf11218     30.70      1.017E7
tf11219     34.60      1.240E7
tf11220     38.50      1.462E7
tf11221     42.40      1.680E7
tf11222     46.40      1.902E7
tf11223     50.30      2.116E7
tf11224     54.20      2.328E7
tf11225     58.10      2.538E7
tf11226     62.00      2.745E7
tf11227     65.90      2.949E7
tf11228     69.80      3.151E7
tf11229     73.59      3.346E7
tf11230     73.60      3.346E7
tf11231     78.60      3.840E7
tf11232     83.60      4.304E7
tf11233     88.60      4.740E7
tf11234     93.60      5.154E7
tf11235     98.60      5.548E7
tf11236    103.50      5.918E7
tf11237    108.50      6.282E7
tf11238    113.50      6.634E7
tf11239    118.50      6.966E7
tf11240    123.50      7.280E7
tf11241    128.40      7.572E7
tf11242    133.40      7.855E7
tf11243    138.40      8.122E7
tf11244    143.40      8.376E7
tf11245    148.30      8.613E7
tf11246    148.40      8.617E7
tf11247    148.50      8.623E7
tf11248    148.60      8.626E7
tf11249    148.70      8.629E7
tf11250    148.80      8.631E7
tf11251    148.90      8.632E7
tf11252    149.30      8.634E7
tf11253    149.60      8.635E7
tf11254    149.90      8.637E7
tf11255    150.20      8.638E7
tf11256    150.60      8.640E7
tf11257    151.00      8.642E7
tf11258    151.50      8.645E7
tf11259    152.00      8.647E7
tf11260    152.50      8.650E7
tf11261    152.51      8.650E7
*
cf12000  ATM-ENRG-SRC   ADD       2  1.0  0.0
cf12001  0.0
cf12010  1.0     0.0    CFVALU.111
cf12011  1.0     0.0    CFVALU.112
*
*******
* pool mass
*******
cf13000  REFLD-MASS-P  TAB-FUN  1  1.0  0.0
cf13003  130
cf13010  1.0     0.0    TIME
*
tf13000  'REFLD-MASS-P' 24  0.4536   0.0    * convert lbm to kg
tf13010     0.0      0.0
tf13011     14.91    0.0
tf13012     20.79    0.0
```

```
tf13013     20.80       6.269E+01
tf13014     22.80       1.165E+04
tf13015     25.80       2.730E+04
tf13016     27.80       3.709E+04
tf13017     31.90       5.481E+04
tf13018     35.90       7.026E+04
tf13019     41.90       9.010E+04
tf13020     45.90       1.021E+05
tf13021     51.90       1.176E+05
tf13022     55.90       1.269E+05
tf13023     61.90       1.390E+05
tf13024     65.90       1.483E+05
tf13025     71.90       1.556E+05
tf13026     73.90       1.556E+05
tf13027    114.90       1.556E+05
tf13028    115.00       1.556E+05
tf13029    120.00       1.559E+05
tf13030    130.00       1.566E+05
tf13031    140.00       1.578E+05
tf13032    148.30       1.590E+05
tf13033    152.51       1.590E+05
*
*******
* pool energy
*******
cf14000   REFLD-ENRG-P  TAB-FUN   1  1.0  0.0
cf14003   140
cf14010   1.0      0.0     TIME
*
tf14000   'REFLD-ENRG-P' 24  1055.     0.0    * convert Btu to J
tf14010      0.0        0.0
tf14011     14.91       0.000E+00
tf14012     20.79       0.000E+00
tf14013     20.80       6.371E+03
tf14014     22.80       1.198E+06
tf14015     25.80       2.833E+06
tf14016     27.80       3.885E+06
tf14017     31.90       5.776E+06
tf14018     35.90       7.476E+06
tf14019     41.90       9.726E+06
tf14020     45.90       1.111E+07
tf14021     51.90       1.297E+07
tf14022     55.90       1.412E+07
tf14023     61.90       1.568E+07
tf14024     65.90       1.662E+07
tf14025     71.90       1.790E+07
tf14026     73.90       1.790E+07
tf14027    114.90       1.790E+07
tf14028    115.00       1.790E+07
tf14029    120.00       1.796E+07
tf14030    130.00       1.817E+07
tf14031    140.00       1.849E+07
tf14032    148.30       1.884E+07
tf14033    152.51       1.884E+07
*
*******
* Misc stored energy sources
*******
cf15000   MISC-ENRGY1  TAB-FUN   1  1.0  0.0
cf15003   150
cf15010   1.0      0.0     TIME
*
tf15000   'MISC-ENRGY1'  3    1055.     0.0    * convert Btu to J
tf15010      0.0        0.0
tf15011     14.90       0.000E+00
tf15012   3614.90       1.150E+07             * assume 1-hour release time
*tf15012    614.90       1.150E+07             * assume 10-minute release time
*
cf15100   MISC-ENRGY2  TAB-FUN   1  1.0  0.0
cf15103   151
cf15110   1.0      0.0     TIME
*
tf15100   'MISC-ENRGY2'  3    1055.     0.0    * convert Btu to J
tf15110      0.0        0.0
tf15111    152.51       0.000E+00
tf15112   3752.51       7.500E+07             *  and assume 1-hour release time
*tf15112    752.51       7.500E+07             *  and assume 10-minute release time
*
cf16000   MISC-ENERGY   ADD     2  1.0  0.0
cf16001   0.0
cf16010   1.0      0.0     CFVALU.150
cf16011   1.0      0.0     CFVALU.151
*
.
```

```
*****************************************************************
**  ANO-2 DBA CONTAINMENT ANALYSIS
**
**  CONTAINMENT SOURCE TABLES
**
**  Reference:  Entergy Letter 2CAN119903, dated Nov. 3, 1999
*****************************************************************
*
*  MSLB mass/energy source as integral quantities  [Table 6.2-9B]
*
*          src-type iestyp  iesflg
cv100c1    mass.3   110     1          * cf110 for integral mass source for atm
cv100c2    ae       120     1          * cf120 for integral energy source for atm
*
*******
* atmosphere mass
*******
cf10100   MSLB-MASS-1  TAB-FUN   1  1.0  0.0
cf10103   101
cf10110   1.0      0.0     TIME
*
cf10200   MSLB-MASS-2  TAB-FUN   1  1.0  0.0
cf10203   102
cf10210   1.0      0.0     TIME
*
cf10300   MSLB-MASS-3  TAB-FUN   1  1.0  0.0
cf10303   103
cf10310   1.0      0.0     TIME
*
cf10400   MSLB-MASS-4  TAB-FUN   1  1.0  0.0
cf10403   104
cf10410   1.0      0.0     TIME
*
cf10500   MSLB-MASS-5  TAB-FUN   1  1.0  0.0
cf10503   105
cf10510   1.0      0.0     TIME
*
tf10100   'MSLB-MASS-1'  90  0.4536   0.0     * convert lbm to kg
tf10110          0.00    0.00000E+00
tf10111          0.09    3.92334E+02
tf10112          0.19    8.26279E+02
tf10113          0.29    1.25851E+03
tf10114          0.39    1.68913E+03
tf10115          0.49    2.11817E+03
tf10116          0.59    2.54568E+03
tf10117          0.69    2.97168E+03
tf10118          0.79    3.39626E+03
tf10119          0.89    3.81940E+03
tf10120          0.99    4.24115E+03
tf10121          1.09    4.66155E+03
tf10122          1.19    5.08060E+03
tf10123          1.29    5.49836E+03
tf10124          1.39    5.91484E+03
tf10125          1.49    6.33005E+03
tf10126          1.59    6.74403E+03
tf10127          1.69    7.15678E+03
tf10128          1.79    7.56834E+03
tf10129          1.89    7.97872E+03
tf10130          1.99    8.38794E+03
tf10131          2.09    8.79603E+03
tf10132          2.19    9.20297E+03
tf10133          2.29    9.60882E+03
tf10134          2.39    1.00136E+04
tf10135          2.49    1.04173E+04
tf10136          2.59    1.08199E+04
tf10137          2.69    1.12215E+04
tf10138          2.79    1.16219E+04
tf10139          2.89    1.20214E+04
tf10140          2.99    1.24197E+04
tf10141          3.09    1.28171E+04
tf10142          3.19    1.32134E+04
tf10143          3.29    1.36086E+04
tf10144          3.39    1.40029E+04
tf10145          3.49    1.43962E+04
tf10146          3.59    1.47885E+04
tf10147          3.69    1.51799E+04
tf10148          3.79    1.55703E+04
tf10149          3.89    1.59598E+04
tf10150          3.99    1.63483E+04
tf10151          4.09    1.67339E+04
tf10152          4.19    1.71226E+04
tf10153          4.29    1.75084E+04
tf10154          4.39    1.78933E+04
tf10155          4.49    1.82774E+04
tf10156          4.59    1.86606E+04
tf10157          4.69    1.90429E+04
tf10158          4.79    1.94244E+04
tf10159          4.89    1.98050E+04
tf10160          4.99    2.01849E+04
tf10161          5.09    2.05639E+04
tf10162          5.19    2.09422E+04
tf10163          5.29    2.13196E+04
tf10164          5.39    2.16962E+04
tf10165          5.49    2.20721E+04
tf10166          5.59    2.24472E+04
tf10167          5.69    2.28216E+04
tf10168          5.79    2.31952E+04
tf10169          5.89    2.35681E+04
tf10170          5.99    2.39403E+04
tf10171          6.09    2.43117E+04
tf10172          6.19    2.46825E+04
tf10173          6.29    2.50525E+04
tf10174          6.39    2.54217E+04
tf10175          6.49    2.57871E+04
tf10176          6.59    2.61497E+04
tf10177          6.69    2.65108E+04
tf10178          6.79    2.68704E+04
tf10179          6.89    2.72287E+04
tf10180          6.99    2.75855E+04
tf10181          7.09    2.79411E+04
tf10182          7.19    2.82953E+04
tf10183          7.29    2.86482E+04
tf10184          7.39    2.89998E+04
tf10185          7.49    2.93502E+04
tf10186          7.59    2.96993E+04
tf10187          7.69    3.00472E+04
tf10188          7.79    3.03940E+04
tf10189          7.89    3.07395E+04
tf10190          7.99    3.10839E+04
tf10191          8.09    3.14271E+04
tf10192          8.19    3.17692E+04
tf10193          8.29    3.21101E+04
tf10194          8.39    3.24500E+04
tf10195          8.49    3.27888E+04
tf10196          8.59    3.31265E+04
tf10197          8.69    3.34631E+04
tf10198          8.79    3.37987E+04
tf10199     8.7900001    0.00000E+00
*
tf10200   'MSLB-MASS-2'  90  0.4536   0.0     * convert lbm to kg
tf10210     8.7899999    0.00000E+00
tf10211     8.7900001    3.37987E+04
tf10212          8.89    3.41332E+04
tf10213          8.99    3.44668E+04
tf10214          9.09    3.47993E+04
tf10215          9.19    3.51308E+04
```

```
tf10216          9.29    3.54613E+04
tf10217          9.39    3.57909E+04
tf10218          9.49    3.61195E+04
tf10219          9.59    3.64471E+04
tf10220          9.69    3.67738E+04
tf10221          9.79    3.70996E+04
tf10222          9.89    3.74244E+04
tf10223          9.99    3.77484E+04
tf10224         10.09    3.80714E+04
tf10225         10.19    3.83935E+04
tf10226         10.29    3.87148E+04
tf10227         10.39    3.90351E+04
tf10228         10.49    3.93546E+04
tf10229         10.59    3.96732E+04
tf10230         10.69    3.99910E+04
tf10231         10.79    4.03079E+04
tf10232         10.89    4.06239E+04
tf10233         10.99    4.09391E+04
tf10234         11.09    4.12535E+04
tf10235         11.19    4.15670E+04
tf10236         11.29    4.18798E+04
tf10237         11.39    4.21917E+04
tf10238         11.49    4.25028E+04
tf10239         11.59    4.28131E+04
tf10240         11.69    4.31226E+04
tf10241         11.79    4.34313E+04
tf10242         11.89    4.37392E+04
tf10243         11.99    4.40464E+04
tf10244         12.09    4.43528E+04
tf10245         12.19    4.46584E+04
tf10246         12.29    4.49632E+04
tf10247         12.39    4.52673E+04
tf10248         12.49    4.55707E+04
tf10249         12.59    4.58733E+04
tf10250         12.69    4.61751E+04
tf10251         12.79    4.64763E+04
tf10252         12.89    4.67767E+04
tf10253         12.99    4.70763E+04
tf10254         13.09    4.73753E+04
tf10255         13.19    4.76735E+04
tf10256         13.29    4.79710E+04
tf10257         13.39    4.82679E+04
tf10258         13.49    4.85640E+04
tf10259         13.59    4.88590E+04
tf10260         13.69    4.91512E+04
tf10261         13.79    4.94425E+04
tf10262         13.89    4.97327E+04
tf10263         13.99    5.00220E+04
tf10264         14.09    5.03103E+04
tf10265         14.19    5.05976E+04
tf10266         14.29    5.08839E+04
tf10267         14.39    5.11694E+04
tf10268         14.49    5.14538E+04
tf10269         14.59    5.17374E+04
tf10270         14.69    5.20200E+04
tf10271         14.79    5.23017E+04
tf10272         14.89    5.25825E+04
tf10273         14.99    5.28624E+04
tf10274         15.09    5.31415E+04
tf10275         15.19    5.34196E+04
tf10276         15.29    5.36969E+04
tf10277         15.39    5.39733E+04
tf10278         15.49    5.42489E+04
tf10279         15.59    5.45236E+04
tf10280         15.69    5.47975E+04
tf10281         15.79    5.50706E+04
tf10282         15.89    5.53429E+04
tf10283         15.99    5.56144E+04
tf10284         16.09    5.58852E+04
tf10285         16.19    5.61551E+04
tf10286         16.29    5.64244E+04
tf10287         16.39    5.66928E+04
tf10288         16.49    5.69606E+04
tf10289         16.59    5.72276E+04
tf10290         16.69    5.74938E+04
tf10291         16.79    5.77593E+04
tf10292         16.89    5.80241E+04
tf10293         16.99    5.82882E+04
tf10294         17.09    5.85516E+04
tf10295         17.19    5.88143E+04
tf10296         17.29    5.90763E+04
tf10297         17.39    5.93376E+04
tf10298         17.49    5.95982E+04
tf10299    17.4900001    0.00000E+00
*
tf10300    'MSLB-MASS-3'  90  0.4536   0.0     * convert lbm to kg
tf10310    17.4899999    0.00000E+00
tf10311         17.49    5.95982E+04
tf10312         17.59    5.98581E+04
tf10313         17.69    6.01174E+04
tf10314         17.79    6.03760E+04
tf10315         17.89    6.06339E+04
tf10316         17.99    6.08912E+04
tf10317         18.09    6.11478E+04
tf10318         18.19    6.14038E+04
tf10319         18.29    6.16591E+04
tf10320         18.39    6.19138E+04
tf10321         18.49    6.21678E+04
tf10322         18.59    6.24213E+04
tf10323         18.69    6.26741E+04
tf10324         18.79    6.29262E+04
tf10325         18.89    6.31778E+04
tf10326         18.99    6.34288E+04
tf10327         19.09    6.36792E+04
tf10328         19.19    6.39289E+04
tf10329         19.29    6.41781E+04
tf10330         19.39    6.44267E+04
tf10331         19.49    6.46747E+04
tf10332         19.59    6.49221E+04
tf10333         19.69    6.51689E+04
tf10334         19.79    6.54152E+04
tf10335         19.89    6.56609E+04
tf10336         19.99    6.59060E+04
tf10337         20.38    6.68811E+04
tf10338         20.78    6.78474E+04
tf10339         21.18    6.88053E+04
tf10340         21.58    6.97550E+04
tf10341         21.98    7.06966E+04
tf10342         22.38    7.16305E+04
tf10343         22.78    7.25569E+04
tf10344         23.18    7.34763E+04
tf10345         23.58    7.43887E+04
tf10346         23.98    7.52943E+04
tf10347         24.38    7.61933E+04
tf10348         24.78    7.70859E+04
tf10349         25.18    7.79721E+04
tf10350         25.58    7.88522E+04
tf10351         25.98    7.97263E+04
tf10352         26.38    8.05945E+04
tf10353         26.78    8.14569E+04
tf10354         27.18    8.23137E+04
tf10355         27.58    8.31650E+04
tf10356         27.98    8.40110E+04
tf10357         28.38    8.48517E+04
tf10358         28.78    8.56873E+04
tf10359         29.18    8.65186E+04
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tf10360        29.58    8.73456E+04
tf10361        29.98    8.81685E+04
tf10362        30.38    8.89872E+04
tf10363        30.78    8.98018E+04
tf10364        31.18    9.06124E+04
tf10365        31.58    9.14191E+04
tf10366        31.98    9.22218E+04
tf10367        32.38    9.30208E+04
tf10368        32.78    9.38159E+04
tf10369        33.18    9.46073E+04
tf10370        33.58    9.53951E+04
tf10371        33.98    9.61792E+04
tf10372        34.38    9.69597E+04
tf10373        34.78    9.77367E+04
tf10374        35.18    9.85103E+04
tf10375        35.58    9.92806E+04
tf10376        35.98    1.00048E+05
tf10377        36.38    1.00811E+05
tf10378        36.78    1.01572E+05
tf10379        37.18    1.02330E+05
tf10380        37.58    1.03084E+05
tf10381        37.98    1.03835E+05
tf10382        38.38    1.04584E+05
tf10383        38.78    1.05329E+05
tf10384        39.18    1.06071E+05
tf10385        39.58    1.06810E+05
tf10386        39.98    1.07547E+05
tf10387        40.38    1.08280E+05
tf10388        40.78    1.09011E+05
tf10389        41.18    1.09739E+05
tf10390        41.58    1.10464E+05
tf10391        41.98    1.11186E+05
tf10392        42.38    1.11906E+05
tf10393        42.78    1.12623E+05
tf10394        43.18    1.13337E+05
tf10395        43.58    1.14049E+05
tf10396        43.98    1.14758E+05
tf10397        44.38    1.15464E+05
tf10398        44.78    1.16168E+05
tf10399   44.7800001    0.00000E+00
*
tf10400  'MSLB-MASS-4'  90  0.4536   0.0    * convert lbm to kg
tf10410   44.7799999    0.00000E+00
tf10411        44.78    1.16168E+05
tf10412        45.18    1.16869E+05
tf10413        45.98    1.18264E+05
tf10414        46.38    1.18958E+05
tf10415        46.78    1.19649E+05
tf10416        47.18    1.20338E+05
tf10417        47.58    1.21025E+05
tf10418        47.98    1.21709E+05
tf10419        48.38    1.22390E+05
tf10420        48.78    1.23070E+05
tf10421        49.18    1.23747E+05
tf10422        49.58    1.24421E+05
tf10423        49.98    1.25093E+05
tf10424        51.98    1.28421E+05
tf10425        53.98    1.31693E+05
tf10426        55.98    1.34911E+05
tf10427        57.98    1.38078E+05
tf10428        59.98    1.41193E+05
tf10429        61.98    1.44257E+05
tf10430        63.98    1.47271E+05
tf10431        65.98    1.50234E+05
tf10432        67.98    1.53148E+05
tf10433        69.98    1.56013E+05
tf10434        71.98    1.58831E+05
tf10435        73.98    1.61602E+05
tf10436        75.98    1.64327E+05
tf10437        77.98    1.67009E+05
tf10438        79.98    1.69648E+05
tf10439        81.98    1.72244E+05
tf10440        83.98    1.74799E+05
tf10441        85.98    1.77314E+05
tf10442        87.98    1.79790E+05
tf10443        89.98    1.82228E+05
tf10444        91.98    1.84628E+05
tf10445        93.98    1.86992E+05
tf10446        95.98    1.89320E+05
tf10447        97.98    1.91613E+05
tf10448        99.98    1.93872E+05
tf10449       101.98    1.96097E+05
tf10450       103.98    1.98289E+05
tf10451       105.98    2.00448E+05
tf10452       107.98    2.02575E+05
tf10453       109.98    2.04670E+05
tf10454       111.98    2.06734E+05
tf10455       113.98    2.08768E+05
tf10456       115.98    2.10773E+05
tf10457       117.98    2.12748E+05
tf10458       119.98    2.14695E+05
tf10459       121.98    2.16614E+05
tf10460       123.98    2.18505E+05
tf10461       125.98    2.20370E+05
tf10462       127.98    2.22208E+05
tf10463       129.98    2.24021E+05
tf10464       131.98    2.25808E+05
tf10465       133.98    2.27567E+05
tf10466       135.98    2.29299E+05
tf10467       137.98    2.31000E+05
tf10468       139.98    2.32672E+05
tf10469       141.98    2.34314E+05
tf10470       143.98    2.35926E+05
tf10471       145.98    2.37508E+05
tf10472       147.98    2.39060E+05
tf10473       149.98    2.40583E+05
tf10474       153.98    2.43536E+05
tf10475       157.98    2.46367E+05
tf10476       161.98    2.49073E+05
tf10477       165.98    2.51651E+05
tf10478       169.98    2.54091E+05
tf10479       173.98    2.56386E+05
tf10480       177.98    2.58526E+05
tf10481       181.98    2.60501E+05
tf10482       185.98    2.62301E+05
tf10483       189.98    2.63922E+05
tf10484       193.98    2.65275E+05
tf10485       197.98    2.66296E+05
tf10486       201.98    2.67085E+05
tf10487       205.98    2.67708E+05
tf10488       209.98    2.68219E+05
tf10489       213.98    2.68638E+05
tf10490       217.98    2.69004E+05
tf10491       221.98    2.69093E+05
tf10492       225.98    2.69155E+05
tf10493       229.98    2.69217E+05
tf10494       233.98    2.69279E+05
tf10495       237.98    2.69340E+05
tf10496       241.98    2.69401E+05
tf10497       245.98    2.69462E+05
tf10498       249.98    2.69523E+05
tf10499  249.9800001    0.00000E+00
*
tf10500  'MSLB-MASS-5'  40  0.4536   0.0    * convert lbm to kg
tf10510  249.9799999    0.00000E+00
tf10511       249.98    2.69523E+05
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tf10512          253.98    2.69584E+05
tf10513          257.98    2.69645E+05
tf10514          261.98    2.69706E+05
tf10515          265.98    2.69766E+05
tf10516          269.98    2.69827E+05
tf10517          273.98    2.69887E+05
tf10518          277.98    2.69948E+05
tf10519          281.98    2.70008E+05
tf10520          285.98    2.70068E+05
tf10521          289.98    2.70129E+05
tf10522          293.98    2.70189E+05
tf10523          297.98    2.70249E+05
tf10524          301.98    2.70309E+05
tf10525          305.98    2.70369E+05
tf10526          309.98    2.70429E+05
tf10527          313.98    2.70490E+05
tf10528          317.98    2.70550E+05
tf10529          321.98    2.70610E+05
tf10530          325.98    2.70670E+05
tf10531          329.98    2.70729E+05
tf10532          333.98    2.70789E+05
tf10533          337.98    2.70849E+05
tf10534          341.98    2.70909E+05
tf10535          345.98    2.70969E+05
tf10536          349.98    2.71029E+05
tf10537          353.98    2.71088E+05
tf10538          357.98    2.71148E+05
tf10539          361.98    2.71208E+05
tf10540          365.98    2.71267E+05
tf10541          369.98    2.71327E+05
tf10542          373.98    2.71386E+05
tf10543          377.98    2.71445E+05
tf10544          381.98    2.71505E+05
tf10545          385.98    2.71564E+05
tf10546          389.98    2.71623E+05
tf10547          393.98    2.71683E+05
tf10548          397.98    2.71742E+05
tf10549          400.00    2.71772E+05
*
cf11000   ATM-MASS-SRC    ADD       5  1.0  0.0
cf11001   0.0
cf11010   1.0      0.0     CFVALU.101
cf11011   1.0      0.0     CFVALU.102
cf11012   1.0      0.0     CFVALU.103
cf11013   1.0      0.0     CFVALU.104
cf11014   1.0      0.0     CFVALU.105
*
*******
* atmosphere energy
*******
cf11100   MSLB-ENRG-1   TAB-FUN   1  1.0  0.0
cf11103   111
cf11110   1.0      0.0     TIME
*
cf11200   MSLB-ENRG-2    TAB-FUN   1  1.0  0.0
cf11203   112
cf11210   1.0      0.0     TIME
*
cf11300   MSLB-ENRG-3    TAB-FUN   1  1.0  0.0
cf11303   113
cf11310   1.0      0.0     TIME
*
cf11400   MSLB-ENRG-4    TAB-FUN   1  1.0  0.0
cf11403   114
cf11410   1.0      0.0     TIME
*
cf11500   MSLB-ENRG-5    TAB-FUN   1  1.0  0.0
cf11503   115
```

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cf11510   1.0     0.0    TIME
*
tf11100   'MSLB-ENRG-1'  90  1055.    0.0     * convert Btu to J
tf11110          0.00    0.00000E+00
tf11111          0.09    4.66320E+05
tf11112          0.19    9.82183E+05
tf11113          0.29    1.49608E+06
tf11114          0.39    2.00814E+06
tf11115          0.49    2.51839E+06
tf11116          0.59    3.02687E+06
tf11117          0.69    3.53363E+06
tf11118          0.79    4.03875E+06
tf11119          0.89    4.54223E+06
tf11120          0.99    5.04410E+06
tf11121          1.09    5.54442E+06
tf11122          1.19    6.04319E+06
tf11123          1.29    6.54047E+06
tf11124          1.39    7.03628E+06
tf11125          1.49    7.53062E+06
tf11126          1.59    8.02355E+06
tf11127          1.69    8.51505E+06
tf11128          1.79    9.00519E+06
tf11129          1.89    9.49396E+06
tf11130          1.99    9.98141E+06
tf11131          2.09    1.04675E+07
tf11132          2.19    1.09523E+07
tf11133          2.29    1.14359E+07
tf11134          2.39    1.19182E+07
tf11135          2.49    1.23992E+07
tf11136          2.59    1.28790E+07
tf11137          2.69    1.33576E+07
tf11138          2.79    1.38350E+07
tf11139          2.89    1.43111E+07
tf11140          2.99    1.47860E+07
tf11141          3.09    1.52597E+07
tf11142          3.19    1.57322E+07
tf11143          3.29    1.62035E+07
tf11144          3.39    1.66737E+07
tf11145          3.49    1.71427E+07
tf11146          3.59    1.76106E+07
tf11147          3.69    1.80773E+07
tf11148          3.79    1.85430E+07
tf11149          3.89    1.90076E+07
tf11150          3.99    1.94711E+07
tf11151          4.09    1.99335E+07
tf11152          4.19    2.03949E+07
tf11153          4.29    2.08552E+07
tf11154          4.39    2.13145E+07
tf11155          4.49    2.17728E+07
tf11156          4.59    2.22301E+07
tf11157          4.69    2.26864E+07
tf11158          4.79    2.31417E+07
tf11159          4.89    2.35960E+07
tf11160          4.99    2.40494E+07
tf11161          5.09    2.45019E+07
tf11162          5.19    2.49534E+07
tf11163          5.29    2.54040E+07
tf11164          5.39    2.58537E+07
tf11165          5.49    2.63025E+07
tf11166          5.59    2.67504E+07
tf11167          5.69    2.71974E+07
tf11168          5.79    2.76436E+07
tf11169          5.89    2.80889E+07
tf11170          5.99    2.85334E+07
tf11171          6.09    2.89770E+07
tf11172          6.19    2.94199E+07
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```

```
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tf11176          6.59    3.11728E+07
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*
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tf11213          8.99    4.11218E+07
tf11214          9.09    4.15199E+07
tf11215          9.19    4.19169E+07
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tf11217          9.39    4.27073E+07
tf11218          9.49    4.31008E+07
tf11219          9.59    4.34933E+07
tf11220          9.69    4.38846E+07
tf11221          9.79    4.42748E+07
tf11222          9.89    4.46639E+07
tf11223          9.99    4.50519E+07
tf11224         10.09    4.54389E+07
tf11225         10.19    4.58248E+07
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tf11227         10.39    4.65936E+07
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tf11232         10.89    4.84976E+07
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tf11234         11.09    4.92521E+07
tf11235         11.19    4.96279E+07
tf11236         11.29    5.00028E+07
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tf11248         12.49    5.44285E+07
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tf11265         14.19    6.04595E+07
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tf11319         18.29    7.37463E+07
tf11320         18.39    7.40525E+07
tf11321         18.49    7.43578E+07
tf11322         18.59    7.46625E+07
tf11323         18.69    7.49664E+07
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tf11325         18.89    7.55720E+07
tf11326         18.99    7.58737E+07
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*
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tf11416          47.18     1.44389E+08
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tf11418          47.98     1.46040E+08
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tf11421          49.18     1.48495E+08
tf11422          49.58     1.49307E+08
tf11423          49.98     1.50117E+08
tf11424          51.98     1.54125E+08
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tf11495        237.98    3.23300E+08
tf11496        241.98    3.23375E+08
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tf11538        357.98    3.25512E+08
tf11539        361.98    3.25585E+08
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tf11541        369.98    3.25731E+08
tf11542        373.98    3.25803E+08
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tf11548        397.98    3.26240E+08
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APPENDIX B

Changes in Input Data Between the Original Licensee Submittal (November 1999) and the Supplement (June 2000)

1. BACKGROUND

The confirmatory calculations described in the main body of this report were performed using data submitted by the licensee in an Amendment Request dated November 1999 (Entergy 1999). After the calculations were completed, the licensee submitted a supplement to their Amendment Request. In the supplement, the licensee stated

> corrections were made to two key input assumptions used in the computer code to perform the containment analysis. A correction was made regarding the surface area assumed for an existing containment heat sink. A second correction was made regarding the time required to fill the containment spray headers, and thus the containment spray system response time. (Entergy 2000)

In particular, the surface area associated with the "Refueling Canal" heat sink was reduced from 18,000 ft^2 to 8000 ft^2. The delay time between receipt of the high-high containment pressure signal and the beginning of containment spray flow was changed from 53.6 s to 60.0 s.

The licensee also modified proposed changes to the ANO-2 Technical Specifications regarding the region of acceptable operation. The only change that affected the confirmatory calculations related to containment maximum pressure, which was changed to a 15.5 psia for <u>all</u> allowed values of containment atmosphere temperature.

Finally, the licensee modified the method for modeling condensation heat/mass transfer on containment structures in two areas. First, the list of structural heat sinks included in the ANO-2 containment model was expanded to include several new items. A total of 20 new heat sinks was identified, most of which were composed of relatively thin steel but involved small surface area. Water-filled piping in the Safety Injection System and the Fire Water System also was added as new heat sinks.

The second modification involved a change to COPATTA modeling assumptions regarding condensate heat/mass transfer. The original assumption was that condensate is transported instantaneously to the containment sump (i.e., the formation and drainage of liquid films are ignored). In the revised analysis, the licensee adopted an assumption allowed under NRC guidance for environmental qualification of safety-related electrical equipment (NRC 1979). Specifically, 8% of the condensate formed on heat sinks was assumed to remain in the containment atmosphere rather than drain to the containment sump while the containment atmosphere is superheated. This amount purportedly represents the latent heat equivalent of the atmosphere superheat absorbed by draining condensate films.

2. REVISED CONFIRMATORY CALCULATIONS

Each of the changes described above was made in the ANO-2 model used for the confirmatory calculations <u>except</u> the one related to condensate heat/mass transfer. The proposed adjustments to accident initial conditions, the safety system actuation criteria, and the list of containment heat sinks appeared reasonable and were accommodated in the confirmatory analysis model easily. However, the original confirmatory analysis (described in the main report) clearly indicated that heat transfer to draining liquid condensate films had an insignificant effect on peak containment temperature and pressure (refer to the baseline and sensitivity case 4 results). Further, heat/mass transfer between draining liquid films and the containment atmosphere is included in the confirmatory analysis model (i.e., MELCOR). Consequently, *a priori* assumptions defining the partitioning of the condensate between the sump and atmosphere are not necessary.

Revised confirmatory calculations were made for the LOCA baseline accident scenario as well as the scenario that generated the bounding containment pressure response (sensitivity case 5). Calculated containment pressure and temperature signatures are compared in Figs. B-1 and B-2, respectively.

In both cases, the changes made to the ANO-2 model resulted in very small changes to the calculated results. Peak pressures were found to be less than 1 psi lower than those generated in the original analysis; peak temperatures (during the post-reflood period) increased by 1°F.

3. CONCLUSIONS

The modifications made to the ANO-2 containment analysis described in the supplement to the licensee's Amendment Request do not alter key calculated results or conclusions drawn from the analysis described in the main body of this report.

REFERENCES

Entergy 1999 Proposed License Amendment (No. 16) to License No. NPF-6, Entergy Operations, Inc., Arkansas Nuclear One, Unit Two, Docket 50-368, an Attachment to 2CAN119903 (November 3, 1999).

Entergy 2000 Supplement to Proposed Technical Specification Change Request Supporting the ANO-2 Containment Building Design Pressure Increase to 59 Psig, 2CAN060014 (June 29, 2000).

NRC 1979 "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment," US Nuclear Regulatory Commission reportNUREG-0588 (December 1979).

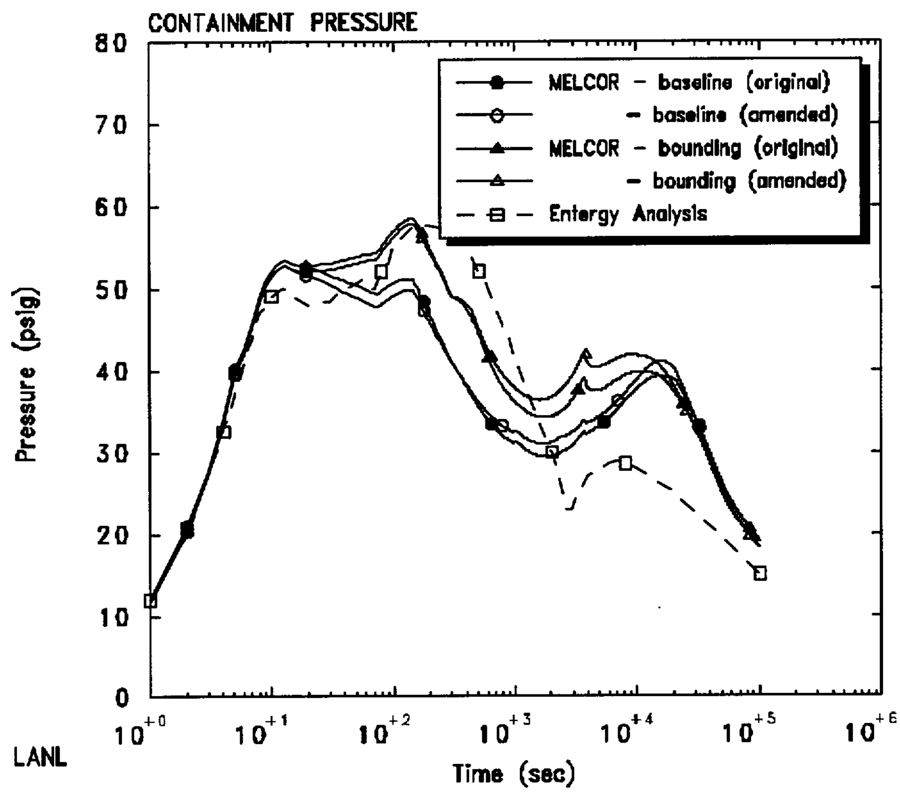

Fig. B-1. Containment Pressure—Original vs Revised Confirmatory Calculations.

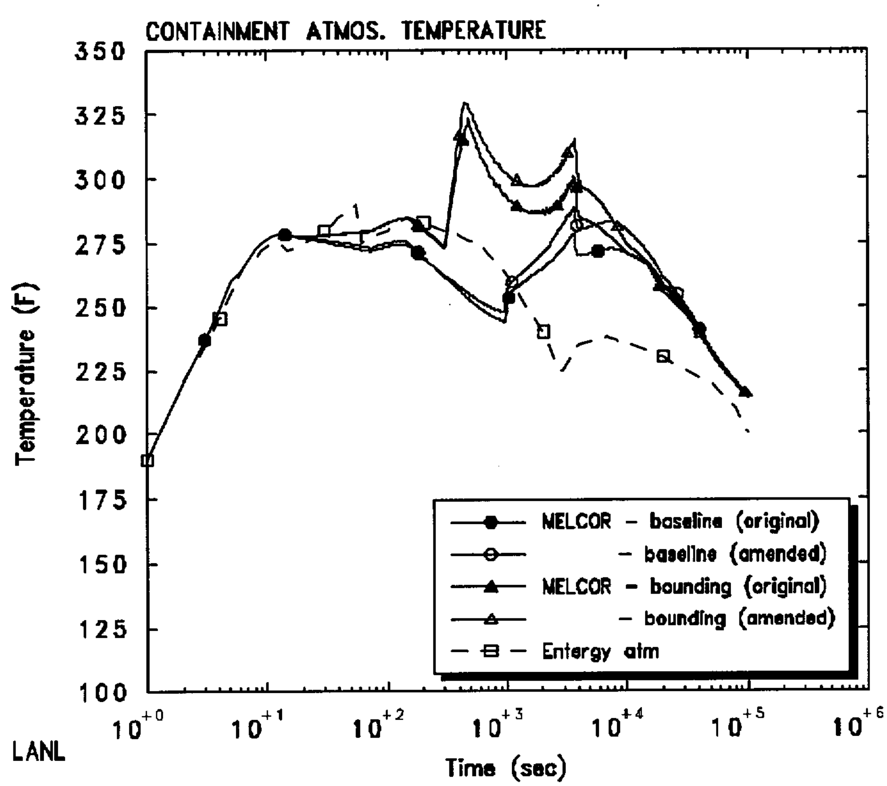

Fig. B-2. Containment Temperature—Original vs Revised Confirmatory Calculations.