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Exhibit SPSB-C-52-6

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 30

Extended Power Uprate

Response to Request for Additional Information

Operation Procedure OP- 2192, Rev. 31

Total number of pages in this Exhibit (excluding this cover sheet) is 5.

VERMONT YANKEE NUCLEAR POWER STATION

OPERATING PROCEDURE

OP 2192

REVISION 31

HEATING, VENTILATING, AND AIR CONDITIONING SYSTEM

USE CLASSIFICATION: REFERENCE

RESPONSIBLE PROCEDURE OWNER: Manager, Operations

REQUIRED REVIEWS		Yes/No
E-Plan	10CFR50.54(q)	No
Security	10CFR50.54(p)	No
Probable Risk Analysis (PRA)		No
Reactivity Management		No

LPC No.	Effective Date	Affected Pages
1	10/26/04	App A Pg 15 of 24
2	11/16/04	51 & ADDED 51A of 62
3	01/22/05	60 of 62
4	05/26/05	29 of 62

Implementation Statement: N/A

Issue Date: 07/06/2004

(2)

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The Turbine Lube Oil Room fire dampers are controlled by a local hand switch located outside the Lube Oil Room door.

The air is exhausted to the atmosphere by wall exhaust fans, roof exhaust fans or through the station stack. Several areas, such as the Control Room and office spaces recirculate air on a continuous cycle.

The system serving the Control Room is designed to provide cooling during the summer and heating during the winter. Air is circulated through a chilled water cooling coil, steam preheat coil, a steam reheat coil and ductwork by one of two system fans. Fresh air is normally drawn into the system mixing with the recirculated flow. A humidistat, on the west hallway wall in the first fan room, controls the relative humidity between 20% and 50% with a humidifier located in SRHC-1. It is operated with instrument air and controls humidity by spraying steam into the air flow. Two exhaust fans in the North wall of the Control Room, kitchen and rest room, serve to exhaust these rooms. The "Control Room H and V" switch on CRP 9-25 is provided to allow the operator to isolate the Control Room and Computer Room by closing the fresh air dampers and the Control Room kitchen and bathroom exhaust vents during off normal conditions. This is accomplished by moving the switch from "NORMAL" to "EMER". If a report was received of a toxic gas release which could affect Control Room personnel, the operators would don the self-contained breathing apparatus located in the Control Room. If Control Room cooling is completely lost, emergency cooling can be initiated using portable smoke ejectors. (UND98080)

The Control Room and Service Building chilled water cooling coils are located in the SAC-1 and SAC-2 supply fan housings respectively. The cooling coils are cooled by dual compressor refrigeration units SCH-1 and 2 that cycle as necessary to maintain chilled water temperature. Demineralized water from the chilled water pumps circulates through the chiller heat exchanger and gives off its heat to the chiller units. The cooled water passes from the chiller units to the cooling coils. The amount of chilled water flowing into the cooling coils is controlled by the mixing valves. Each mixing valve is controlled by a thermostat that senses supply air temperature. The Services Building chilled water piping system can be valved into the Control Room HVAC because both the NNS piping system and the current SC3 piping system, respectively, were designed and built to the same specifications (i.e., non-seismic), therefore, failure mechanism(s) are the same for each system. In addition, isolation of the NNS and SC3 systems can be accomplished because the valves are in a mild environment area. Continued operation of the Control Room HVAC by valving in the Service Building HVAC to supply chilled water is consistent with the Safety Class Manual and the HVAC DBD.

Air for air compressor cooling is drawn through a wall louver located in the outside wall. This louver also supplies any required room ventilation air. Discharge dampers which exhaust into the room are located on the air compressor discharge duct to allow for air recirculation.

Two oil-fired steam boilers supply steam for the heating coils and some of the unit heaters. Other unit heaters are run electrically.

All RRUs and TRUs utilize service water as the cooling medium except the drywell RRU-1 through RRU-4 which use RBCCW. (MOOID9502_14)

(4)

7. For minimum ECCS RRU corner room support operation, RRU 7 must be operable for the Northeast corner room and RRU 8 must be operable for the Southeast corner room. RRUs 7 and 8 can be removed from service for maintenance and the associated Core Spray Pump/RHR Pump may remain operable. Refer to OP 2181, Service Water/Alternate Cooling Operating Procedure, Precautions and Limitations, for administrative requirements and actions necessary to maintain operability.

8. SP-1, SCH-1 and SAC-1 supply air conditioning for the Control Room. This is a Safety Class 3 system and requires special consideration for its timely repair.

9. To prevent the possibility of reverse air flow, building ventilation should be secured in the following order:

   a. Radwaste Building
   b. Turbine Building
   c. Reactor Building
   d. Service Building

10. Minimize the time that TEF-2/3 are operated in manual. The UFSAR specified minimum Turbine Building design temperature, which includes the DG rooms, is 50°F and the AS-2 battery load calculation assumes an electrolyte temperature of 50°F. (ER960055_01)

11. Securing TRU-5 with the condensate pumps running will result in a condensate pump bearing temperature rise. Planned maintenance on TRU-5 should be coordinated such that the time the unit is out of service is minimized.

12. Control Room temperatures in excess of 78°F are indicative of a need for corrective action. Corrective actions need to be completed prior to exceeding 95°F to ensure the Control Room does not reach 120°F (upper temperature operability limit for Control Room instrumentation). (UND98080)

13. HS-139 and HS-140 in the Reactor Building must remain locked closed during plant operation due to House Heating Steam, High Energy Line Break concerns. These valves may only be opened with the permission of the Design Engineering Department. (ER96-0482, TAG_REVIEW_9703_26)

14. The Main Station Battery Room must be maintained at ≥60°F. The main station battery load calculations are based upon this minimum temperature.

15. One of the two standby gas treatment trains should be placed in service whenever normal Reactor Building ventilation is secured.

16. In order to meet environmental qualification program requirements, the RCIC room fan or alternate ventilation from the Reactor Building must be operable and the RCIC room temperature must be less than 112°F. However, to satisfy station blackout analysis, the RCIC Room temperature must be maintained less than 104°F. (EPC_9504)

2. Shutdown

a. Secure the West Switchgear Room exhaust fan SWGR-EF-1A.

b. If the temperature cannot be maintained in the required range, notify the Operations Manager of the need to initiate actions to provide supplemental heating/cooling.

Q. Loss of Control Room Ventilation (UND98080)

1. If a loss of normal Control Room ventilation occurs, refer to Section J and place SAC-1B in service.

2. If Control Room cooling is lost, perform applicable action:

a. Refer to Section L and cross-connect chilled water from the Service Building to the Control Room.

b. Perform the following:

1) In the Control Room back panel area, remove 11 full size ceiling tiles.

2) Open Control Room panel doors.

3) Notify Security and Shift Engineer that Control Room doors will be opened.

4) Open Control Room doors.

5) Using two smoke ejectors or other portable cooling equipment to create temporary air flow paths, ventilate Control Room.

6) Implement the administrative requirements of AP 0077.

R. Local Manual Operation of EDG Room A(B) Exhaust Fan TEF-2(3) (Use VYOPF 2192.01) (ER990738_01)

1. Ensure the selected EDG Room temperature is ≥60°F [RATS-1A(B)].

2. Obtain Shift Manager permission for local manual operation of TEF-2(3).

3. Obtain key #D018.

4. Station a dedicated Auxiliary Operator at the selected Diesel Generator Room area.

BVY 05-072
Docket No. 50-271

Exhibit SPSB-C-52-4

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 30

Extended Power Uprate

Response to Request for Additional Information

Calculation VYC-2405, Rev.0

Total number of pages in this Exhibit (excluding this cover sheet) is 85.

CALCULATION COVER PAGE

☐ IP-2 ☐ IP-3 ☐ JAF ☐ PNPS ☒ VY

Calculation No.	This revision incorporates the following MERLIN DRNs or Minor Calc Changes:	Sheet 1 of 85
VYC-2405 Rev. 0		

Title: **Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.**

☒QR ☐NQR

Discipline: Fluid Systems Design Engineering

Design Basis Calculation? ☒Yes ☐No

This calculation supersedes/voids calculation: N/A

Modification No./Task No/ER No: **EPU**

☐ No software used

☒ Software used and filed separately (Include Computer Run Summary Sheet).
If "YES', Code: **GOTHIC V7.0p2**

☐ Software used and filed with this calculation. If "YES', Code:

System No./Name: _____

Component No./Name: _____

(Attach additional pages if necessary)

REV #	STATUS (Prel, Pend, A, V, S)	PREPARER (Print/Sign)	REVIEWER/ DESIGN VERIFIER (Print/Sign)	OTHER REVIEWER/ DESIGN VERIFIER	APPROVER (Print/Sign)	DATE
0	Prelim	Liliane Schor 3/17/05	Alan L. Robertshaw 3/17/05	NA	James G. Rogers	3-17-05

RECORD OF REVISIONS

Calculation Number: VYC-2405 Rev 0 Page 2 of 85

Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Revision No.	Description of Change	Reason For Change
0	Original Issue	N/A

CALCULATION SUMMARY PAGE
Calculation No. VYC-2405 Revision No.0 **Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.**
CALCULATION OBJECTIVE: This calculation will address the VY drywell temperature for Station Blackout (SBO) at Extended Power Uprate (EPU) Conditions. The calculation will look into means to mitigate the drywell temperature for this event, such that there will be no need for Emergency Depressurization.
CONCLUSIONS: See Section 7.0
ASSUMPTIONS: See Assumption in Section 4.0. (see also list of open items – assumptions which need verification or implementation - Section 4.1)
DESIGN INPUT DOCUMENTS: See Design Input Documents identified in References Section 8.0
AFFECTED DOCUMENTS: See Assumption Section, Section 4.2
METHODOLOGY: See Section 3.0

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Torus Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

PAGE	REV.	PAGE	REV.	PAGE	REV.
All	0				

1.0 Background

The Station Blackout (SBO) torus temperature calculation (Reference 1) accommodated a higher coping time of 2 hours versus 10 minutes previously assumed. In addition to an increased coping time, Reference 1 also eliminated the potential need for Containment Overpressure (COP) for the SBO event. In the process, it was determined that in order to implement coping strategies for the two hours, two additional parameters need to be analyzed:

- Drywell temperature and the coping strategy to accommodate an expected higher drywell temperature, and
- Procedural direction for the operators (if needed) to limit the drywell temperature while ensuring capability of HPCI/RCIC to maintain vessel level

2.0 Purpose

This calculation will address the VY drywell temperature for Station Blackout (SBO) at Extended Power Uprate (EPU) Conditions. The calculation will look into means to reduce the drywell temperature for this event, such that there will be no need for Reactor Pressure Vessel Emergency Depressurization (RPVED – Reference 30).

This analysis will address control of the drywell temperature by controlled depressurization (cooldown) and will show that RCIC/HPCI injection is maintained until power is restored and the low pressure pumps (RHR and CS) are available.

As indicated in Section 1.0 of Reference 1, for the SBO event, the Alternate AC (AAC) power source is restored at 2 hours into the event. After the restoration of power, torus cooling and drywell spray will become available.

2.1 Acceptance Criteria

To evaluate the results the following criteria are applied:

1. The maximum allowable drywell bulk average temperature should remain below the EQ temperature (340°F for the first 30 minutes and 325°F for the next 270 minutes) (Reference 19).
2. The maximum allowable drywell surface temperature is 281 °F (Reference 20).
3. The maximum allowable drywell air pressure is 56 psig, (Reference 27).
4 Maintain the torus pressure below PSP curve (Reference 30) during the 2 hour coping duration and the 10 minutes of low pressure pumps restoration period.
5. The analyses should provide assurance that there is no need to spray the drywell in the unsafe region of the DWSIL curve (Reference 30).

3.0 Method of Analysis

The model developed in Reference 1 is modified to accommodate changes related to the purpose described in Section 2.

The GOTHIC code (Reference 7), Version 7.0p2 has been selected for use in this analysis. This code was used in the original suppression pool temperature calculation (Reference 6) and in the analysis for SBO at EPU conditions, Reference 1. This specific version of the code has been installed and complies with the ENVY SQA procedures ENN-IT-104 (it replaced VY procedure AP-6030) as documented in calculation VYC-2208 (Reference 8).

The following changes to the input *SBO-NoLeak-80* to produce *SBO-drywell2* are being added:

- drywell heat load
- drywell heat slabs
- leakage from drywell to wetwell
- modifications to the vacuum breaker modeling

The GOTHIC input file for the case *SBO-drywell2* is presented in attachment A.

4.0 Inputs and Assumptions

The inputs and assumptions for the SBO event were developed in Reference 1. For completeness, they are added to this calculation. The more important modifications to the model have been made, for this analysis, by the addition of the Drywell Heat Loads and Drywell Heat Slabs (see Section 5.0 for details).

The SBO scenario postulates a complete loss of onsite and offsite AC power. The vessel is assumed to be isolated at the start of the event.

The scenario is modeled as follows:

1) Scram occurs at time zero.

2) The MSIVs are isolated at time zero (this is a conservative assumption for the drywell temperature calculation since the energy transferred to the condenser while the MSIVs are opened will remain in the vessel).

3) The Reactor Vessel level is maintained with HPCI or RCIC in a band between 127-177 inches above Top of Active Fuel (TAF). Level is maintained with HPCI at a nominal flow of 4250 gpm. In reality HPCI flow will be adjusted to keep level in the band and to prevent excessive start/stop cycles. The HPCI (or RCIC) modeling in the GOTHIC input as a continuous flow (lower flow) or as intermittent flow has no effect on the drywell temperature analysis results. The choice of RCIC or HPCI or the flow capacity has no effect on the analysis since HPCI injects intermittently to maintain inventory or can be throttled as required to maintain level. If RCIC were used, it would inject more often.

4) HPCI takes suction from CST at 135°F. The CST inventory available for injection is 75000 gal.

The GOTHIC input value in lbm = 75000 gals * 1 ft^3/7.48 gals /0.01627 lbm/ft^3 (Reference 31 for the density a 135 °F) = 616271.7 lbm

5) Power is restored at 2 hours. Torus cooling is initiated at 2 hours and 10 minutes. Two RHR Service Water pumps are available at 2 hours and 10 minutes, delivering 4700 gpm. The second RHRSW pump is discontinued at 16 hours in the transient to maintain the Corner Room temperatures below the EQ limit (Reference 1, Attachment B). The drywell temperature analysis is performed for only 25000 seconds for the base case and for 14400 (4 hours) seconds for the sensitivity cases since, after 2 hours and 10 minutes (7800 seconds), the low pressure pumps are available to spray the drywell, if needed, hence there is no need to analyze the drywell temperature for a longer duration.

6) An orderly reactor cooldown is initiated at one hour in order to maintain the drywell temperature below the EQ limit (Reference 19) and the drywell shell metal below 281 °F (Reference 20). Two cooldown rates will be analyzed: 80°F/hr and 45°F/hr.

7) The RPV level is controlled by HPCI until the CST is depleted or HPCI shutoff pressure is reached. When the pressure permissive is reached, one Core Spray pump starts (after 2 hours and 10 minutes) to inject into the vessel . After the level is recovered in the normal range, the Core Spray system is used to maintain the level with the vessel pressure being controlled by an SRV cycling between 50 and 100 psig. The suppression pool is cooled continuously by the RHR system. The reactor vessel is maintained in this configuration. The RHR pump in torus cooling is also available for drywell spray after 2 hour and 10 minutes.

8) The HPCI turbine takes steam from the vessel to provide its motive power. It returns the exhaust steam to the torus. The steam to the turbine is not modeled since the model assumes SRV opening and closing to maintain pressure. Any steam not removed by the HPCI turbine will be removed through the SRV to maintain a certain pressure. The total flow through the SRV is increased, but the details of SRV flow are not important for this applications and the two (SRV flow and HPCI turbine) can be combined for model simplicity.

9) The liquid leak is modeled as a fixed flow of 8.4585 lb/sec (61 gpm, Reference 3) [(61 gpm /60 s/min /7.4805 gal/ft^3 /0.0161 ft^3/lb = 8.4585 lb/sec)] and it stays on for the entire transient. (Analyses will be performed with and without leak for one depressurization (cooldown) rate: 80 °F/hour). In reality, the leak is variable depending on pressure. Assuming a density of 62 lb/ft^3 and fixed flow is conservative for the drywell temperature analysis.

Analysis of drywell temperature for a 45 °F/hour cooldown with no RPV leakage was not performed because for the case with 80 °F/hr cooldown, for the period of interest the drywell temperature stays below 300 °F for both cases (with and without RPV Leakage). For the 45 °F/hour cooldown, the temperature in the drywell for the no-leak case is expected to remain below 300 °F as in the 45 °F/hour cooldown case with RPV leakage for the analysis duration.

10) The analysis will assume a fouling of 0.0018 in the tubes and 0.0005 in the shell. This corresponds to an overall RHR Heat Exchanger (RHRHX) fouling of:

$$R_f = R_{fi}(\frac{d_o}{d_i}) + R_{fo}$$

where:

R_{fi} and R_{fo} = tube and shell fouling factors, respectively (hr-ft^2-°F/Btu)
d_o = outside tube diameter (in)
d_i = inside tube diameter (in)

d_o = 0.625 in (Reference 22)
d_i = 0.527 in (Reference 22)
R_{fo} = 0.0005 hr-ft^2-°F/Btu (Reference 22)
R_fi = 0.0018 hr-ft^2-°F/Btu (from 0.0020)

Overall RHRHX fouling

$$R_f = 0.0018 * (\frac{0.625}{0.527}) + 0.0005 = 0.0026$$

This number compares well with the maximum fouling calculated in Reference 23 of 0.002307 and 0.002445 for the RHR HX E14-1A and RHR HX E-14-1B, respectively.

11) A variable SW temperature is used, consistent with Reference 1.
Since this change of depressurization (cooldown) function of service water temperature requires procedure changes, it is added in Section 4.1 as an unverified Assumption.

- For SW> 75°F, depressurize the vessel at 80°F/hr or higher.
- For lower SW temperature (SW ≤ 75°F no restrictions on depressurization) rates.

12) - Various assumptions made concerning the added Heat Conductors:

- The heat load decreases linearly when the temperature difference between RPV and drywell becomes smaller.
- For all conductors, only heat conduction is conservatively assumed in the air and concrete layers.
- The outer surface boundary condition is conservatively assumed to be adiabatic (i.e., the heat transfer coefficient is set to zero)

Table 1 – Vessel and Core Initial Conditions and Parameters, Primary Variables

Parameter	Nominal Value	Analysis Value	Basis
Initial Reactor Power	1912 Mwth	1950 MWth	100% power +2 % uncertainty (per NEI-87-001, SBO can be performed at 100% power, however this analysis used 102% power, consistent with CLTP and the Reference 1 analysis).
Core Decay Heat	ANS 5.1	ANS 5.1 +2 σ	ANS 5. 1 1979 standard+2 σ uncertainty -(Reference 24)
MSIV closure time	3.0-5.0 sec	0.0 sec (MSIVs not modeled)	Minimum value allowed retains the maximum energy in the vessel.
RPV Pressure	1015-1025 psia (Reference 28)	1045.2 psia	Higher value, conservative, maximizes the vessel energy.
Initial Vessel Level	162 inches	172 inches	Analysis value conservatively accounts for 3 inches increase above normal (uncertainty and operational fluctuations) and 7 inches for dimensional uncertainties. These assumptions are LOCA assumptions and are judged conservative for SBO.
Core Flow Rate	48.0E6 lb/hr	51.36e6 lb/hr	Includes ICF of 7%.
Initial Feedwater Flowrate	7.876e6 lb/hr	8.076e6 lb/hr	Reference 25 (TE 2003-20)
Initial feedwater temperature	393.5-393.6 °F	393.9 °F	See discussion in Reference 25. Feedwater is tripped at time 0, due to SBO. The feedwater is used only for the steady state initialization.
SRV Cycling	1080-1047.6 psi (between RPV and Drywell)	1080-1047.6 psi (between RPV and Drywell)	The setpoints for the SRVs are nominal. No additional as found allowable of 3% is added since it will have no effect on the drywell temperature since the SRVs open to remove the decay heat and, until the depressurization starts, indifferent of setpoints, the SRVs will cycle to remove the decay heat. The operators will take manual control of the SRV and will cycle between 800 and 1000 psig (EOP-1- Reference 37) to reduce the numbers of times the valves cycle. There is no effect on the calculation since the valves in any operational mode will open to remove decay heat.
Vessel Leak	61 gpm	61 gpm	A constant 61 gpm leakage is assumed; (Reference 3). The analysis will be performed with & without leakage, since the drywell temperature will have a different profile for the cases with no leakage.

Table 2- ECCS Initial Conditions and Parameters

Parameter	Nominal	Analysis Value	Basis	Comments
HPCI flow rate	4250 gpm	4250 gpm	Tech Spec Flow (Reference 2)	Since the flow is intermittent there is no need to use the min flow of 3570 gpm (uncertainty added) (References 2 and 5). In reality the HPCI flow will be adjusted to maintain level to prevent excessive pump stop/start.
HPCI pressure range	1135-165 psia		1135-165 psia	Reference 5 and 27. HPCI is shut off if vessel pressure drops below 165 psia.
CST Temperature	120 °F	135 °F		OPEN Item
CST available inventory	75000 gallons (VY Tech Spec – Reference 2)	75000 gallons	Available CST inventory for HPCI injection	Per Reference 3, the Tech Spec value can be used. An administrative limit for the CST level of 25% is required.
Core Spray Flow	Curve of flow vs. vessel-torus ΔP.	Same as nominal.	The core spray flow rate used in the SBO analysis of Reference 1 will be used. The flow rate is determined as a function of the vessel-torus ΔP. (consistent with the LOCA analysis)	The Core Spray System will be used for level control only after the CST is depleted and/or the low pressure is reached. OPL4 –Reference 5
RHR Flow (t=7800 seconds)	7000 gpm	6400gpm	6400gpm used in analyses	Consistent with Reference 1 limiting case and Reference 5.
RHR Hx Fouling	0.0005 shell, 0.0018 tube	0.0005 shell, 0.0018 tube		Assumption input #10, supported by Reference 23.
RHR Hx Tube Plugging	N/A	5%	Allowable plugging margin	Design value providing margin above the current plugging value of 3.6%
RHRSW Flow	4700	4700 gpm (2 RHRSW pumps) 4700 gpm = 650.98 lb/sec (at 85 °F)	4700 gpm	(Reference 4)
RHRSW Inlet Temperature	32-85 °F	Variable, see assumptions, based on depressurization (cooldown) rate	If SW is > 75 °F, depressurize the RPV with rates 80 °F/hr or higher.	Maximum Allowable Service Water Temperature (Reference 2) only for depressurization rates > 80 °F/hr For lower depressurization rates the SW has to be below 75 °F. This requirement is derived from the torus temperature calculation (Reference 1). The rate of depressurization was shown in this calculation to have minimal impact on the strategies to control the drywell temperature for SBO.

Table 3- Primary Containment Initial Conditions and Parameters

Parameter	Nominal Value	Analysis Value	Basis	Comments
Drywell Temperature	110-170 °F	170 °F	Reference 5	The highest drywell temperature is used.
Drywell Pressure	16.4 psia	16.4 psia	VY Tech Spec (Reference 2)	
Wetwell Temperature	88 °F	90 °F	Maximum Tech Spec Value (Reference 2)	A 2 °F uncertainty is applied via procedure to account for instrument uncertainty (Reference 26)
Wetwell Pressure	14.7 psia	14.7 psia	Normal Torus operating pressure (vented to atmosphere via Standby Gas Treatment System)	
Drywell Humidity	20 -100 %	100% (base case) Sensitivity performed at 20% humidity	Nominal Values: VY UFSAR (Reference 27)	Use maximum drywell humidity consistent with Reference 1 for the base case. Sensitivities performed at 20% drywell humidity.
Wetwell Humidity	100%	100%	Nominal Values: VY UFSAR (Reference 27)	Minimal to no impact on the SBO drywell temperature.
Wetwell Water Volume	68000 ft^3	68000 ft^3	Minimum Tech. Spec. Value (Reference 2)	
Drywell free volume	128,370 -131,470 ft^3	131,470 ft^3 (includes vents) The values proposed are consistent with OPL-4A	Reference 5 Consistent with Reference 6, the volume of the drywell side of the torus-drywell vacuum breakers of 372.3 ft^3 will be added to the proposed value.	The maximum value in OPL-4A is used for SBLOCA, IBLOCA and Small Steam Breaks. Vents: 16703 ft^2 (VYC-2306 –Reference 32) Total Drywell Volume = 131470 – Vents Volume + Drywell side of Vacuum Breakers = 131470 -16703 + 372.3 = 115139.3 ft^3
Wetwell free volume	For the minimum water level of	Nominal Values used.	Reference 5	The value at Dp>0 of 105,932.0 ft^3 is used for a

Parameter	Nominal Value	Analysis Value	Basis	Comments
	68000 ft^3, the wetwell free volume is 107,104.8 ft^3 for Dp =0.0 and 105,932.0 for Dp>0.0 where Dp is the pressure difference between drywell and torus.	The values proposed are consistent with OPL-4A	Consistent with Reference 6, the volumes of the drywell side of the torus-drywell vacuum breakers of 99.4 ft^3 will be added the proposed value.	total volume of 105,932 + 68,000 = 173932 ft^3 Used in calculation: 173932 + 99.4 = 174031.4 ft^2
Vacuum Breakers-pressure difference between wetwell and drywell for vacuum breakers to be fully open	0.5 psi	0.5 psi	0.5 psi	Reference 2
Drywell-to Wetwell Bypass Leakage	Max allowable area =0.12 ft^2 Tech Spec Allowable =0.0033 ft2	Base case =0.12 ft^2 Sensitivity =0.0033 ft^2		Reference 5 for the max leakage, Reference 33 for Tech Spec Allowable

4.1- Assumptions that need Verification or Implementation

1) Two (2) hour restoration of outside power (coping time).
2) Ten (10) minutes to start RHR flow through the RHRHX, and the use of 2 RHRSW pumps and CS.
3) Acceptability of using 75000 gal from CST (change of level setpoint).
4) Maximum CST temperature of 135°F.
5) The depressurization rate function of Service Water temperature needs to be verified and proceduralized as follows:
   - For SW> 75°F; depressurize the vessel at 80°F/hr or higher.
   - For lower SW temperature (SW ≤ 75°F) no restrictions on cooldown rates.

4.2 Affected Documents

1) DBD – for Residual Heat Removal – change the maximum tube side fouling resistance from 0.002 hr-ft^2-°F/Btu to 0.0018 hr-ft^2-°F/Btu as well as the total fouling.
2) Change the description of the SBO event in the DBD for Safety Analysis.
3) Change all DBDs and documents that address the SBO coping time (identify and modify).
4) Change DBD Containment Pressure Suppression System to incorporate results of this calculation.
5) Review following documents for need of modification: VY UFSAR, and PUSAR.
6) Modify SBO procedure (OT-3122-Reference 36) to incorporate cooldown at one hour and provide guidance to the operators such that RPVED is precluded based on the results of this calculation.

Note: Section 4.1 & 4.2 items are being tracked via LO-VTYLO-2005-00135.

5.0 Input and Design Criteria

The GOTHIC input from Reference 1 is modified to implement the features described in this section. The modified input is called *SBO-drywell2*.

The main features added to the SBO model are the drywell heat load and drywell heat structures. A schematic of the system modeled is presented in Figure 1

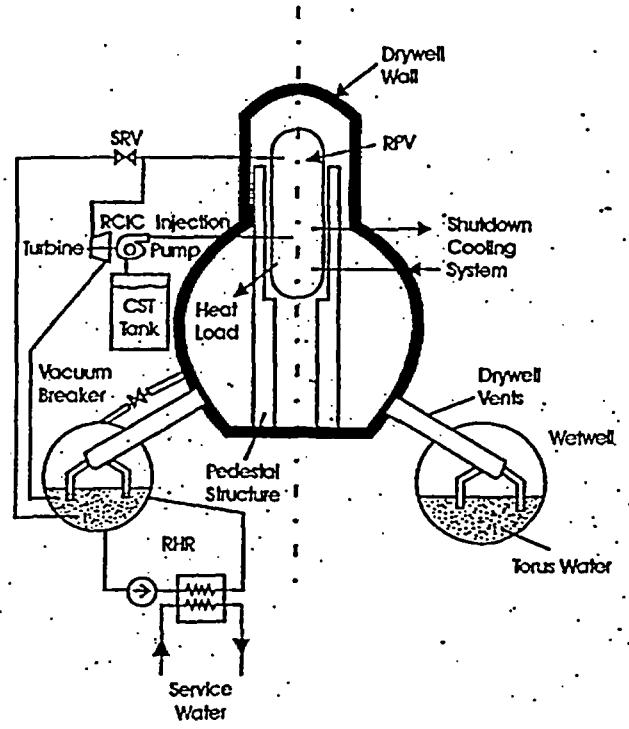

Figure 1 – VY Containment and the Associated Systems

Note: only RCIC pump is shown in this simplified model. Actually, HPCI is assumed to inject.

5.1 Drywell Heat Load Calculation

The Drywell Heat Load Summary at Current Licensed Thermal Power (CLTP) is summarized in Reference 10. The total amount of heat given to the drywell at CLTP is 1,691,300 Btu/hr. The drywell heat load was recalculated in Reference 18 for the Extended Power Uprate (EPU) as 1,700,675 Btu/hr. Since the Extended Power Uprate is performed at constant pressure, only the feedwater pipe and valves will be at higher temperatures (Reference 18), hence a higher Q for this component; (124,000 Btu/hr –Reference 10 versus 133,375 Btu/hr at EPU –Reference 18) is calculated.

The total power to the drywell for EPU is presented in Table 4.

Table 4 Drywell Heat Load (Reference 18)

Item No.	Component	Cooling Load (Btu/hr)
1	Reactor Vessel	459,000
2	Recirc. Pumps, Valves and Pipe	278,000
3	Feedwater Pipe & Valves	133,375 (EPU Modified-Reference 18)
4	Steam Pipe & Valves	212,000
5	Condensate & Instrument Lead Lines	82,000
6	Control Rod Drive Pipe	50,400
7	Clean-up Pipe & Valves	17,800
8	Shutdown Supply Pipe	8,100
9	Steam Safety/Relief Valves	206,600
10	Biological Shield (Gamma Heating)	16,400
11	Safeguards System Piping	82,000
12	Steam Leak	155,000
Total		1,700,675 Btu/hr

5.1.1 Drywell Load Modeling

The drywell heat is modeled as two heater #5H and #6H. The heater 5 represents the heat source which varies function of the liquid temperature in the vessel, while heater 6 represents the heat source which varies as a function of the vapor temperature in the vessel. See explanation of these two heaters in Section 5.1.2.

The heat loads which are exposed to the steam atmosphere (for Heater #6H) are:

Table 5 Heat Loads Exposed to Steam

Item No.	Component	Cooling Load (Btu/hr)
1	30% of Reactor Vessel Heat Load	459,000*0.3 = 137700
4	Steam Pipe & Valves	212,000
9	Steam Safety/Relief Valves	206,600
12	Steam Leak	155,000
Total		711,300

The normal level is at about 0.3 of the total vessel height. From Reference 34 the distance from the 152 inches above TAF to the top of the vessel is 21.432 ft in the GOTHIC vessel model and to the vessel bottom is 41.193 ft.

The middle range of 152 inches is calculated as (177 inches + 127 inches)/2 = 152 inches. The model assumes a normal level of 172 inches (Table 1) which is 20 inches above the 152 inches, hence from 172 inches above TAF to the top of the vessel there are 21.432 – 1.667 = 19.765 ft

The liquid height = 41.193 + 1.667 = 42.86 ft

Total GOTHIC vessel height = 62.625ft (from Reference 34 = 330.542 – 267.917 =62.625 ft)

Steam region = 19.765 /62.625 = 0.31 (used 0.3)

Heater 6 load = 711300 /3600 = 197.58 Btu/sec

Total Heat load = 1,700,675/3600 = 472.41 Btu/sec

Thus, Heater 5 load = 472.41 – 197.58 = 274.83 Btu/sec

5.1.2 Transient Heat Load Behavior

It is assumed that the heat load decreases linearly when the temperature difference between RPV and drywell becomes smaller. In order to calculate the transient heat load, the following transient heat load procedure is used

1. When the difference between the vessel temperature and the drywell temperature is less than or equal to zero, the power of the heat source is zero.

2. When the temperature difference is greater or equal with to T_{set}, the heater power will increase above the nominal value.

3. When a temperature difference exists between T_{set}, and zero, the power is linearly interpolated between the nominal value and 0.0.

T_{set} is defined in the way that the calculated power of the heat source is equal to the nominal value at the beginning of the transient. Two GOTHIC control variable CV 41 and CV 42 are defined as the temperature difference between the vessel internal water temperature and the temperature inside the drywell (CV41) and between the vessel steam temperature and the temperature inside the drywell (CV42), respectively. The model shows higher steam temperature than saturation because of the heat slab exposed to steam which represents the heat structures in the Reactor Pressure Vessel (RPV) exposed to a steam environment. Sensitivity studies which placed this heat structure in liquid eliminated the steam superheat, as expected. This is a conservatism of the model. In reality all structures will be exposed to $T_{sat} = T_{liq} = T_{vap}$

The control variables are used as the independent variable of the functions, which gives the transient heat loads to the drywell, as described above.

5.2 Drywell Thermal Conductor Model Development

The following thermal conductors are being added to the model.

There are several types of heat sinks and thermal conductors inside the drywell. The components included as heat sinks are the metal mass of 4 RRUs, vent pipes and the drywell liner. Miscellaneous steel exists in the drywell, but has not been previously quantified in detail. Minimum heat sink components are considered conservative; therefore, miscellaneous steel is not included as heat sinks.

<u>Drywell liner</u> divided in (Reference 21):

1) Lower Drywell spherical portion,
2) Upper Drywell cylindrical portion, and
3) Drywell head.

The drywell wall consists of the concrete, the inner surface steel plate and the air gap. Zero heat flux boundary condition on the outside surface of the drywell wall is used.

The data on OPL-4A (Reference 5) is used to model the steel liner. The surface area calculation for the liner was performed in Reference 9.

Table 6 – Drywell Steel Liner

Item #–from Ref. 9	Elevation	Steel Thickness (in)	Surface Area (ft^2)	GOTHIC thermal conductor No.
2, page 47 of Ref. 9	El. 237.74'-El 257.75'	1.0 page 47 of Ref 9	1856.24	5
3,page 47 of Ref. 9	El. 247.24'-El 257.75'	0.8125 page 51 of Ref 9	2041.28	6
4.1, page 47,48 of Ref. 9	El. 257.75'-El. 259.92'	0.6875 page 51 of Ref 9	1250.47	9
4.2, page 48 of Ref. 9	El. 259.92'-El 283.69'	0.6875 page 51 of Ref 9	3802.73	7
5, page 48 of Ref. 9	El. 283.69'-El. 289.61'	2.5 page 51 of Ref 9	780.68	8
6, page 48 of Ref. 9	El. 289.61'-El 308.00'	0.635 page 51 of Ref 9	1898.24	10
7, page 48,49 of Ref. 9	El. 308.00'- El 318.50'	1.25 page 51 of Ref 9	1114.72	11
8, page 49 of Ref. 9	El 318.50'- El 327.75'	1.25 page 51 of Ref 9	783.4	12
9, page 49 of Ref. 9	El. 327.75'-top of drywell	1.3125 page 51 of Ref 9	1718.3	13
Total			**15246.06 ft^2**	

The items 2 through 7 have 0.0025 inches of paint per Reference 13 and Reference 9, Appendix VI (for properties) and a 2 inches thick air gap (Reference 14) and a conservative low thickness of concrete of 24 inches is used from Reference 21.

Item 8 (side of drywell head –small cylinder) is modeled, with a 2.5 ft air gap outside the steel wall and conservatively low thickness of 1.5 ft of concrete (scaled from Reference 21). The thermal conductor has an adiabatic heat transfer boundary condition. Only heat conduction is assumed in the air and concrete layers. This is conservative.

Item 9 (top of drywell head) is modeled with a 6.7ft air gap outside the steel wall and a conservative low thickness of 24 inches of concrete (part of the concrete plugs) – (scaled from Reference 21).

RRUs (References 11 and 12)

A_{RRU} = 1272.8 ft^2, thickness =0.125 inches (used in OPL-4A-Reference 12).

Vent Pipes

Vent pipes surface area

A vent pipe = 2885.7 ft^2, thickness =0.125 inches (used in OPL-4A-Reference 12)

NOTE: The total Surface Area of the steel components adds up to the value obtained from OPL-4a (i.e., Table 6 Total = 15246.06 ft^2, RRUs = 1272.8 ft^2, Vent Pipes = 2885.7 ft^2, thus Total = 19405 ft^2)

Total Surface area of Concrete Exposed to Drywell Air Space

The surface area of the pedestal is the only concrete component quantified in OPL-4A. The drywell floor is ignored because it may be covered with liquid and not directly exposed to the drywell airspace. Only the outer surface area of the pedestal was considered in OPL- 4A as well as Reference 9 because the inner surface has limited communication with the drywell atmosphere. The biological shield wall (BSW) is a concrete structure surrounding the reactor pressure vessel and located above the reactor pedestal. Because of the proximity to the reactor pressure vessel the BSW is at a temperature greater than the drywell (DW) ambient and thus a heat source (already incorporated into the drywell heater) and a heat sink only when its temperature drops below the DW temperature. Because of the uncertainty of the BSW temperature and its limited value as a heat sink, the BSW is not considered here.

The OPL-4A value for the area is used and = 2068 ft^2 (A value of 2108 ft^2 was used in the model, addressed in Case 5).

Thickness of Concrete Exposed to Drywell Air Space

From Reference 5 = 4ft.

Properties of Materials

Table 7 - Thermo physical properties of Passive Heat Sink Materials (Reference 5)

Material	Density (lbm/ft^3)	Specific Heat (Btu/lbm-°F)	Thermal Conductivity (Btu/hr-ft °F)	References
Carbon Steel	489.0	0.11	32 °F 31.8 68 °F 31.2 212 °F 30.0 392 °F 27.8 572 °F 26.0	15
Concrete	145	0.156	0.92	16
Paint	288	0.2	0.125	9

Air Thermal Properties

From Reference 15.

T (°F)	K (Btu/hr-ft-°F)	Cp (Btu/lbm-°F)	ρ(lbm/ft^3)
100	0.0157	0.24	0.07092
150	0.0167	0.241	0.06511
200	0.0181	0.241	0.06017
250	0.0192	0.242	0.05593
300	0.0203	0.243	0.05225
400	0.0225	0.245	0.04617

Heat Transfer Boundary Conditions

On the inner surface of all the thermal conductors, the heat transfer coefficient is calculated by the GOTHIC code. The following options are used:

-Direct Heat transfer Option.
-Summation of the condensation and convection heat transfer.
-Max of Uchida and Guido-Koestel condensation heat transfer option (sensitivity with Uchida for the limiting cases).
- Radiation heat transfer option is OFF for all heat structures with exception of the drywell dome.(sensitivity with option OFF for the limiting case).
- The surface orientation is "FACE DOWN for the drywell dome", thermal conductor #13,and "VERT SURF" for heat conductors 5 through 12.
-All thermal conductors use 'VAP" option.

The outer surface boundary condition is conservatively assumed to be adiabatic. The heat transfer coefficient is set to zero.

5.3 GOTHIC Drywell SBO Model Development

The following changes to the input *SBO-NoLeak-80* (Reference 1) to produce *SBO-drywell2* are being added:

- drywell heat load
- drywell heat slabs
- leakage from drywell to wetwell
- modifications to the vacuum breaker modeling

The GOTHIC input is presented in Attachment A.

The GOTHIC model used for all cases is presented in Figure 2.

SBO - 80F-Noleak-drywell1
Mar/15/2005 14:09:56
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2

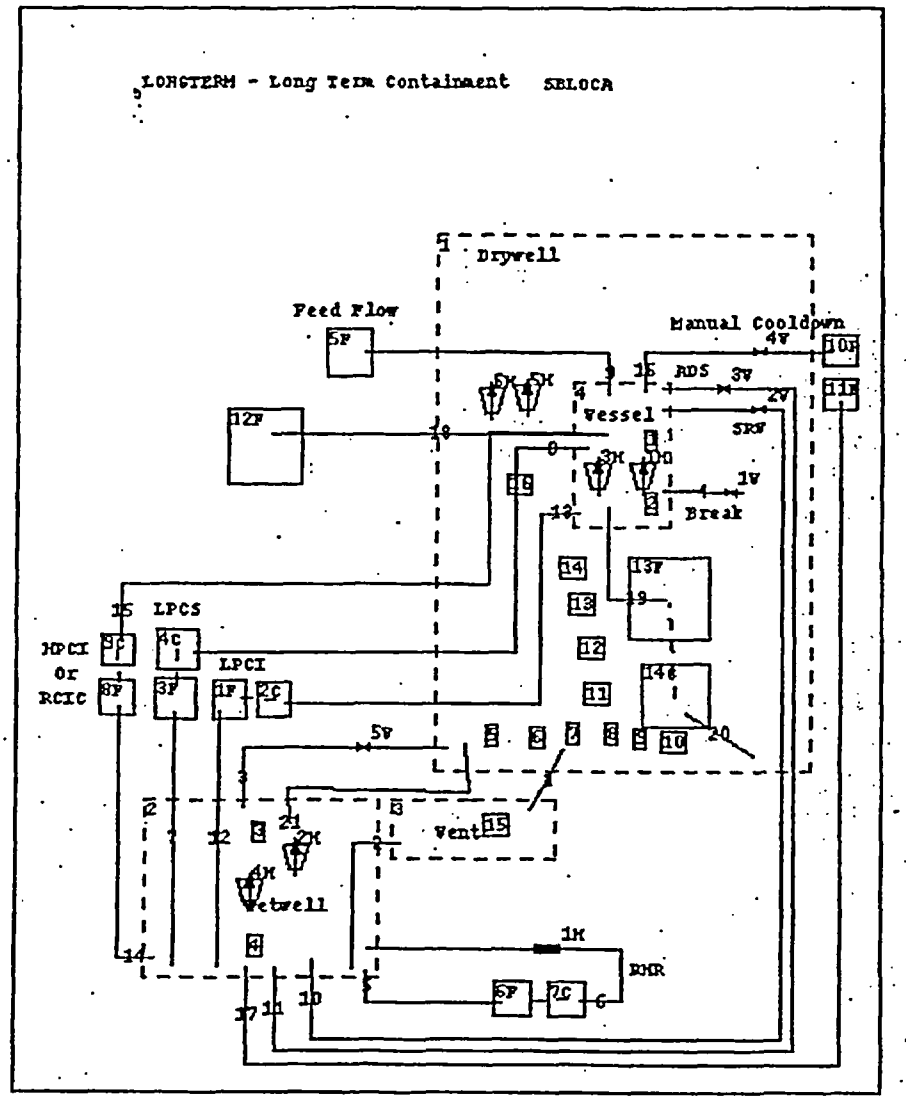

Figure 2 – GOTHIC SBO Model

Flow Paths

Flow path 21 is added to model the vacuum breakers leakage path from the drywell air space to the wetwell air space. Per Reference 5, the maximum leakage area is 0.12 ft^2. The elevations and the height of this junction were elected to be the same as the vacuum breaker junction since the leakage is around the vacuum breakers.

The $K_{reverse} = K_{forward} = 1.5$ (expansion & contraction) (Reference 29)

Thermal Conductors

Twelve new thermal conductors were added. The description of the thermal conductors was given in Section 5.2.

The temperatures of 11 of the thermal conductors were set at 160 °F, the pedestal thermal conductor is set at 152 °F. On page 73 of Reference 9 the average temperature for the middle and the top drywell node is calculated as 151.94 °F. Hence, the thermal conductors are set, conservatively at 160 °F. The pedestal is in the lower drywell and middle drywell hence 152 °F is used (average for middle and top drywell is conservative). In Case 5, the temperatures of the heat slabs which represent the drywell wall were set at 170 °F (very conservative assumption).

Functions

Two new functions are added

Function 17 (FF17) represents the power to the drywell from the structures exposed to steam.

The function multiplies $Q_{initial}$ and represents ($T_{liquid} - T_{drywell}$).

The FF17 is:

ΔT (CV41)	
-500	0
0	0
380	1
380000	1000

The independent variable is the temperature difference between ($T_{liquid} - T_{drywell}$), CV41.

Function 18 is identical to the Function 17, but the independent variable is CV42 (T_{vapor}- $T_{drywell}$)

Tref = Initial Vessel temperature – Initial Drywell temperature = 550°F -170°F =380 °F where 550 °F is the initial vessel temperature, and 170 °F is the initial drywell temperature. (550 is determined from the GOTHIC model at time zero and 170 °F is the maximum drywell temperature, OPL4A-Reference 5).

Valves

A new valve (V5) was added to represent the vacuum breaker. It opens on trip 33 (0.5 psi difference between wetwell and drywell (Reference 2) and it closes on trip 34 (0.3 psi-arbitrary, since the vacuum breaker valves reseat when the pressure difference becomes less than 0.5 psi. A quick close valve is used for this component since the valve will close as soon as the 0.5 psi difference between wetwell and drywell disappears.

The vacuum breaker valve is modeled as Valve Type 3, with an area of 17.6737 ft^2 (Reference 9). Note: the area of the valve from Reference 9 is slightly larger than the area of the flow path in which it is located. The valve area will have minimal impact on this analysis because the flow is limited by the area of the flow path. The area of the valve was changed to the area of the flow path in the final case analyzed, Case 5.

Materials

Four new materials are added. The properties for the new materials are described in Section 5.2.

Trips and Controls

Trip 18 is modified to ADS when the vessel pressure difference between RPV and drywell is lower than 100 psi instead of 50 psi in the original model. This trip is not used, however, the SRV valves will open at a ΔP of 100 psi, not 50 psi .

Trip 21 is modified to start depressurization (cooldown) at one hour (3600 seconds) in order to limit the drywell temperatures.

Trips 33 and 34 are added to open the vacuum breakers valves at 0.5 psi pressure difference between wetwell and drywell (trip 33) and close it on a ΔP of 0.3 psi.

Coolers & Heaters

Two new heaters are added, 5H and 6H to model the vessel heat to the drywell. These heaters are described in Section 5.1.

For heater 5H the heat rate of 274.83 is multiplied by the FF 17, while for heater 6H the heat rate of 1997.58 is multiplied by FF 18.

Heat Transfer Coefficients Types

Two heat transfer coefficients are added.

The following options are used:

-Direct Heat transfer Option.
-Summation of the condensation and convection heat transfer.
-Max of Uchida and Guido-Koestel condensation heat transfer option (sensitivity with Uchida for the limiting cases).
- Radiation heat transfer option is OFF for heat transfer coefficient type 6.
- Radiation heat transfer option is ON for heat transfer coefficient type 7.

The use of the radiation option has no effect on the results at these low temperatures

- The surface orientation is "VERT SURF" for heat transfer coefficient type 6.
- The surface orientation is "FACE DOWN for the drywell dome", heat transfer coefficient type 7.

The use of the surface orientation is appropriate since this is the thermal conductor physical arrangement.

-The heat transfer coefficient types 6 and 7 use 'VAP" option since this is the drywell medium.

-Convection bulk T model: T_g-T_f. The bulk temperature is the calculated vapor temperature. T_f is the maximum between the calculated wall temperature and the calculated saturation temperature.

- Condensation heat transfer Bulk T Model : T_b –T_w used. T_b is the minimum between the calculated vapor temperature and the calculated saturation temperature.

Control Variables

Two control variables are added, 41 and 42 they represent the ΔT between T_{liq} in RPV and T_V drywell and between T_{vap} in RPV and T_V drywell, respectively. See Section 5.1.2 for additional information on the operation of these Control Variables.

6.0 Calculation / Analyses

Five (5) cases are analyzed:

Case 1 is called *SBO-drywell2*. It is the base deck, developed from Reference 1 and described in Section 5.3. Case 1 assumes no RPV leakage, depressurization (cooldown) with a rate of 80 °F/hour a 100% humidity and base deck inputs as described in Section 5.0.

Case 2 is called *Case SBO-drywell2-80-sensy2-NoLeak*. Case 2 is identical to Case 1 with the change in humidity, changes in the leakage area and minor changes in the heat transfer type 6 and 7. Case 2 assumes 20% humidity and minor changes in the heat transfer type 6 and 7. These changes are described in Section 6.2.1.

Case 3 is identical to case *SBO-drywell2-80-sensy2-NoLeak* but with leak. It is called *SBO-drywell2-Leak-80-sensy*. These changes are described in Section 6.3.1.

Case 4 is called *SBO-drywell2-Leak-45-sensy* and is identical to Case 3 but with a slower depressurization (cooldown) rate. It assumes a depressurization of 45 °F/hour with leak in order to show that with an early depressurization and slower cooldown rate the results are not changed and the drywell temperature is not impacted negatively by a slower cooldown. Consistent with Reference 1, the RHRSW temperature is changed to 75 °F. Case 5 addresses changes found during documentation and as part of review. These changes are described in Section 6.4.1.

Case 5 is called *SBO-drywell2-comments*. The following changes are made in Case 5 to address changes found during documentation and review:

- change the temperatures of the steel structures from 160 °F to 170 °F (very conservative assumption),
- change the K reverse for the Junction 3 from to 3.93 from 3.964,
- set the V3 Valve with the same area as the junction, and
- change the area for the pedestal from 2108 ft2 to 2068 ft2, consistent with OPL-4A.

Case 5 changes are described in Section 6.5.1.

6.1.1 *SBO-drywell2* Model Development

SBO-drywell2 represents the base model for this calculation. The modification to the input are presented in Section 5.0 and the GOTHIC input deck is presented in Attachment A.

6.1.2 Case *SBO drywell2* Results

Figure 3 through Figure 11 present the main parameters for the base case SBO-drywell2. Figure 3 presents the drywell temperature. The drywell temperature increases to about 285 °F after one hour. The heatup is arrested due to depressurization. At about 4 hours into the transient the temperature in the drywell starts increasing due to lower heat removal into the passive heat sinks (walls). The maximum drywell temperature is 290 °F. The air gap acts as an insulation and the steel liner is almost at 245 °F. However, after 2 hours and 10 minutes the low pressure pumps are available so the operators can spray the drywell with the RHR pump, if needed. The results indicate that the temperatures in the drywell stay below the EQ limit and the drywell liner is well below the 281 °F for the SBO coping duration.

Figure 4 presents the containment pressure. Due to the higher leak area the drywell and the wetwell are at the same pressure. At about 2 hours the pressure in the drywell is too low to spray the drywell, (unsafe area of DWSIL(EOP-3 –Primary Containment Control –Reference 30)) however the pressure increases to about 6 psig at about 12000 seconds at which point the operators would able to spray the drywell with the RHR pump, if needed.

Figure 5 presents the RPV pressure. At one hour into the event it is assumed that the operators start depressurization (cooldown). The pressure drops to the HPCI shutoff pressure of 165 psia at about 12000 seconds. At that point only about 450000 lb were injected from CST (Figure 12). At this point the RPV is depressurized and the CS is available to inject.

Figure 7 presents the RPV level. The core stays covered. There is a dip in the normal level at about 12000 seconds when HPCI stops injecting and CS pump has not yet injected. This is due to the fact that the CS pump was set to inject at 14000 seconds; however CS is ready to inject at 7800 seconds.

Figure 8, Figure 9, and Figure 10 presents the drywell liner temperature. The drywell liner stays below 260 °F for the 7 hours analyzed. After 2 hours and 10 minutes the low pressure pumps are available for suppression pool cooling, drywell spray and maintaining vessel inventory.

Figure 11 presents the suppression pool temperature. Since the vessel is depressurized early, the suppression pool temperature is below the maximum of 182.2 °F calculated in Reference 1, hence no containment overpressure is required.

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:28:01
GOTHIC Version 7.0p2(QA) - April 2002
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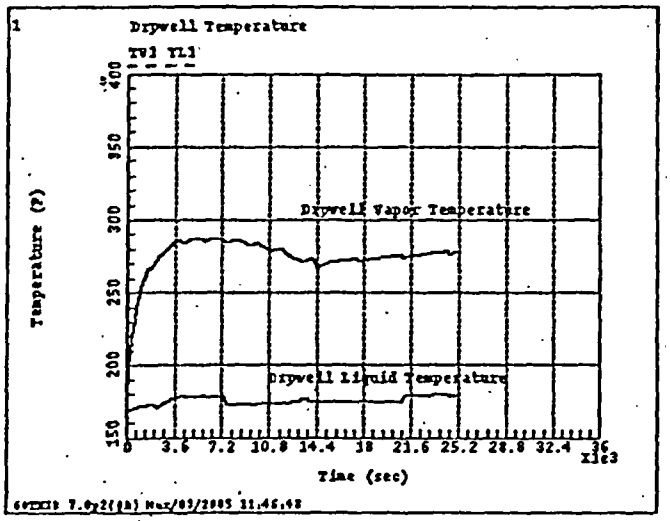

Figure 3 Drywell Temperature Case *SBO-drywell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:33:59
GOTHIC Version 7.0p2(QA) - April 2002
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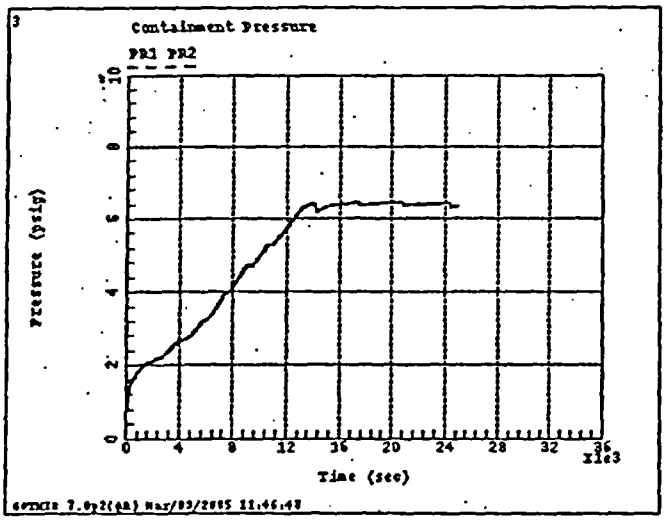

Figure 4 Containment Pressure – case *SBO-drywell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:29:48
GOTHIC Version 7.0p2(QA) - April 2002
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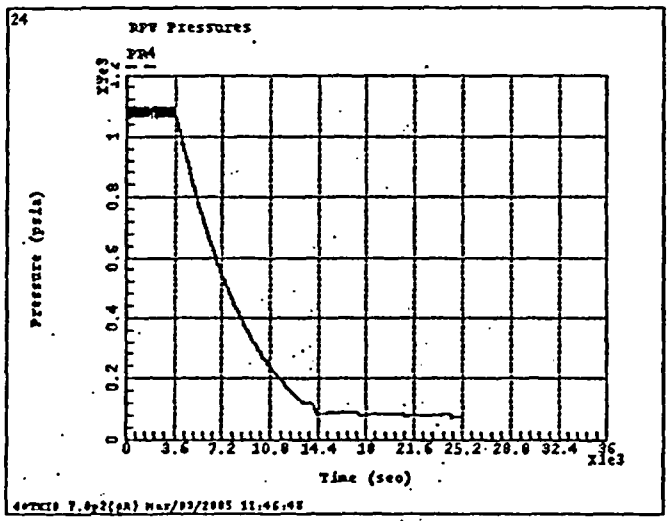

Figure 5 – RPV Pressure - Case *SBO –drywell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:30:33
GOTHIC Version 7.0p2(QA) - April 2002
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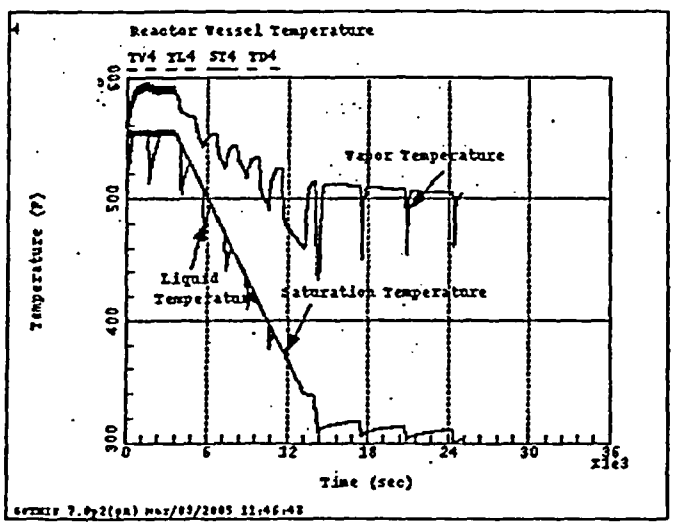

Figure 6- RPV Temperature – Case *SBO-drywell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:01:07
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2

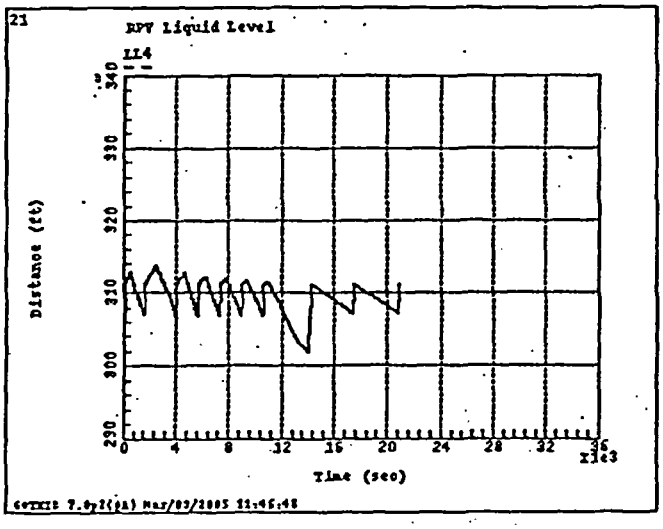

Figure 7 – RPV Level - Case *SBO-drywell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:29:11
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2

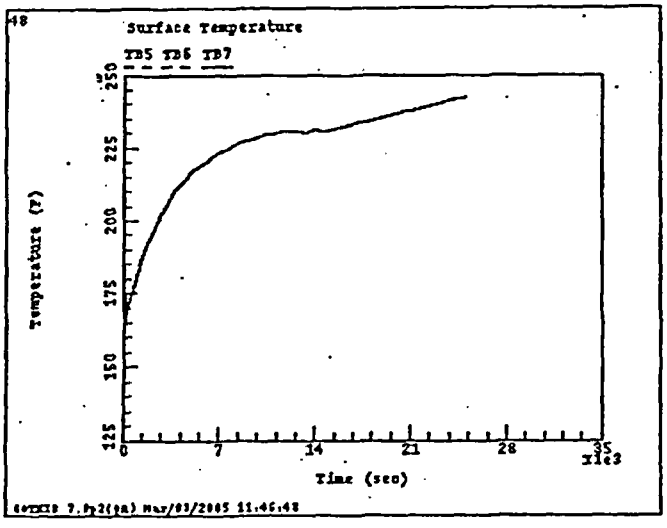

Figure 8 - Surface Temperature for Heat Slabs 5,6 & 7 - Case *SBO-drwell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:28:24
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2

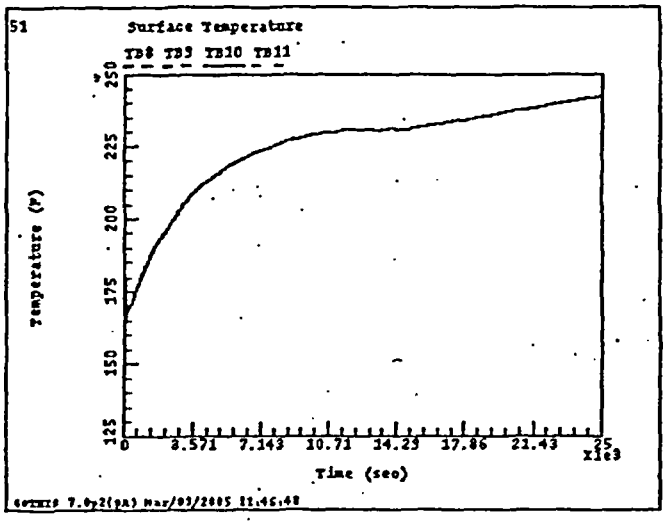

Figure 9 Surface Temperature for Heat Slabs 8,9,10,11 - Case *SBO-drwell2*

SBO - 80F-Noleak-drywell1
Mar/14/2005 14:45:07
GOTHIC Version 7.0p2(QA) - April 2002
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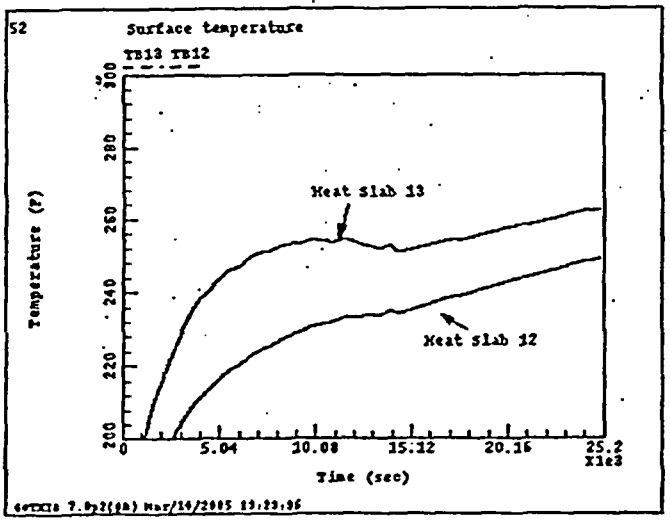

Figure 10 - Surface Temperature for Heat Slabs 12 and 13 - Case *SBO-drwell2*

SBO - 80F-Noleak-drywell1
Mar/03/2005 13:31:38
GOTHIC Version 7.0p2(QA) - April 2002
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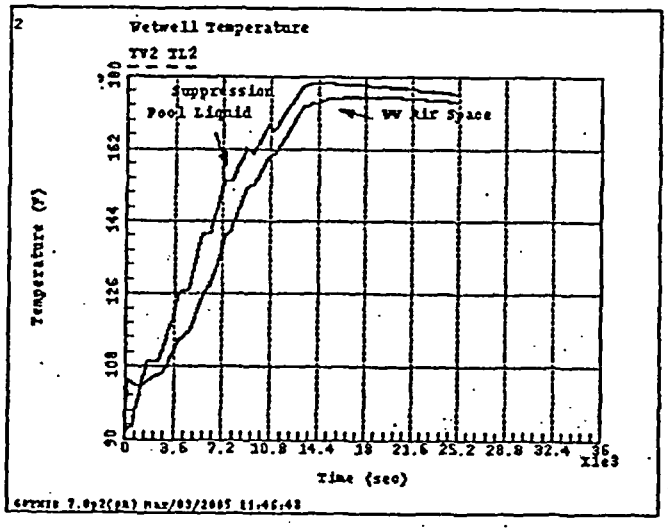

Figure 11 Suppression Pool Temperature case *SBO-drywell2*

SBO - 80F-Noleak-drywell1
Mar/14/2005 14:02:38
GOTHIC Version 7.0p2(QA) - April 2002
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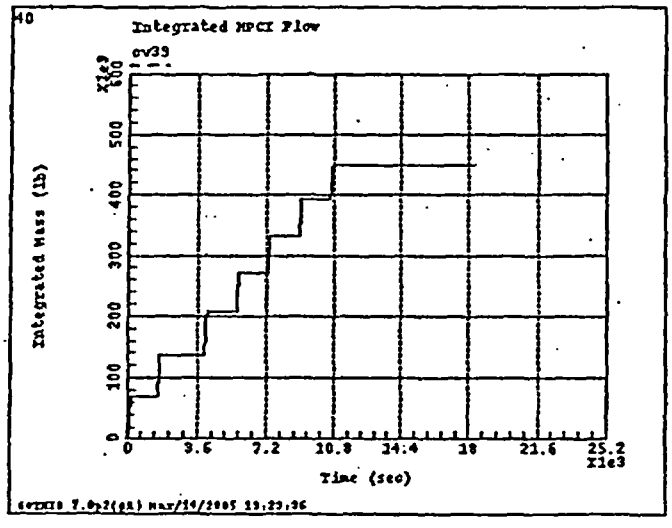

Figure 12- Integrated HPCI Flow – *SBO-drywell2*

6.2 Case *SBO-drywell2-80-sensy2-NoLeak*

6.2.1 Model modification

Table 8 presents the modifications to the base deck *SBO-drywell2* to produce *SBO-drywell2-80-sensy2-NoLeak.*

The following modifications were made:

The Heat Transfer Coefficient Types 6 and 7 were modified to use Uchida correlation for condensation heat transfer instead of MAX (maximum of Uchida or Guido-Koestel). For this case since there is no RPV leakage, the choice of condensation correlation should have a minimal impact on results.

For the Heat Transfer Coefficient Type 7 the radiation option was turned off. Again, at these small temperatures, the radiation has a minimal impact on results.

The humidity in Volume 1 (Drywell) was modified from 100% humidity to 20% humidity to encompass all the humidity range in the drywell (Reference 5).

The reverse loss coefficient for the vacuum breakers was changed from 1e18 to 3.964 (equal to the forward loss coefficient).

A coefficient of 3.93 should have been used. This is corrected in Case 5.

The vacuum breaker reverse coefficient is the weighted sum of the flow paths 7, 8 & 9 of Reference 9. (Same as the forward loss coefficient)

K reverse = $1.168\ (15.63/16.23)^2 + 2.528\ (15.63/16.23)^2 + 0.5\ (1.53/1.53)^2 = 3.93$
(A K of 3.96 was used, less than a 1% difference)

The area of junction 21 is changed from 0.12 ft^2, maximum leakage to 0.0033 ft^2 (allowable Tech Spec leakage) –Reference 33.

Table 8; Input Modifications –*SBO-drywell2-80-sensy2-NoLeak* vs. *SBO-drywell2*

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-80-sen
Mar/10/2005 10:42:03
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-80-sensy2-NoLeak

Graphs (continued)

Graph #	Title	Mon	Curve Number 1	2	3	4	5
42	Heat to the sup		CQ4H	CQ2H			
43	Leak Flow		FL4	FL19	FL20		
44	Integrated Leak		cv40				
45	Title		cv39				
46			FV18	FL18	FD18		
47			cv38				
48	Surface Tempera		TB5	TB6	TB7		
49	Surface Tempera		TA8	TA9	TA10		
50	Surface Tempera		TA11	TA12	TA13		
51	Surface Tempera		TB8	TB9	TB10	TB11	
52	Surface tempera		TB13	TB12			
53			TP8t600	TP9t600	TP10t60	TP11t60	
54			TP13t50	TP12t50			
55	Drywell Tempera		TV1	TL1			

Heat Transfer Coefficient Types - Table 1

Type #	Heat Transfer Option	Nominal Value	FF	Cnd Cnv Opt	Cnd Opt	Sp Cnv HTC	Nat Cnv Opt	For Cnv Opt	Rad Opt
1	Correlat		0				VERT SURF	PIPE FLOW	OFF
2	Correlat		0				VERT SURF	PIPE FLOW	OFF
3	Correlat						FACE DOWN	PIPE FLOW	OFF
4	Correlat						FACE UP	PIPE FLOW	OFF
5	Sp Heat	0.							
6	Direct			ADD	UCHI		VERT SURF	PIPE FLOW	OFF
7	Direct			ADD	UCHI		FACE DOWN	PIPE FLOW	OFF

Run Control Parameters (Seconds)

Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int	Phs Chng Time Scale
1	1e-06	1.	1.	100.	5.	0.1	1e+06	0.	DEFAULT
2	1e-06	1.	1.	1200.	50.	1.	1e+06	0.	DEFAULT
3	1e-06	1.	1.	1300.	500.	10.	1e+06	0.	DEFAULT
4	1e-06	1.	1.	25000.	600.	10.	1e+06	0.	DEFAULT

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-BO-sen
Mar/10/2005 10:42:03
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-BO-sensy2-NoLeak

Volume Initial Conditions

Vol #	Pressure (psia)	Vapor Temp. (F)	Liquid Temp. F	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf.A. (ft2)
def	14.7	80.	80.	60.	0.	0.	0.
1	16.4	170.	170.	20.	0.	0.	0.
2	14.7	90.	90.	100.	0.39497	0.	0.
3	16.4	90.	90.	100.	0.00595	0.	0.
4	1045.2	549.97	533.12	100.	0.60794	0.	0.

Graphs

Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	Drywell Tempera		TV1	TL1			
2	Wetwell Tempera		TV2	TL2			
3	Containment Pre		PR1	PR2			
4	Reactor Vessel		TV4	TL4	ST4	TD4	
5	RHR Heat Exchan		xq1H				
6	Reactor Vessel		AL4				
7	Torus Water Vol		AL2				
8	Heat Exchanger		t11H	t21H			
9	Wetwell, Vessel		TL2	TL4	TL1		
10	Conductor Tempe		TA1	TA2	TA3	TA4	
11	Integral Vessel		QL4	QV4			
12	Vapor & Conduct		TV4	TA1			
13	Liquid & Conduc		TL4	TA2			
14	Vapor & Conduct		TV2	TA3			
15	Liquid & Conduc		TL2	TA4			
16	Vapor Heat Tran		HA1				
17	Liquid Heat Tra		hA2				
18	Vapor Heat Tran		HA3				
19	Liquid Heat Tra		hA4				
20	Feedwater & Bre		FL9	FL4			
21	RPV Liquid Leve		LL4				
22	SRV and ADS Flo		FV10	FV11			
23	Feedwater Entha		cv29				
24	RPV Pressures		PR4				
25	Feedwater Contr		cv27	cv28			
26	Integrated Feed		cv4				
27	RHR Flow		FL5				
28	Vessel Droplet		AD4				
29	ECCS Injection		FL7	FL12	FL14		
30	RPV Pressure		PR4	VC2V	FL7		
31	ADS Valve Posit		VC3V				
32	SRV Position		VC2V				
33	Cooldown Flow		FV16				
34	Vessel Drop Dia		DI4				
35	Reactor Vessel		PR4				
36	Suppression poo		TL2				
37	Reactor Vessel		PR4				
38	Suppression Poo		LL2				
39	HPCI Flow Rate		FL18				
40	Integrated HPCI		cv39				
41	Core Spray Flow		FL8				

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-80-sen
Mar/10/2005 10:42:03
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-80-sensy2-NoLeak

Flow Paths - Table 2

Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Dep Bend (deg)	Mom Trn Opt	Strat Flow Opt
1	283.529	6.75	89.13	0.		0.	-	NONE
2	286.114	1.948	4.16	0.		-1.	-	NONE
3	15.63	1.5625	44.925	28.72		0.	-	NONE
4	0.001005	0.03568	0.1			0.	-	NONE
5	3.14	2.	0.01			0.	-	NONE
6	3.14	2.	0.01			0.	-	NONE
7	3.14	2.	0.01			0.	-	NONE
8	3.14	2.	0.01			0.	-	NONE
9	3.14	2.	0.01			0.	-	NONE
10	0.09945	0.35584	0.01			0.	-	NONE
11	0.3978	0.35584	0.01			0.	-	NONE
12	3.14	2.	0.01			0.	-	NONE
13	3.14	2.	0.01			0.	-	NONE
14	3.14	2.	0.01			0.	-	NONE
15	3.14	2.	0.01			0.	-	NONE
16	3.14	2.	0.01			0.	-	NONE
17	3.14	2.	0.01			0.	-	NONE
18	3.14	2.	0.01			0.	-	NONE
19	0.5454	0.8333	0.1	0.1			-	NONE
20	0.5454	0.5454	0.1	0.1			-	NONE
21	0.0033	1.	1.	0.			-	NONE

Flow Paths - Table 3

Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.	Critical Flow Model	Exit Loss Coeff.	Drop Breakup Model
1	4.2243	4.2243	ON	TABLES	1.	OFF
2	1.	0.78	ON	TABLES	1.	OFF
3	3.964	3.964	ON	OFF	0.	OFF
4	0.		OFF	TABLES	1.	OFF
5			OFF	OFF	0.	OFF
6			OFF	OFF	0.	OFF
7			OFF	OFF	0.	OFF
8			OFF	OFF	0.	OFF
9			OFF	OFF	0.	OFF
10			OFF	TABLES	0.	OFF
11			OFF	TABLES	0.	OFF
12			OFF	OFF	0.	OFF
13			OFF	OFF	0.	OFF
14			OFF	OFF	0.	OFF
15			OFF	OFF	0.	OFF
16		1e+18	OFF	OFF	0.	OFF
17			OFF	OFF	0.	OFF
18			OFF	OFF	0.	OFF
19			OFF	OFF	0.	OFF
20			OFF	OFF	0.	OFF
21	1.5	1.5	OFF	OFF	0.	OFF

6.2.2 Case *SBO drywell2-80-sensy2-NoLeak* Results

Figure 13 through Figure 20 present the main parameters for the case *SBO-drywell2-80-sensy2-NoLeak*. Figure 13 presents the drywell temperature. The maximum drywell temperature is about 289.4 °F and is reached after one hour and 30 minutes.. The heatup is arrested due to depressurization. At about 4 hours into the transient the temperature in the drywell starts increasing due to lower heat removal into the passive heat sinks (walls) . The air gap acts as an insulation and the steel liner is almost at 255 °F. However, after 2 hours and 10 minutes the low pressure pumps are available so the operators can spray the drywell with the RHR pump, if needed. The results indicate that the temperatures in the drywell stay below the EQ limit and the drywell liner is well below the 281 °F for the SBO coping duration.

Figure 14 presents the containment pressure. Due to a lower leak area the drywell and the wetwell are at not at the same pressure, the vacuum breaker opens to relieve the pressure difference at about 14000 seconds. At about 2 hours the pressure in the drywell is too low to spray the drywell, (unsafe area of DWSIL (EOP-3 –Primary Containment Control –Reference 30)) however the pressure increase to about 6 psig at about 10800 seconds at which point the operators would be able to spray the drywell with the RHR pump, if needed.

Figure 15 presents the RPV pressure. At one hour into the event it is assumed that the operators start depressurization. The pressure drops to the HPCI shutoff pressure of 165 psia at about 12000 seconds. At this point only about 450000 lb were injected from CST (Figure 17). The RPV is depressurized, and the CS pump is available to inject.

Figure 16 pump presents the RPV level. The core stays covered. There is a dip in the normal level at about 12000 seconds when HPCI stops injecting and CS does not inject yet. This is due to the fact that the CS pump was set to inject at 14000 seconds; however CS is ready to inject at 7800 seconds, provided the pressure permissive is reached.

Figure 18, Figure 19, and Figure 20 presents the drywell liner temperature. The drywell liner stays below 260 °F for the 7 hours analyzed. After 2 hours and 10 minutes the low pressure pumps are available for suppression pool cooling, drywell spray and maintaining vessel inventory.

The suppression pool temperature for this case is very similar to the case *SBO-drywell2* since the input changes results in minor changes to the drywell temperature and pressure but not in the suppression pool temperature since the heat transferred to the drywell is not subtracted from the vessel energy.

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 10:36:15
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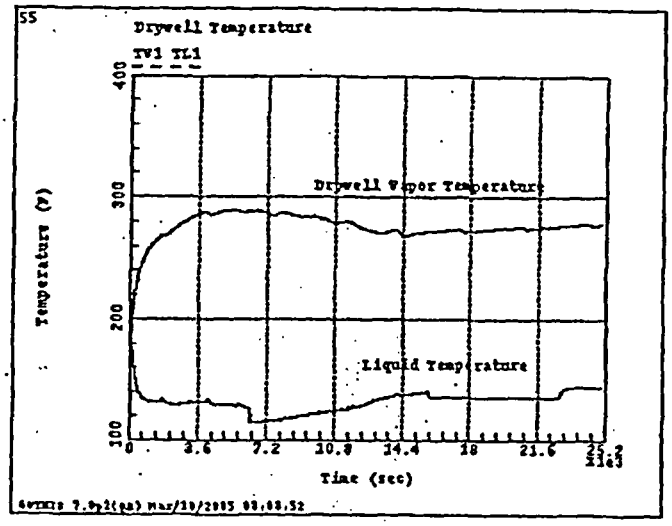

Figure 13 – Drywell Temperature –Case *SBO-drwell2-80-sensy2-NoLeak*

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 10:56:11
GOTHIC Version 7.0p2(QA) - April 2002
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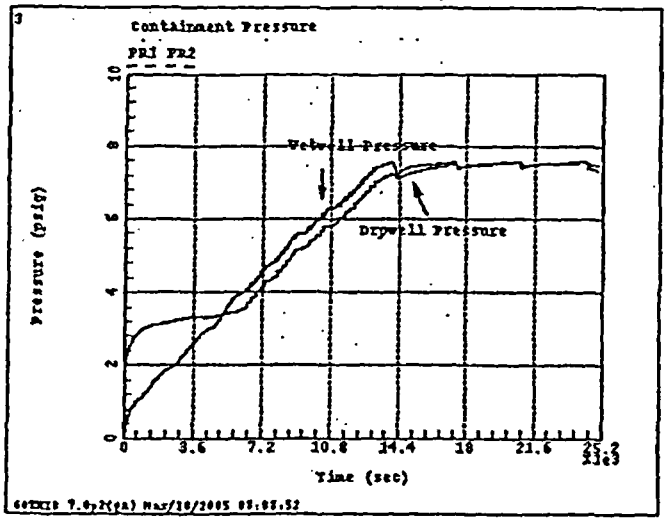

Figure 14 –Containment Pressure - Case *SBO-drwell2-80-sensy2-NoLeak*

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 11:11:35
GOTHIC Version 7.0p2(QA) - April 2002
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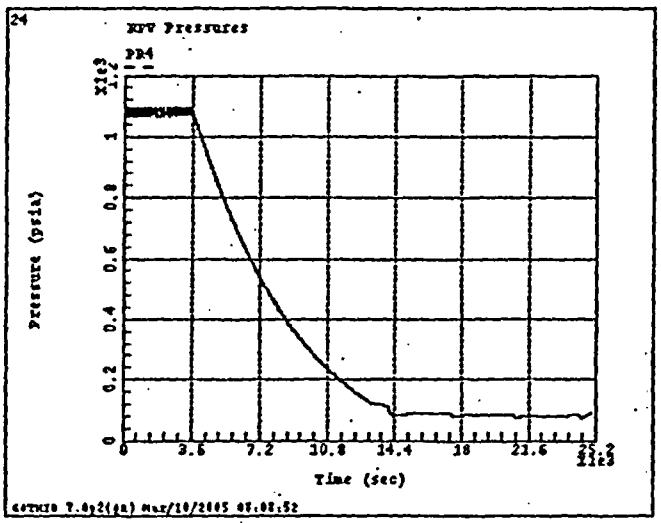

Figure 15 – RPV Pressure - Case *SBO-drwell2-80-sensy2-NoLeak*

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 11:15:46
GOTHIC Version 7.0p2(QA) - April 2002
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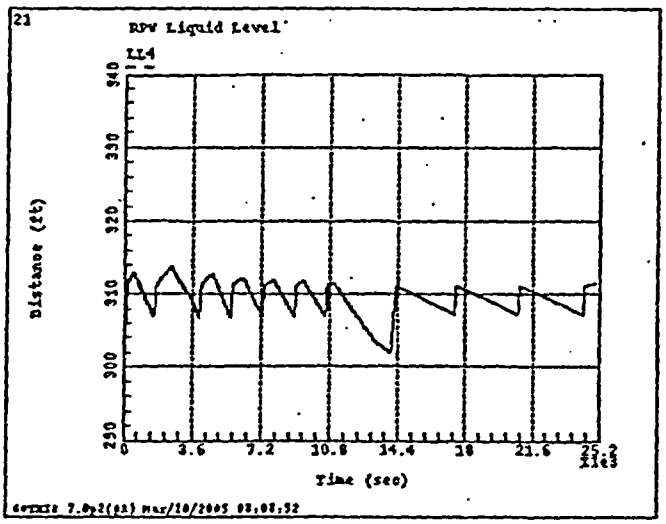

Figure 16 – RPV Level - Case *SBO-drwell2-80-sensy2-NoLeak*

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 11:10:47
GOTHIC Version 7.0p2(QA) - April 2002
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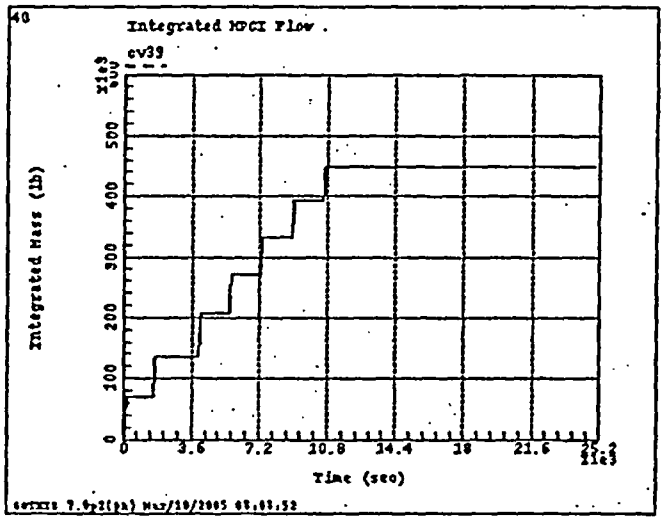

Figure 17 Integrated HPCI Flow - Case *SBO-drwell2-80-sensy2-NoLeak*

SBO - 80F-Noleak-drywell2-sensitivities-set2
Mar/10/2005 10:33:12
GOTHIC Version 7.0p2(QA) - April 2002
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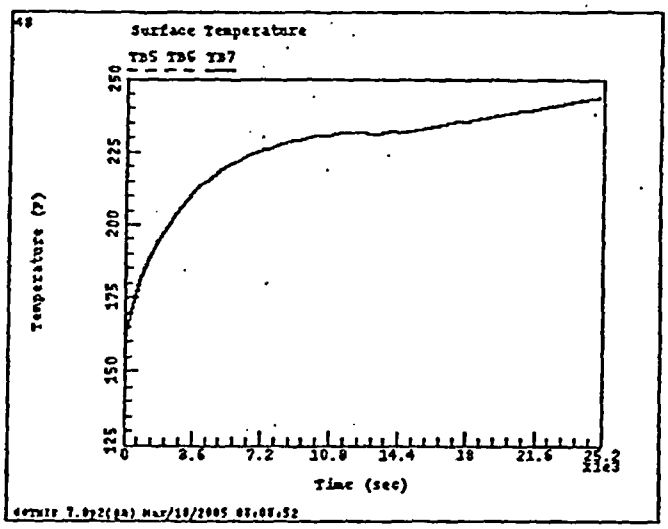

Figure 18- Surface Temperature for Heat Slabs 5,6 & 7 - *Case SBO-drwell2-80-sensy2-NoLeak*

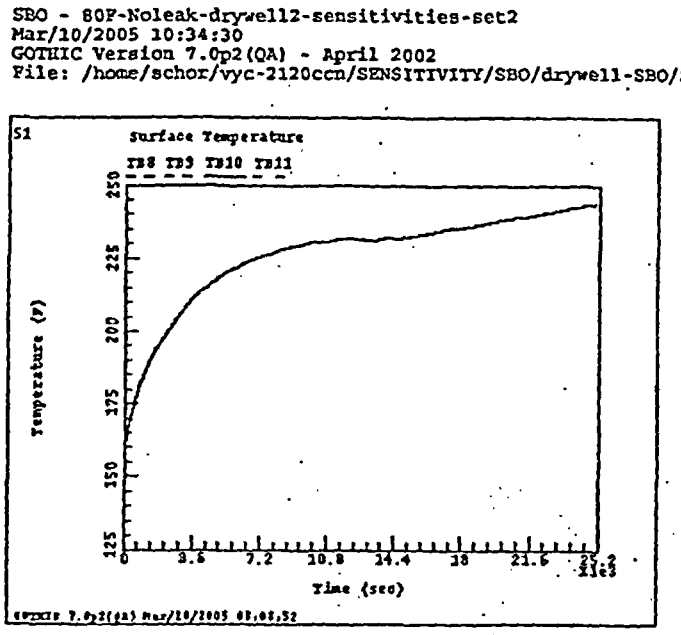

Figure 19 – Surface Temperature for Heat Slabs 8, 9, 10 & 11 - *Case SBO-drwell2-80-sensy2-NoLeak*

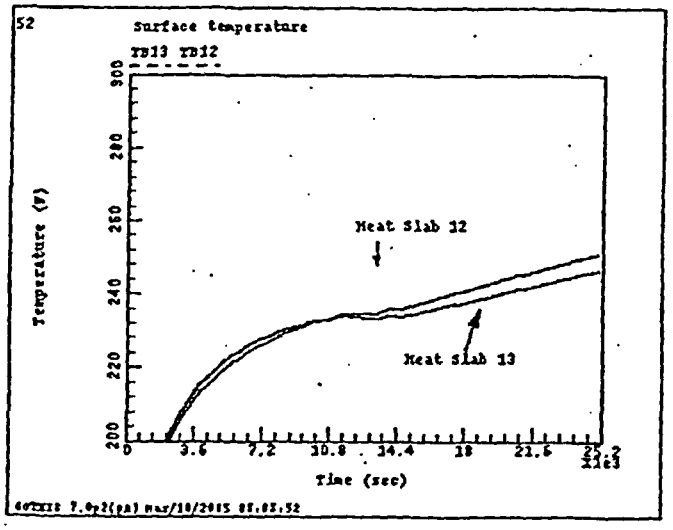

Figure 20 Surface Temperature for Heat Slabs 12 & 13 - *Case SBO-drwell2-80-sensy2-NoLeak*

6.3 Case *SBO-drywell2-Leak-80-sensy*

6.3.1 Model modification

Table 9 presents the modifications to the deck *SBO-drywell2-80-sensy2-NoLeak* to produce *SBO-drywell2-Leak-80-sensy*

The following modifications were made:

On BC 13, the ON trip is set to zero (0). This allows for a constant leak of 8.4585 lb/sec to leave the vessel.

The end time was changes to 14400 seconds (4 hours) since the purpose of this calculation was to show that the drywell temperature stays below the EQ drywell temperature and the drywell shell stays below 281 °F for the duration of 2 hour and 10 minutes.

Table 9 *SBO-drywell2-Leak-80-sensy* vs *SBO-drywell2-80-sensy2-NoLeak*

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-8
Mar/14/2005 15:38:40
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-80-sensy

Fluid Boundary Conditions - Table 1

BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1F	RHR/LPCI Suctio	20.		160		v-0.002	8	1	13
2C	RHR/LPCI Discha	20.		160					
3F	LPCS Suction	20.		160		v-0.002	7	30	31
4C	LPCS Discharge	20.		160					
5F	Feedwater	1000.		el	5	1000	9	1	5
6F	RHR/Torus Sucti	20.		160		v-0.002	6	21	1
7C	RHR/Torus Disch	20.		160				0	
8F	HPCI/RCIC Sucti	20.		160		-326.1	9	1	0
9C	HPCI/RCIC Disch	20.		160					
10P	Cooldown Inlet	1.	10	1	11			21	0
11F	Cooldown Outlet	1.	10	1	11	1	12		
12F	CST Tank	14.7		135		587	13	28	27
13F	Vessel Leak	1050.		554.		-8.4585	13	0	
14C	Vessel leak to	1050.	0	554					

Run Control Parameters (Seconds)

Time Int	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int	Phs Chng Time Scale
1	1e-06	1.	1.	100.	5.	0.1	1e+06	0.	DEFAULT
2	1e-06	1.	1.	1200.	50.	1.	1e+06	0.	DEFAULT
3	1e-06	1.	1.	1300.	500.	10.	1e+06	0.	DEFAULT
4	1e-06	1.	1.	14400.	600.	10.	1e+06	0.	DEFAULT

Graphs

Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	Drywell Tempera		TV1	TL1			
2	Wetwell Tempera		TV2	TL2			
3	Containment Pre		PR1	PR2			
4	Reactor Vessel		TV4	TL4	ST4	TD4	
5	RHR Heat Exchan		xq1H				
6	Reactor Vessel		AL4				
7	Torus Water Vol		AL2				
8	Heat Exchanger		t11H	t21H			
9	Wetwell, Vessel		TL2	TL4	TL1		
10	Conductor Tempe		TA1	TA2	TA3	TA4	
11	Integral Vessel		QL4	QV4			
12	Vapor & Conduct		TV4	TA1			
13	Liquid & Conduc		TL4	TA2			
14	Vapor & Conduct		TV2	TA3			
15	Liquid & Conduc		TL2	TA4			
16	Vapor Heat Tran		HA1				
17	Liquid Heat Tra		hA2				
18	Vapor Heat Tran		HA3				
19	Liquid Heat Tra		hA4				
20	Feedwater & Bre		FL9	FL4			

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-8
Mar/14/2005 15:38:40
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-80-sensy

Graphs (continued)

Graph #	Title	Mon	Curve Number 1	2	3	4	5
21	RPV Liquid Leve		LL4				
22	SRV and ADS Flo		FV10	FV11			
23	Feedwater Entha		cv29				
24	RPV Pressures		PR4				
25	Feedwater Contr		cv27	cv28			
26	Integrated Feed		cv4				
27	RHR Flow		FL5				
28	Vessel Droplet		AD4				
29	ECCS Injection		FL7	FL12	FL14		
30	RPV Pressure		PR4	VC2V	FL7		
31	ADS Valve Posit		VC3V				
32	SRV Position		VC2V				
33	Cooldown FLow		FV16				
34	Vessel Drop Dia		DI4				
35	Reactor Vessel		PR4				
36	Suppression poo		TL2				
37	Reactor Vessel		PR4				
38	Suppression Poo		LL2				
39	HPCI Flow Rate		FL18				
40	Integrated HPCI		cv39				
41	Core Spray Flow		FL8				
42	Heat to the sup		CQ4H	CQ2H			
43	Leak Flow		FL4	FL19	FL20		
44	Integrated Leak		cv40				
45	Title		cv39				
46			FV18	FL18	FD18		
47			cv38				
48	Surface Tempera		TB5	TB6	TB7		
49	Surface Tempera		TA8	TA9	TA10		
50	Surface Tempera		TA11	TA12	TA13		
51	Surface Tempera		TB8	TB9	TB10	TB11	
52	Surface tempera		TB13	TB12			
53			TP8t600	TP9t600	TP10t60	TP11t60	
54			TP13t50	TP12t50			
xxxxx	xxxxxxx	xxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx

6.3.2 Results Case *SBO-drywell2-Leak-80-sensy*

Figure 21 through Figure 29 present the main parameters for the case *SBO-drywell2-Leak-80-sensy*. Figure 21 presents the drywell temperature. The maximum drywell temperature is about 290 °F and is reached at about 12240 seconds (3.4 hours). The drywell heatup rate is arrested due to depressurization, however the leak brings enough energy from the vessel to continue the heatup. At 7800 seconds the drywell temperature is 285.8 °F, well below the EQ limit of 325 °F.

Figure 22 presents the containment pressure. The available water to spray the drywell (Reference 30) is the Diesel fire pump per Appendix M of OE 3107 (Reference 35) and it takes about one hour for aligning the fire pump for drywell spray. The drywell pressure is high enough to allow for drywell spray, if needed. The drywell temperature does not exceed the EQ drywell temperature limit and the drywell shell temperature stays below the limit of 281 °F hence the analysis shows that drywell spray is not needed for the coping duration. At about 3 hours and 30 minutes the wetwell pressure reaches equilibrium with drywell and slightly exceeds the drywell pressure. The vacuum breakers do not open during the time of interest.

At about 4 hours the wetwell pressure is about 26 psig, close to the PSP limit of 27 psig. However at this time the RHR pump is available for containment spray.

Figure 23 presents the RPV pressure. At one hour into the event it is assumed that the operators start depressurization. The pressure drops to the HPCI shutoff pressure of 165 psia at about 12000 seconds. At that point only about 540000 lb were injected from CST (Figure 25). At this time the RPV is depressurized, and the CS pump is available to inject.

Figure 24 pump presents the RPV level. The core stays covered. There is a dip in the normal level at about 12000 seconds when HPCI stops injecting and CS does not inject yet. This is due to the fact that the CS pump was set to inject at 14000 seconds; however, CS is ready to inject at 7800 seconds, provided the pressure permissive is reached.

Figure 27, Figure 28, and Figure 29 presents the drywell liner temperature. The drywell liner stays below 280 °F for the 4 hours analyzed. After 2 hours and 10 minutes the low pressure pumps are available for suppression pool cooling, drywell spray and maintaining vessel inventory.

The suppression pool temperature is not a parameter of importance for this calculation. In Reference 1 it was shown that the suppression pool temperature is lower for the cases RPV with leakage and lower for earlier depressurization hence the maximum suppression pool temperature will be lower that 182.2 °F, calculated in Reference 1.

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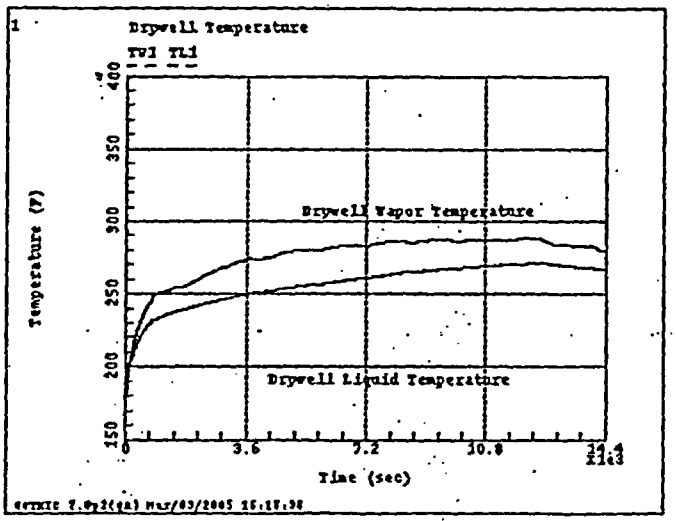

Figure 21 –Drywell Temperatures - *SBO-drywell2-Leak-80-sensy*

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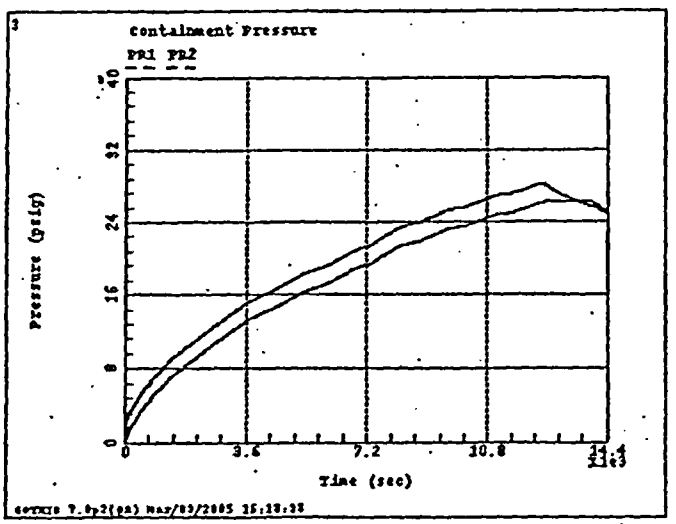

Figure 22 – Containment Pressure - *SBO-drywell2-Leak-80-sensy*

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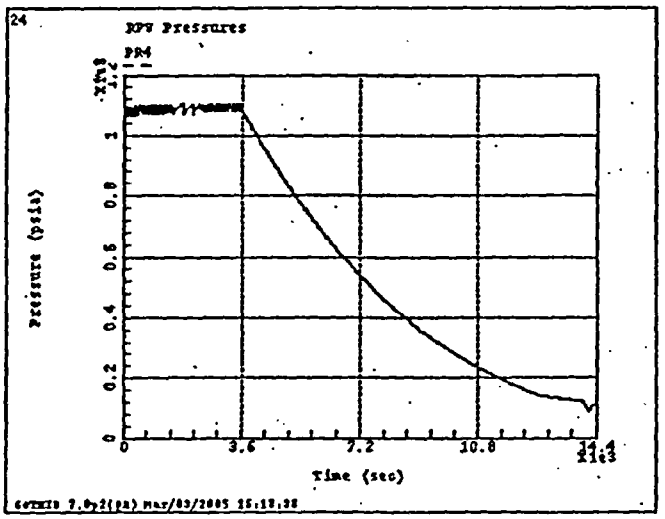

Figure 23 – RPV Pressure - *SBO-drywell2-Leak-80-sensy*

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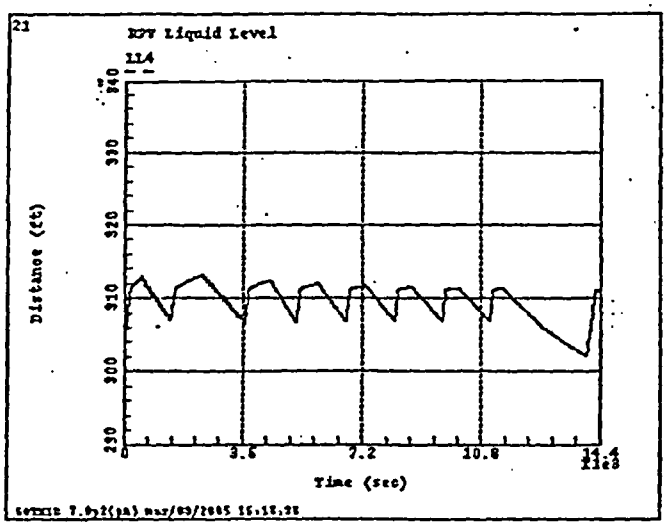

Figure 24 RPV Level - *SBO-drywell2-Leak-80-sensy*

SBO - 80F-Noleak-drywell2-Leak-80-sensitivities
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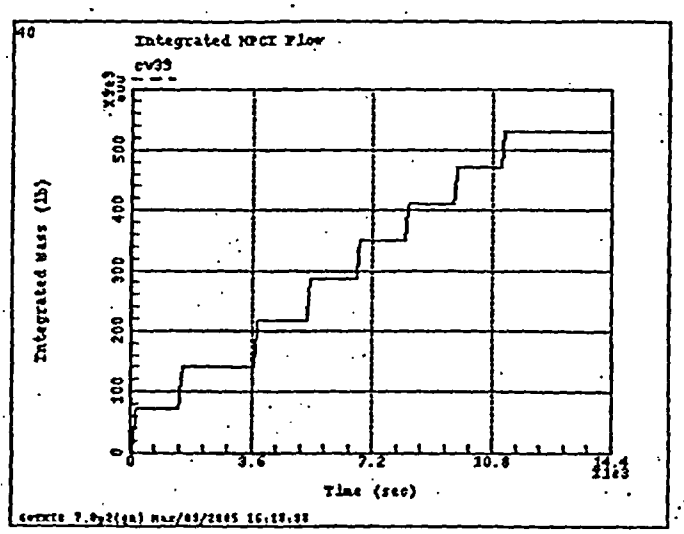

e 25 – Integrated HPCI Flow - *SBO-drywell2-Leak-80-sensy*

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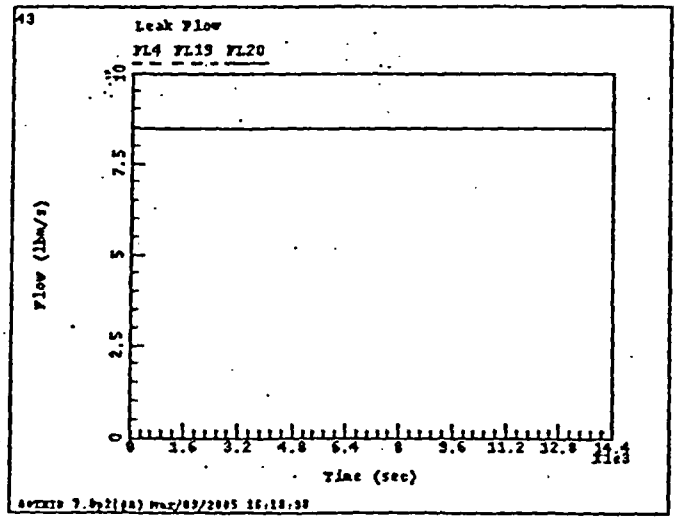

Figure 26 –Leak Flow - *SBO-drywell2-Leak-80-sensy*

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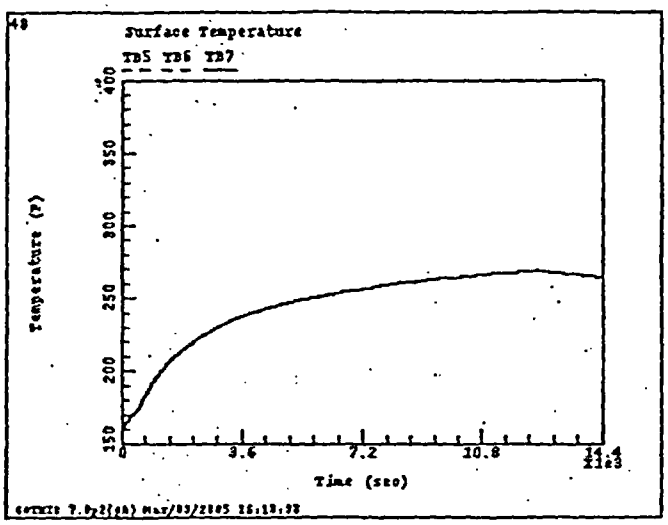

Figure 27 - Surface Temperature, Heat Structures 5,6,7 - *SBO-drywell2-Leak-80-sensy*

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Mar/14/2005 11:06:34
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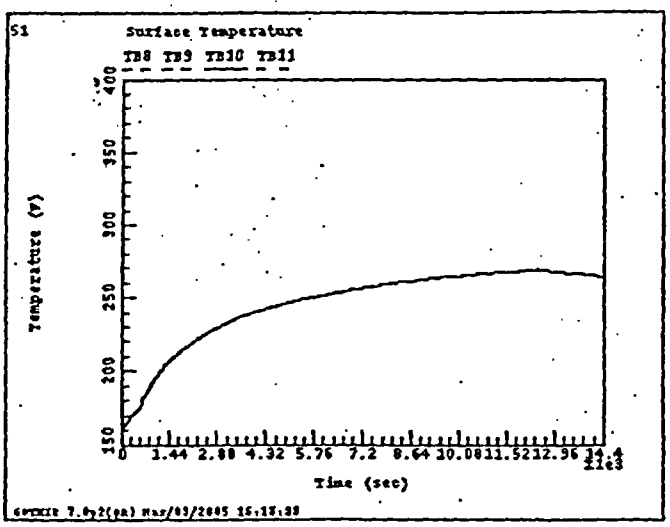

Figure 28 – Surface Temperature, Heat Structures 8, 9, 10, 11 - *SBO-drywell2-Leak-80-sensy*

SBO - 80F-Noleak-drywell2-Leak-80-sensitivities
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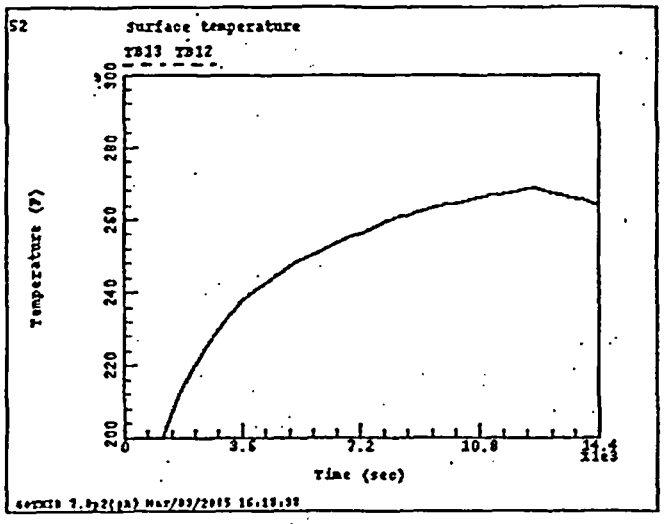

Figure 29 - Surface Temperature, Heat Structures 12,13 - *SBO-drywell2-Leak-80-sensy*

6.4 Case *SBO-drywell2-Leak-45-sensy*

6.4.1 Model modification

Table 10 presents the modifications to the deck *SBO-drywell2-Leak-80-sensy* to produce *SBO-drywell2-Leak-45-sensy.*

Two modifications are made, the depressurization (cooldown) table, is changed from 80 °F/hour to 45 °F/hr (same cooldown curve as in Reference 1- Function 10).

The RHRSW temperature is changed from 85 °F to 75 °F consistent with Assumption 13 and Reference 1.

Table 10 *SBO-drywell2-Leak-45-sensy* vs *SBO-drywell2-Leak-80-sensy*

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-4
Mar/14/2005 17:49:07
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-45-sensy

Functions

FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	RHR Hx Tube	Reynolds N	Nusselt Nu	34
2	RHR Hx Shell	Reynolds N	Nusselt Nu	34
3	Decay Heat	Time (sec)	Decay Heat	50
4	Pump Heat	Time (sec)	Heat Rate	6
5	Feed Enthalpy	cv4	Dep. Var.	34
6	RHR/Torus	Time (sec)	Flow (gpm)	3
7	LPCS Flow Curve	cv26	Flow (gpm)	13
8	LPCI Flow Curve	cv26	Flow (gpm)	12
9	Feed Flow	cv28	Dep. Var.	3
10	Cooldown Pressu	Time (sec)	Pressure (	39
11	Cooldown Temper	cv33	Dep. Var.	3
12	Cooldown Flow	cv32	Dep. Var.	3
13	Constant	Ind. Var.	Dep. Var.	6
14	ECCS Pump Heat	Time (sec)	Heat Rate	6
15	Check Valve	Ind. Var.	Dep. Var.	6
16	SW	Time (sec)	Service Wa	6
17	Drywell Power C	cv41	Dep. Var.	4
18	Drywell Power C	cv42	Dep. Var.	4

Heat Exchangers - Table 2

Heat Ex. #	Scndy Flow (lbm/s)	Scnd Flow FF	Scndy Temp (F)	Scnd Temp FF	Ext. Flow (lbm/s)	Ext. Flow FF	Ext. Heat (Btu/s)	Ext. Heat FF
1H	1.	16	75.					

Graphs

Graph #	Title	Mon	Curve Number 1	2	3	4	5
1	Drywell Tempera		TV1	TL1			
2	Wetwell Tempera		TV2	TL2			
3	Containment Pre		PR1	PR2			
4	Reactor Vessel		TV4	TL4	ST4	TD4	
5	RHR Heat Exchan		xq1H				
6	Reactor Vessel		AL4				
7	Torus Water Vol		AL2				
8	Heat Exchanger		t11H	t21H			
9	Wetwell, Vessel		TL2	TL4	TL1		
10	Conductor Tempe		TA1	TA2	TA3	TA4	
11	Integral Vessel		QL4	QV4			
12	Vapor & Conduct		TV4	TA1			
13	Liquid & Conduc		TL4	TA2			
14	Vapor & Conduct		TV2	TA3			
15	Liquid & Conduc		TL2	TA4			
16	Vapor Heat Tran		HA1				
17	Liquid Heat Tra		hA2				
18	Vapor Heat Tran		HA3				

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-4
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Graphs (continued)

Graph #	Title	Mon	Curve Number 1	2	3	4	5
19	Liquid Heat Tra		hA4				
20	Feedwater & Bre		FL9	FL4			
21	RPV Liquid Leve		LL4				
22	SRV and ADS Flo		FV10	FV11			
23	Feedwater Entha		cv29				
24	RPV Pressures		PR4				
25	Feedwater Contr		cv27	cv28			
26	Integrated Feed		cv4				
27	RHR Flow		FL5				
28	Vessel Droplet		AD4				
29	ECCS Injection		FL7	FL12	FL14		
30	RPV Pressure		PR4	VC2V	FL7		
31	ADS Valve Posit		VC3V				
32	SRV Position		VC2V				
33	Cooldown FLow		FV16				
34	Vessel Drop Dia		DI4				
35	Reactor Vessel		PR4				
36	Suppression poo		TL2				
37	Reactor Vessel		PR4				
38	Suppression Poo		LL2				
39	HPCI Flow Rate		FL18				
40	Integrated HPCI		cv39				
41	Core Spray Flow		FL8				
42	Heat to the sup		CQ4H	CQ2H			
43	Leak Flow		FL4	FL19	FL20		
44	Integrated Leak		cv40				
45	Title		cv39				
46			FV18	FL18	FD18		
47			cv38				
48	Surface Tempera		TB5	TB6	TB7		
49	Surface Tempera		TA8	TA9	TA10		
50	Surface Tempera		TA11	TA12	TA13		
51	Surface Tempera		TB8	TB9	TB10	TB11	
52	Surface tempera		TB13	TB12			
53			TP8t600	TP9t600	TP10t60	TP11t60	
54			TP13t50	TP12t50			
55							

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Leak-4
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GOTHIC Version 7.0p2(QA) - April 2002
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Function
10
Cooldown Pressure
Ind. Var.: Time (sec)
Dep. Var.: Pressure (psia)

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	1078.5	600.	1014.5
1200.	953.5	1800.	895.3
2400.	839.8	3000.	787.
3600.	736.8	4200.	689.1
4800.	643.7	5400.	600.7
6000.	559.9	6600.	521.3
7200.	484.8	7800.	450.2
8400.	417.6	9000.	386.8
9600.	357.8	10200.	330.5
10800.	304.9	11400.	280.8
12000.	258.2	12600.	237.1
13200.	217.3	13800.	198.9
14400.	181.7	15000.	165.6
15600.	150.8	16200.	136.9
16800.	124.2	17400.	112.3
18000.	101.4	18600.	91.3
19200.	82.1	19800.	73.6
20400.	65.8	21000.	58.7
21600.	52.3	22200.	46.4
1000000.	46.4		

6.4.2 Results Case *SBO-drywell2-Leak-45-sensy*

Figure 30 through Figure 38 present the main parameters for the case *SBO-drywell2-Leak-45-sensy*. Figure 30 presents the drywell temperature. The maximum drywell temperature is about 293 °F and is reached at the end of the run (4 hours). The run was not extended beyond the 4 hours even though the drywell temperature continues to increase because at 4 hours the RHR pump is available for drywell spray, if needed. The mission time of 2 hour and 10 minutes is achieved. The drywell heatup rate is arrested due to depressurization; however the leak brings enough energy from the vessel to continue the heatup. At 7800 seconds the drywell temperature is about 290 °F, well below the EQ limit of 325 °F.

Figure 31 presents the containment pressure. The drywell pressure is high enough to allow for drywell spray after one hour into the transient, if needed. The available water to spray is the Diesel fire pump (Reference 30) per Appendix M of OE 3107 (Reference 35) and it takes about one hour for aligning the fire pump for drywell spray. The drywell temperature does not exceed the EQ drywell temperature limit and the drywell shell temperature stays below the limit of 281 °F for the mission time of 2 hour and 10 minutes hence spray from Diesel fire pump is not needed.

The vacuum breakers do not open during the time of interest.

At 4 hours the torus pressure is about 25 psig and increasing, close to the PSP limit of 27 psig. However at this time the RHR pump is available for containment spray.

Figure 32 presents the RPV pressure. At one hour into the event it is assumed that the operators start depressurization. The vessel pressure during the 4 hours of the run time does not reach the shutoff pressure for the HPCI pumps, so at 4 hours the HPCI pumps still inject to maintain inventory. At 4 hour into the event only about 540000 lb were injected from CST (Figure 34). At this time the RPV is not depressurized, and the HPCI pump continues to inject.

Figure 33 presents the RPV level. The core stays covered and HPCI maintains inventory for the duration of the analyses. There is no need to continue the calculation beyond 4 hours because the coping time of 2 hours was demonstrated.

Figure 35 shows that the leak is maintain constant for the duration of the transient.

Figure 36, Figure 37, and Figure 38 presents the drywell liner temperature. The drywell liner stays below 280 °F for the 4 hours analyzed. After 2 hours and 10 minutes the low pressure pumps are available for suppression pool cooling, drywell spray and maintaining vessel inventory.

The suppression pool temperature is not a parameter of importance for this calculation. In Reference 1 it was shown that the suppression pool temperature is lower for the cases with leak and lower for earlier depressurization hence the maximum suppression pool temperature will be lower that 182.2 °F, calculated in Reference 1.

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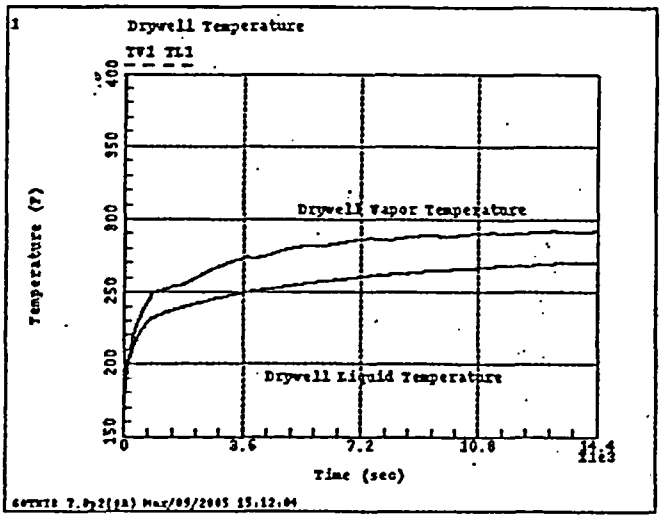

Figure 30 –Drywell Temperature –Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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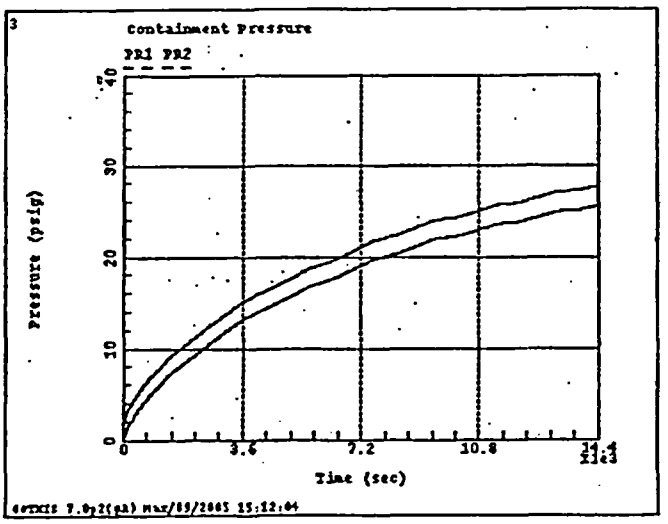

Figure 31-Containment Pressure - Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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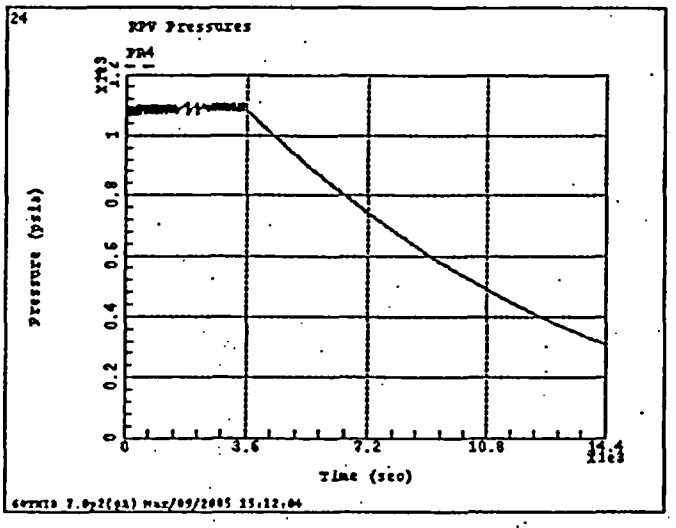

Figure 32 – RPV Pressure –Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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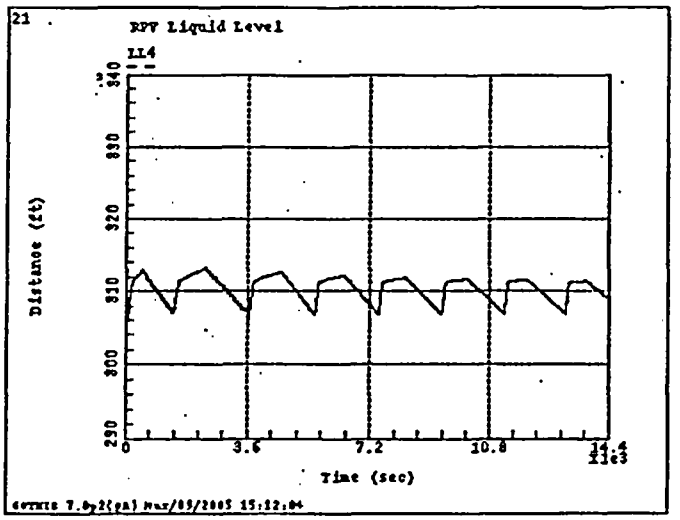

Figure 33 – RPV Level - Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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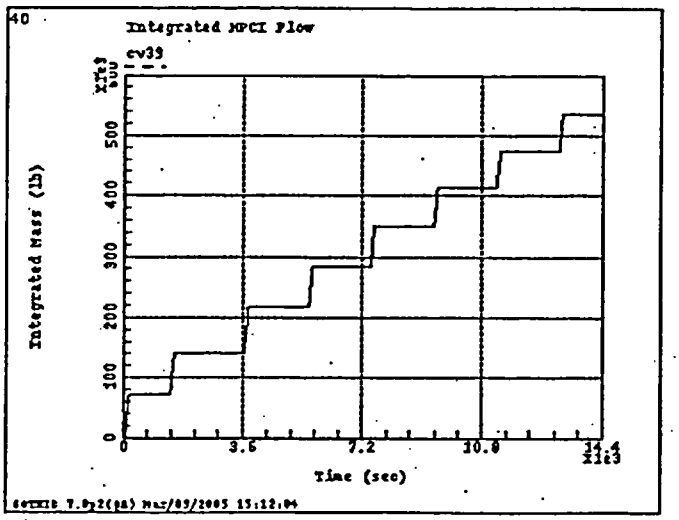

Figure 34 – Integrated HPCI Flow - Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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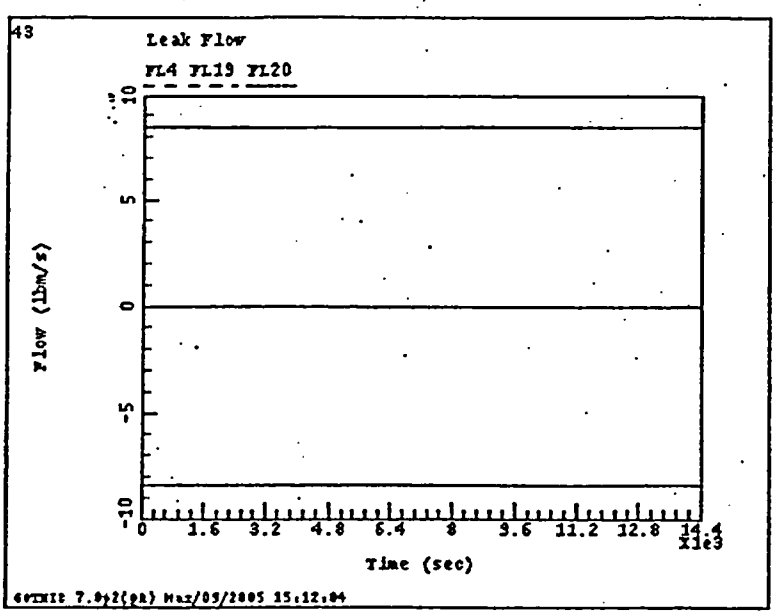

Figure 35 – Leak Flow –Case *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
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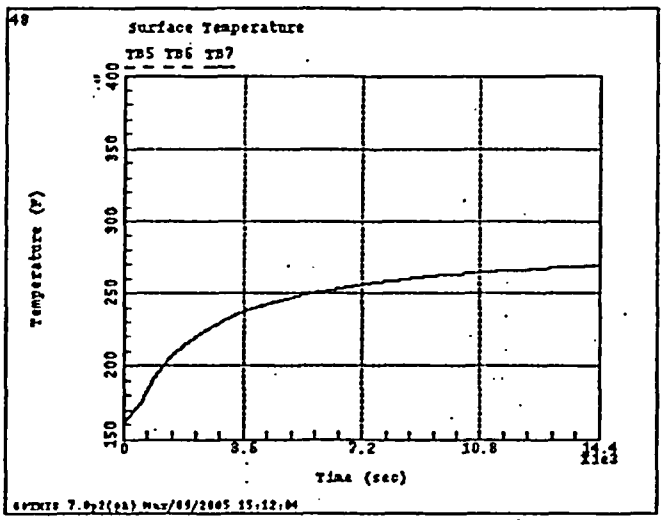

Figure 36 - Surface Temperature, Heat Structures 5,6,7 - *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
Mar/09/2005 19:08:37
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Le

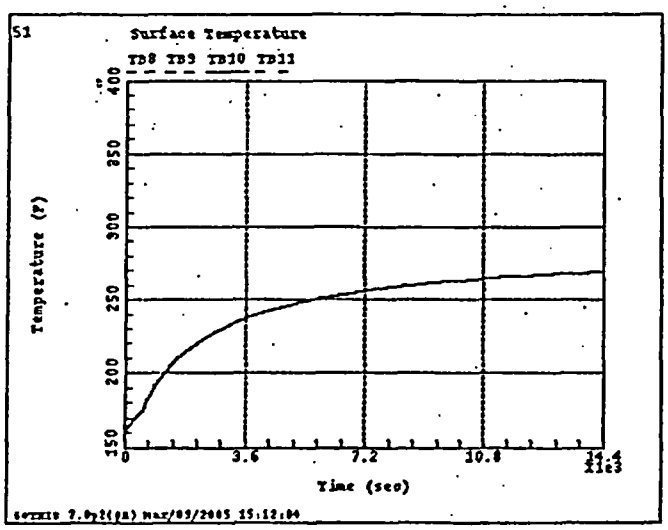

Figure 37 Surface Temperature, Heat Structures 8,9,10,11 - *SBO-drywell2-Leak-45-sensy*

SBO - drywell2-Leak-45-sensitivities
Mar/09/2005 19:11:15
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell2-Le

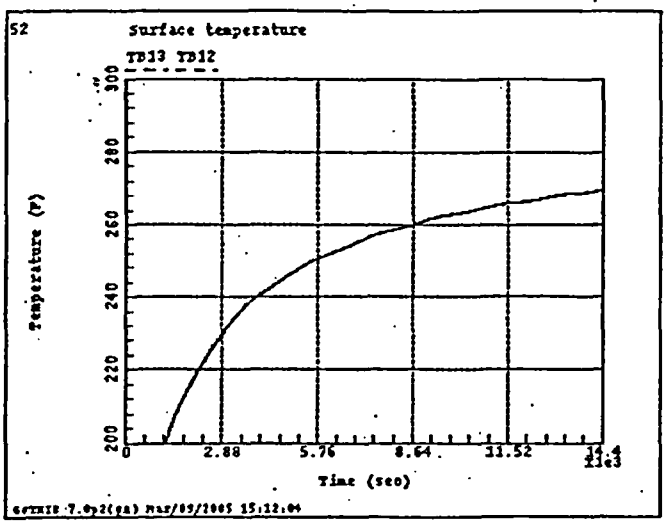

Figure 38 - Surface Temperature; Heat Structures 12,13 - *SBO-drywell2-Leak-45-sensy*

6.5 Case *SBO-drywell-comments*

6.5.1 Model Modifications

This case addresses the reviewer comments and also some discrepancies found during the documentation. The following changes are being made:

-change the initial temperature for Heat Structures 14 from 160 °F to 170 °F.
-change the $K_{reverse}$ in junction 3 to 3.93 from 3.964.
-change the flow area of the valve V3 to 15.63 ft^2, same as the flow path flow area
-change the surface area of the concrete pedestal to 2068 ft^2

The changes are made to case 2 but it could be done to any of the other cases.

Table 11 presents the modifications made to file *SBO-drywell2-80-sensy2-NoLeak* to create SBO-drywell2-comments.

Table 11 Comparison between *SBO-drywell-comments* vs *SBO-drywell2-80-sensy2-NoLeak.*

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-comment
Mar/15/2005 14:07:44
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-comments

Flow Paths - Table 3

Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.	Critical Flow Model	Exit Loss Coeff.	Drop Breakup Model
1	4.2243	4.2243	ON	TABLES	1.	OFF
2	1.	0.78	ON	TABLES	1.	OFF
3	3.964	3.93	ON	OFF	0.	OFF
4	0.		OFF	TABLES	1.	OFF
5			OFF	OFF	0.	OFF
6			OFF	OFF	0.	OFF
7			OFF	OFF	0.	OFF
8			OFF	OFF	0.	OFF
9			OFF	OFF	0.	OFF
10			OFF	TABLES	0.	OFF
11			OFF	TABLES	0.	OFF
12			OFF	OFF	0.	OFF
13			OFF	OFF	0.	OFF
14			OFF	OFF	0.	OFF
15			OFF	OFF	0.	OFF
16		1e+18	OFF	OFF	0.	OFF
17			OFF	OFF	0.	OFF
18			OFF	OFF	0.	OFF
19			OFF	OFF	0.	OFF
20			OFF	OFF	0.	OFF
21	1.5	1.5	OFF	OFF	0.	OFF

Thermal Conductors - Table 1

Cond #	Description	Vol A	HT Co	Vol B	HT Co	Cond Type	S. A. (ft2)	Init. T.(F)	Or
1	Steam Exposure	4	1	4	1	1	2965.72	609.23	I
2	Liquid Exposure	4	2	4	2	1	11521.8	647.4	I
3	Torus, Vapor	2	3	2	5	2	13553.7	90.	I
4	Torus, Liquid	2	4	2	5	2	13553.7	90.	I
5	Lower Drywell	1	5	1	6	3	1856.24	170.	I
6	Lower Drywell	1	5	1	6	4	2041.28	170.	I
7	Middle Drywell	1	5	1	6	5	3802.73	170.	I
8	Middle Drywell	1	5	1	6	6	780.68	170.	I
9	Middle Drywell	1	5	1	6	5	1250.47	170.	I
10	Middle drywell	1	5	1	6	7	1898.24	170.	I
11	Middle Drywell	1	5	1	6	8	1114.72	170.	I
12	Top Drywell	1	5	1	6	13	783.45	170.	I
13	Top Drywell	1	5	1	7	14	1718.3	170.	I
14	RRUs	1	5	1	6	11	1272.8	170.	I
15	Vent Pipes	3	5	3	6	11	2885.7	160.	I
16	Concrete Shield	1	5	1	6	12	2068.	152.	I

Modifications in /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-comment
Mar/15/2005 14:07:44
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-comments

Valve/Door Types

Valve Type #	Valve Option	Stem Travel Curve	Loss Coeff. Curve	Flow Area (ft2)
1	QUICK OPEN	0	0	1.
2	CHECK VALVE	0	15	3.141
3	QUICK CLOSE	0	0	15.63

6.5.2 Case *SBO-drywell-comments* Results

The results of this case are presented in Figure 39 through Figure 40. Figure 39 presents the drywell temperature. Due to the fact that the initial temperature for the drywell thermal conductors increase by 10 °F, the drywell temperature is increased from 289.4 °F to 295.2 °F.

The containment pressure (Figure 40) is identical to the Case 2, hence the changes in the vacuum breaker inputs have no effect on results, as described in section 6.2.1.

Figure 41, Figure 42, Figure 44 presents the drywell liner temperature. The drywell liner stays below 260 °F for the 7 hours analyzed. After 2 hours and 10 minutes the low pressure pumps are available for suppression pool cooling, drywell spray and maintaining vessel inventory.

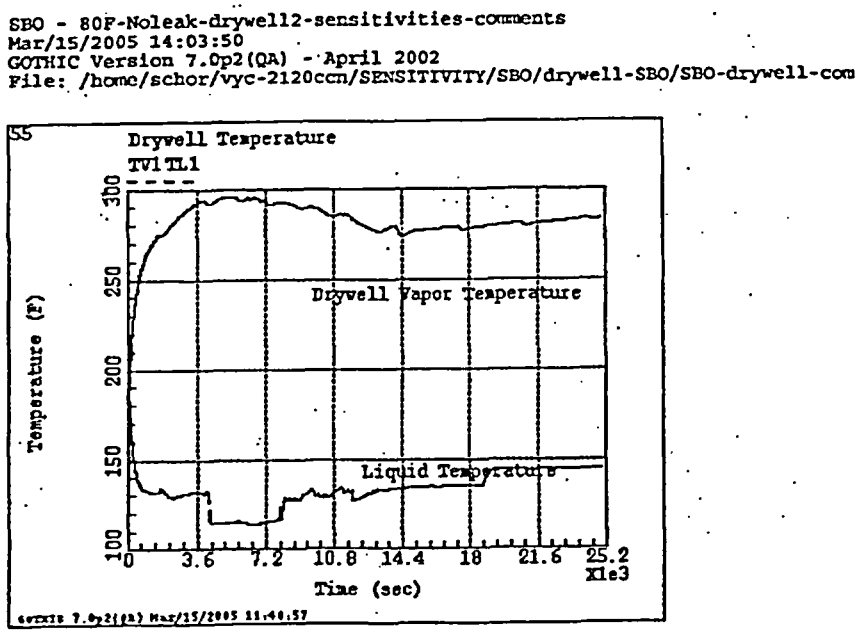

Figure 39 – Drywell Temperature - Case *SBO-drywell-comments*

SBO - 80F-Noleak-drywell2-sensitivities-comments
Mar/15/2005 14:05:35
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-com

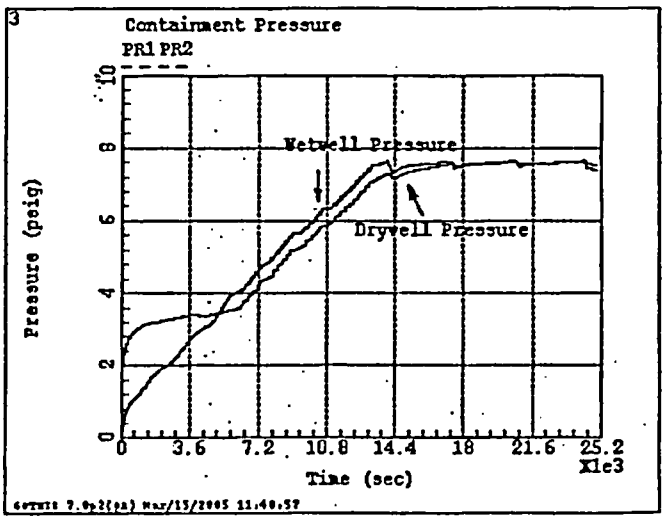

Figure 40 – Containment Pressure – Case *SBO-drywell-comments*

SBO - 80F-Noleak-drywell2-sensitivities-comments
Mar/15/2005 14:04:06
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-com

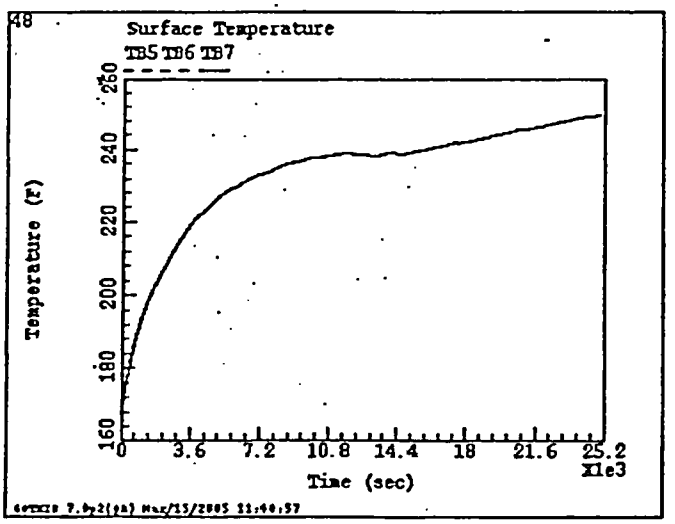

Figure 41 - Surface Temperature, Heat Structures 5,6,7 - *SBO-drywell-comments*

SBO - 80F-Noleak-drywell2-sensitivities-comments
Mar/15/2005 14:04:52
GOTHIC Version 7.0p2(QA) - April 2002
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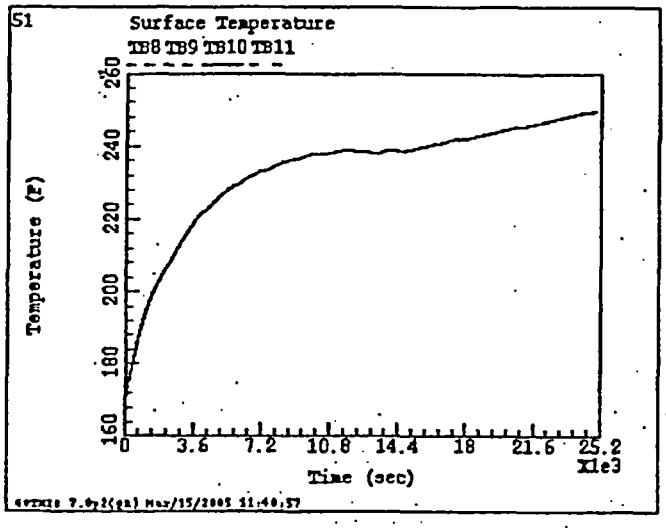

Figure 42 - Surface Temperature, Heat Structures 8,9,10,11 - *SBO-drywell-comments*

SBO - 80F-Noleak-drywell2-sensitivities-comments
Mar/15/2005 14:05:12
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-com

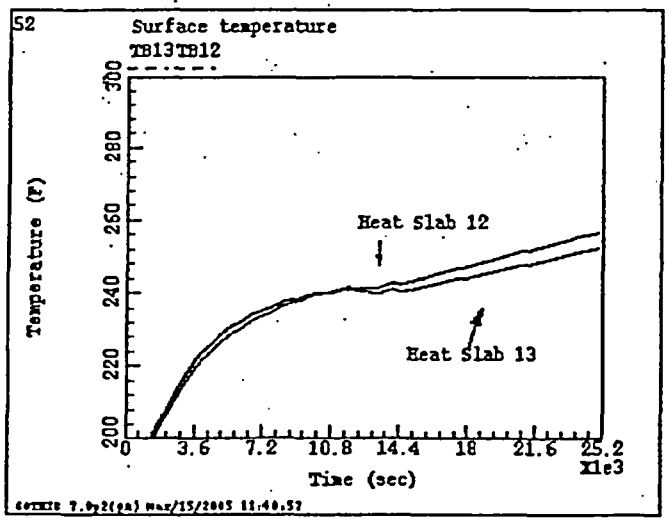

Figure 43 - Surface Temperature, Heat Structures 8,9,10,11 - *SBO-drywell-comments*

SBO - 80F-Noleak-drywell2-sensitivities-comments
Mar/15/2005 14:05:12
GOTHIC Version 7.0p2(QA) - April 2002
File: /home/schor/vyc-2120ccn/SENSITIVITY/SBO/drywell-SBO/SBO-drywell-com

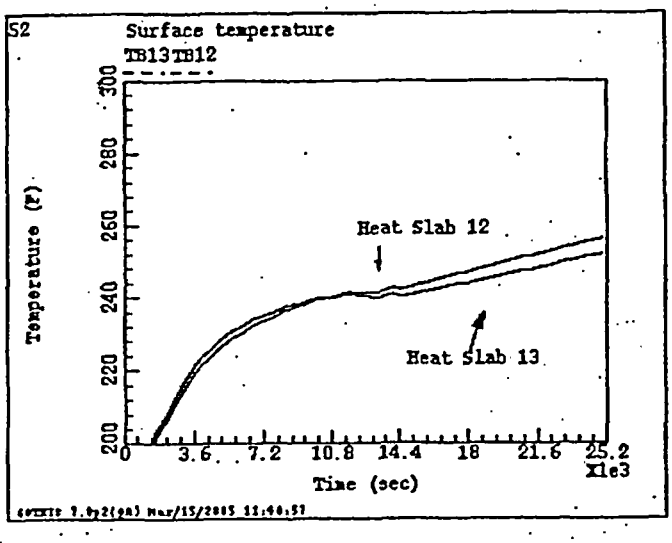

Figure 44 – Surface Temperature Heat Structures 12, 13 – Case *SBO-drywell-comments*

7.0 Results and Conclusions

Assuming a Station Blackout with RPV depressurization (cooldown) at 1 hour after the event the following results and conclusions are found:

1) The drywell temperature for all cases analyzed stays below the EQ drywell temperature profile for the entire SBO coping period of 2 hours and the additional 10 minutes to power the low pressure pumps (i.e., the drywell temperature for all cases analyzed stays below 300 °F for more than 4 hours of transient).

2) The drywell liner temperature stays below the design temperature of 281 °F for more than 4 hours after the SBO event.

3) The drywell pressure stays below the design pressure of 56 psig.

4) For 2 hour and 10 minutes the wetwell pressure stays below the PSP curve for all cases analyzed.

5) The analysis shows that there is no need to spray the drywell when in the unsafe region of DWSIL.

6) There is enough inventory in the CST to insure that the CST is not depleted before the time of low pressure pumps availability such that the core stays covered. A CST inventory of 75000 gallons was assumed.

7) The maxim suppression pool temperature for all cases stays below 182.2 °F.

8) The analysis predicts a conservatively high drywell temperature. Several factors contribute to this conservatism:

   - The heat transfer from the vessel to the drywell is based on a constant heat transfer coefficient at normal operating differential temperatures. However, this heat transfer coefficient will vary with the temperature difference to the ¼ power based on the dependence on the Grashoff number.
   - The heat transfer to the drywell from the drywell heaters is not subtracted from the vessel.
   - The reactor building side of the thermal conductors are considered adiabatic.
   - A constant leakage is assumed; the leakage will decrease as the vessel is depressurized.

9) No restriction on the rate of cooldown is applied to protect the drywell temperature beyond the restriction of depressurization (cooldown) function of RHRSW temperature (Reference 1).

Note: "Unverified Assumptions" and "Affected Documents" items are being tracked via LO-VTYLO-2005-00135 (also see Section 4.1 and 4.2).

8.0 References

The References are divided into Section 8.1 and General References (Section 8.2). Section 8.1 includes all references.

8.1 Design Input References and General References:

1 VYC-2398 Rev 0 Torus Temperature Calculation for a Station Blackout Event at Extended Power Uprate, dated March 2005.

2 VY Tech Spec.

3 NUMARC 87-00, dated 11/20/87, including NRC accepted errata and Q&A from NUMARC seminars and Topical Report F.

4 VYC-2397, Maximum RHRSW Flow to RHRHX for SBO & Appendix R, dated 1/24/2005.

5 DRF 0000-0011-5646, OPL-4A (Containment Analysis Input Values) for Vermont Yankee Nuclear Power Station EPU/MELLLA+, dated 2/6/03.

6 Calculation VYC-1628 Rev 0, Torus Temperature and Pressure Response to Large Break LOCA and MSLB Accident Scenarios, dated 4/27/98.

7 George, T. L., et. al, GOTHIC Containment Analysis Package, Version 7.0, July 2001.

8 VYC-2208 "GOTHIC 7.0 Code Installation Validation and Verification at VY", dated July 18, 2002.

9 VYC-1457, VY Containment Heatup Analysis – Appendix R Application, dated 8/19/96.

10 GE Design Specification, No. 22A1184, "Drywell Atmosphere Cooling System", Table I, Drywell Cooling Load Summary, #8 on Sheet 9.

11 VYC-1254 Rev 3 , Containment and RPV Volume Calculations, dated 5/21/98.

12 VYC-1850 Rev 1, OPL-4A Input Preparation, dated 6/22/99.

13 GE Design Specification # 22A1182 Rev1 "Protective Coatings-Special"

14 Drawing G191526 Rev 2.

15 J. P. Holman, "Heat Transfer", McGraw Hill Book Company, 1981.

16 Standard Review Plan Branch Technical Position CSB 6-1.

17 VYC-1628D Rev 0 CCN02, Torus Temperature and Pressure Response for to Appendix R and Station Blackout Scenarios, dated 06/23/2003.

18 VYC-2279, Evaluation of EPU Impact on Ambient Space Temperatures During Normal Operation, dated 8/26/2003.

19 EQ Manual Vol 1.

20 22A1265, Rev 1, Reactor Containment Design Specification, September 1969.

21 VY Drawing G191489 Rev 2.

22 VYC-1290 Rev 0, Vermont Yankee Post-LOCA Torus Temperature and RHR Heat Exchanger Evaluation, approved August1, 1994.

23 VYC-2045 Rev 0 Residual Heat Removal Heat Exchangers Fouling Factors and Projected Heat Rates for Cycle 21, dated 12/1/99.

24 GE-VYNPS-AEP-146, Letter Michael Dick (GE) to Craig Nichols (ENOI), VYNPS EPU Task T0400: Decay Heat for Containment Analysis dated March 10, 2003.

25 TE-2003-020, Feedwater Parameters for Power Uprate, April14, 2003.

26 VY Memo VYS 2000/39, P A Rainey/T. P. Bowman to J. R. Lynch, "Torus Temperature/SW Design Temperature Recommendations", April16, 2000.

27 VY UFSAR Rev. 19.

28 OP 0105 Rev 11, Reactor Operation.

29 Crane Technical Paper No. 410, Flow of Fluids through Valves, Fittings, and Pipe, 1976 Crane Co.

30 EOP-3 Primary Containment Control, Rev3, dated 10/19/02.

31 ASME Steam Tables –Third Edition, 1977.

32 VYC-2306, Torus Temperature for Appendix R events at EPU Conditions, dated 08/29/2003.

33 VYC-1850A Rev 0, "OPL 4A Input Preparation", dated 7/28/99.

34 VYC-1628B Rev 0, "Torus Temperature and Pressure Response to Small Break LOCA Scenarios, Model Development", dated 11/3/98.

35 OE-3107 Rev 17, EOP/SAG Appendices dated 04/29/2004.

36 OT 3122 Rev 19, Loss of Normal Power, dated 04/18/2000.

37 EOP-1 Rev2 RPV Control, dated 10/19/02

8.1 General References

George, T. L., et. al, GOTHIC Containment Analysis Package, Version 7.0, July 2001

GOTHIC 7.0 Code Installation Validation and Verification at VY, dated July 18, 2002.

ASME Steam Tables –Third Edition, 1977

J. P. Holman, "Heat Transfer", McGraw Hill Book Company, 1981

Crane Technical Paper No. 410, Flow of Fluids through Valves, Fittings, and Pipe, 1976 Crane Co.

ATTACHMENT 9.10 COMPUTER RUN SUMMARY SHEET

COMPUTER RUN SUMMARY SHEET

Page 1 of 1

Calculation No. VYC-2405 Revision 0 Date 16 March 2005

Sheet 1 of 1

Subject: **Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate**

Code GOTHIC V7.0p2 Catalog No. 02543 Version 7.0

SQA Classification Level A

Run Title (variable, described in Section 6.0 and Att. A)

Run No. No _____ Run Date _____ By _____

Output Use: ☐ Variable Values As Noted ☒ Plot Attached ☒ Disk. _____ ☐ File No. _____

Description Of Output:

- Figures in text.
- Input file on Disk.
- Multiple cases were run, all are described in Section 6.0.
- One case (base case) is attached in attachment A).
- The Figures in text, for each case, have the date of the run & the run name.

Comments: None

(Attached additional pages if necessary)

Review:

☒ Information Entered Above is Accurate

☒ Input Entry Accurate

☒ Code Properly Executed (Based on User Manual)

☒ Output Accurately Extracted or Location Specified

Reviewer Comments None.

Preparer (Print/Sign)	Date	Reviewer (Print/Sign)	Date
Liliane Schor		Alan L. Robertshaw	
Schor	3/17/05	Alan L Robertshaw	3/17/05

Calculation Impact Review Pages (ENN-DC-126 Attachment 9.7)

From System Engineering

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	ENN-DC-126	REV. 4
		INFORMATIONAL USE	PAGE 35 OF 57	

ATTACHMENT 9.7 CALCULATION IMPACT REVIEW PAGE

CALCULATION IMPACT REVIEW PAGE

Date: 14 February 2005 ☒ QR ☐ NQR

(Note: X Indicates required distribution)

To:
- ___ Mechanical Engineering
- ___ I&C Engineering
- ___ Electrical Engineering
- ___ Civil Engineering
- X System Engineering
- ___ Reactor Engineering
- X DBD Owner RHR, P. Perez
- X DBD Owner SA, P. Perez (Name)
- X Licensing
- ___ Elect Maintenance
- ___ I&C Maintenance
- ___ Mech Maintenance
- ___ Component Engineering
- ___ Program Engineering
- ___ Nuclear Engineering
- ___ EQ
- (Other)
- X Operations
- ___ Chemistry
- ___ HP/Radiological
- ___ Computer Applications
- ___ Rad Engineering
- ___ ISI Engineering
- ___ IST Engineering
- ___ PSA
- ___

From : Liliane Schor 802-451-3013
(Originator Print Name and Phone extension)

Calculation No.: VYC-2405 Revision No. 0

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Reference: N/A

Date Response Required: 16 February 2005

MESSAGE: Work organizations are requested to review the subject calculation (parts attached) to identify impacted calculations, procedures, Technical Specifications, FSAR sections, other design documents (e.g., EQ files, DBD, Appendix R, ISI/IST, PSA, MOVs/AOVs, etc.) and other documents, which must be updated because of the calculation results. Also provide the name of the individual responsible for the action and the tracking number. The tracking item should include a requirement to ensure that any ER implementation associated with the item is completed prior to revising the impacted document. Sign and return the form to the originator.

IMPACT REVIEW RESULTS:

Affected Documents	Responsible Individual	Tracking Number	Remarks
EOP-3			
EOP Study Guide			
DBD-SADBD			

Responding Supervisor/Manager (or designee): Brian Naeck [signature] 3/16/05
Name/Signature Date

Calculation Impact Review Pages (ENN-DC-126 Attachment 9.7), Continued

From System Engineering

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	ENN-DC-126	REV. 4
		INFORMATIONAL USE	PAGE 35 OF 57	

ATTACHMENT 9.7 CALCULATION IMPACT REVIEW PAGE

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Date: 14 February 2005 ☒ QR ☐ NQR

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- ___ Civil Engineering
- X System Engineering
- ___ Reactor Engineering
- X DBD Owner RHR, P. Perez
- X DBD Owner SA, P. Perez (Name)
- X Licensing
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- ___ Mech Maintenance
- ___ Component Engineering
- ___ Program Engineering
- ___ Nuclear Engineering
- ___ EQ
- (Other)
- X Operations
- ___ Chemistry
- ___ HP/Radiological
- ___ Computer Applications
- ___ Rad Engineering
- ___ ISI Engineering
- ___ IST Engineering
- ___ PSA
- ___

From: Liliane Schor 802-451-3013
(Originator Print Name and Phone extension)

Calculation No.: VYC-2405 Revision No. 0

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Reference: N/A

Date Response Required: 16 February 2005

MESSAGE: Work organizations are requested to review the subject calculation (parts attached) to identify impacted calculations, procedures, Technical Specifications, FSAR sections, other design documents (e.g., EQ files, DBD, Appendix R, ISI/IST, PSA, MOVs/AOVs, etc.) and other documents, which must be updated because of the calculation results. Also provide the name of the individual responsible for the action and the tracking number. The tracking item should include a requirement to ensure that any ER implementation associated with the item is completed prior to revising the impacted document. Sign and return the form to the originator.

IMPACT REVIEW RESULTS:

Affected Documents	Responsible Individual	Tracking Number	Remarks
OP 4032	S. Jonasch		See attached comments

Responding Supervisor/Manager (or designee): Stephen Jonasch [signature] 3/16/05
Name/Signature Date

Calculation Impact Review Pages (ENN-DC-126 Attachment 9.7), Continued

From RHR and SA DBD Owner

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		INFORMATIONAL USE	PAGE 35 OF 57	

ATTACHMENT 9.7 CALCULATION IMPACT REVIEW PAGE

CALCULATION IMPACT REVIEW PAGE

Date: 14 February 2005 ☒ QR ☐ NQR

(Note: X indicates required distribution)

To:
- ___ Mechanical Engineering
- ___ I&C Engineering
- ___ Electrical Engineering
- ___ Civil Engineering
- X System Engineering
- ___ Reactor Engineering
- X DBD Owner RHR, P. Perez
- X DBD Owner SA, P. Perez (Name)
- X Licensing
- ___ Elect Maintenance
- ___ I&C Maintenance
- ___ Mech Maintenance
- ___ Component Engineering
- ___ Program Engineering
- ___ Nuclear Engineering
- ___ EQ
- X Operations
- ___ Chemistry
- ___ HP/Radiological
- ___ Computer Applications
- ___ Rad Engineering
- ___ ISI Engineering
- ___ IST Engineering
- ___ PSA
- (Other) _____

From: Lillane Schor 802-451-3013
(Originator Print Name and Phone extension)

Calculation No.: VYC-2405 Revision No. 0

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Reference: N/A

Date Response Required: 16 February 2005

MESSAGE: Work organizations are requested to review the subject calculation (parts attached) to identify impacted calculations, procedures, Technical Specifications, FSAR sections, other design documents (e.g., EQ files, DBD, Appendix R, ISI/IST, PSA, MOVs/AOVs, etc.) and other documents, which must be updated because of the calculation results. Also provide the name of the individual responsible for the action and the tracking number. The tracking item should include a requirement to ensure that any ER implementation associated with the item is completed prior to revising the impacted document. Sign and return the form to the originator.

IMPACT REVIEW RESULTS:

Affected Documents	Responsible Individual	Tracking Number	Remarks
SA DBD	P. Perez	LO-VTYLO-2005-00135	May need update for Drywell – SBO assumptions / Methodology of VYC-2405.

Responding Supervisor/Manager (or designee): JG Rogers 3-16-05
Name/Signature Date

Calculation Impact Review Pages (ENN-DC-126 Attachment 9.7), Continued

From Operations – EPU Engineering

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	ENN-DC-126	REV. 4
		INFORMATIONAL USE	PAGE 35 OF 57	

ATTACHMENT 9.7 CALCULATION IMPACT REVIEW PAGE

CALCULATION IMPACT REVIEW PAGE

Date: 14 February 2005 ☒ QR ☐ NQR

(Note: X indicates required distribution)

To: ___ Mechanical Engineering
___ I&C Engineering
___ Electrical Engineering
___ Civil Engineering
X System Engineering
___ Reactor Engineering
X DBD Owner RHR, P. Perez
X DBD Owner SA, P. Perez
(Name)

X Licensing
___ Elect Maintenance
___ I&C Maintenance
___ Mech Maintenance
___ Component Engineering
___ Program Engineering
___ Nuclear Engineering
___ EQ
(Other)

X Operations
___ Chemistry
___ HP/Radiological
___ Computer Applications
___ Rad Engineering
___ ISI Engineering
___ IST Engineering
___ PSA
___

From : Liliane Schor 802-451-3013
(Originator Print Name and Phone extension)

Calculation No.: VYC-2405 Revision No. 0

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Reference: N/A

Date Response Required: 16 February 2005

MESSAGE: Work organizations are requested to review the subject calculation (parts attached) to identify impacted calculations, procedures, Technical Specifications, FSAR sections, other design documents (e.g., EQ files, DBD, Appendix R, ISI/IST, PSA, MOVs/AOVs, etc.) and other documents, which must be updated because of the calculation results. Also provide the name of the individual responsible for the action and the tracking number. The tracking item should include a requirement to ensure that any ER implementation associated with the item is completed prior to revising the impacted document. Sign and return the form to the originator.

IMPACT REVIEW RESULTS:

Affected Documents	Responsible Individual	Tracking Number	Remarks
EOP-3 Study Guide			
OT-3122			
Lesson Plan for EOP-3			
ON-3147			
ON 3148			

Responding Supervisor/Manager (or designee): Bryan Croke Bryan Croke 3/16/2005

Name/Signature Date

Calculation Impact Review Pages (ENN-DC-126 Attachment 9.7), Continued

From Licensing

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	ENN-DC-126	REV. 4
		INFORMATIONAL USE	PAGE 35 OF 57	

ATTACHMENT 9.7 CALCULATION IMPACT REVIEW PAGE

CALCULATION IMPACT REVIEW PAGE

Date: 14 February 2005 ☒ QR ☐ NQR

(Note: X indicates required distribution)

To: ___ Mechanical Engineering
___ I&C Engineering
___ Electrical Engineering
___ Civil Engineering
X System Engineering
___ Reactor Engineering
X DBD Owner RHR, P. Perez
X DBD Owner SA, P. Perez
(Name)

X Licensing
___ Elect Maintenance
___ I&C Maintenance
___ Mech Maintenance
___ Component Engineering
___ Program Engineering
___ Nuclear Engineering
___ EQ
(Other)

X Operations
___ Chemistry
___ HP/Radiological
___ Computer Applications
___ Rad Engineering
___ ISI Engineering
___ IST Engineering
___ PSA
___

From : Liliane Schor 802-451-3013
(Originator Print Name and Phone extension)

Calculation No.: VYC-2405 Revision No. 0

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate.

Reference: N/A

Date Response Required: 16 February 2005

MESSAGE: Work organizations are requested to review the subject calculation (parts attached) to identify impacted calculations, procedures, Technical Specifications, FSAR sections, other design documents (e.g., EQ files, DBD, Appendix R, ISI/IST, PSA, MOVs/AOVs, etc.) and other documents, which must be updated because of the calculation results. Also provide the name of the individual responsible for the action and the tracking number. The tracking item should include a requirement to ensure that any ER implementation associated with the item is completed prior to revising the impacted document. Sign and return the form to the originator.

IMPACT REVIEW RESULTS:

Affected Documents	Responsible Individual	Tracking Number	Remarks
See note 1 FSAR	Civil Engineer	See note (2)	None

Responding Supervisor/Manager (or designee): Jim Delisiento [signature] 3/17/05
Name/Signature Date

(1) This may constitute "new or revised safety analysis" per AP4036. As part of the ER on EPU consideration to include a summary in the FSAR.
(2) To be generated by design development / close out.

Calculation Design Verification and Review (ENN-DC-134)

ENN-DC-134 REVISION 1 ATTACHMENT 9.1 DESIGN VERIFICATION COVER PAGE

DESIGN VERIFICATION COVER PAGE

☐ IP-2 ☐ IP-3 ☐ JAF ☐ PNPS ☒ VY

Document No. VYC-2405	Revision 0	Page 1 of 8

Title: Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate

☒ Quality Related ☐ Non Quality Related

DV Method: ☒ Design Review ☐ Alternate Calculation ☐ Qualification Testing

VERIFICATION REQUIRED	DISCIPLINE	VERIFICATION COMPLETE AND COMMENTS RESOLVED (DV print, sign, and date)
☐	Electrical	
☐	Mechanical	
☐	Instrument and Control	
☐	Civil/Structural	
☒	Design Engineering, Fluid Systems	Alan L. Robertshaw Alan L Robertshaw 3/17/05
☐		

Print/Sign After Comments Have Been Resolved

Originator: Liliane Schor Schor	Date: 3/17/05

ENN-DC-134 REVISION 1 ATTACHMENT 9.7 CALCULATION DESIGN VERIFICATION CHECKLIST

IDENTIFICATION:				DISCIPLINE:
Document Title:	Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate			☐ Civil/Structural
Doc. No.:	VYC-2405	Rev. 0	QA Cat.	☐ Electrical
Verifier:	Alan L. Robertshaw (Print)	(Sign)	(Date)	☐ I & C
Manager authorization for supervisor performing verification. ☐ N/A	(Print)	(Sign)	(Date)	☐ Mechanical ☐ Nuclear ☒ Other: Design Engineering, Fluid Systems

METHOD OF VERIFICATION:

Design Review ☒ Alternate Calculations ☐ Qualification Test ☐

1. **Design Inputs – Were the inputs correctly selected and incorporated into the design?**

Design inputs include design bases, plant operational conditions, performance requirements, regulatory requirements and commitments, codes, standards, field data, etc. All information used as design inputs should have been reviewed and approved by the responsible design organization, as applicable.

All inputs need to be retrievable or excerpts of documents used should be attached.

See site specific design input procedures for guidance in identifying inputs.

Reference
Page No. Section 5 of VYC-2405
OR
Paragraph No. _____

Completion of the Reference Boxes is optional for all questions.

Yes ☒ No ☐ N/A ☐

Verifier Comments:

Section 5.0, Input and Design Criteria, of VYC-2405, has been satisfactorily reviewed. Any identified Design Input needing verification is listed in Section 4.1 of VYC-2405 and tracked via LO-VTYLO-2005-00135 (see Item #2 of this Calculation Design Verification Checklist). All other Design Input has been verified in VYC-2405.

Resolution: None needed.

2. Assumptions – Have the assumptions been verified?	Reference
Yes ☐ No ☒ N/A ☐	Page No. Calculation Summary Page and Sect. 4.1 of VYC-2405 OR Paragraph No.

Verifier Comments:

Section 4.1, Assumptions that need Verification or Implementation, and LO-VTYLO-2005-00135 CA02, document identified "Unverified Assumptions" from VYC-2405 Drywell Temperature Calculation for a Station Blackout Event at Extended Power Uprate. The following lists the various "Unverified Assumptions" from VYC-2405:

1) 2 hour restoration of outside power (coping time).
2) 10 minutes to start RHR through the RHRHX, 2 RHRSW pumps and CS.
3) Acceptability of using 75000 gal from CST (change of level setpoint).
4) Maximum CST temperature of 135°F.
5) The depressurization rate function of Service Water temperature needs to be verified and proceduralized as follows:
   - For SW> 75°F; depressurize the vessel at 80°F/hr or higher.
   - For lower SW temperature (SW ≤ 75°F) no restrictions on depressurization rates.

Upon verification of these assumptions, the calculation should be revised to convert the assumptions to Design Input and the calculation Status should be changed.

Resolution:

LO-VTYLO-2005-00135 CA02 has been issued to track these Unverified Assumptions.

Upon verification of these assumptions, the calculation should be revised to convert the assumptions to Design Input and the calculation Status should be changed.

3. Quality Assurance – Is the Quality level correct?	Reference
Yes ☒ No ☐ N/A ☐	Page No. Cover Sheet of VYC-2405 OR Paragraph No.

Verifier Comments: VYC-2405 is correctly designated "Quality Related."

Resolution: None needed.

4.	**Codes, Standards and Regulatory Requirements –** Are the applicable codes, standards and regulatory requirements, including issue and addenda properly identified and are their requirements for design met? Yes ☒ No ☐ N/A ☐	Reference Page No. _____ OR Paragraph No. _____

Verifier Comments: Appropriate use of requirements (inputs, assumptions, methodology) set forth in the VY Technical Specifications and UFSAR have been followed in VYC-2405 as needed.

Resolution: None needed.

5.	**Operating Experience –** Have applicable construction and operating experience been considered? Yes ☒ No ☐ N/A ☐	Reference Page No. _____ OR Paragraph No. _____

Verifier Comments:

Consideration (discussions and reviews) has been given to various timelines for operator actions, equipment start times, cooldown rates, etc. Some Unverified Assumptions exists which will rely on, in part, to VY operating experience (e.g., two hour restoration of outside power (coping time of 2 hours and 10 minutes), ten minutes to start RHR flow through the RHRHX, the use of 2 RHRSW pumps and CS, and the acceptability of using 75000 gal from CST (change of level setpoint). See Item #2, Assumptions, of this Calculation Design Verification Checklist.

Resolution: Consideration has been given to VY operating experience. Some Unverified Assumptions exist (for which commitments have been issued). See Resolution of Item #2, Assumptions, of this Calculation Design Verification Checklist.

6.	**Interfaces –** Have the design interface requirements been satisfied and documented? Yes ☒ No ☐ N/A ☐	Reference Page No. _____ OR Paragraph No. _____

Verifier Comments:

The relationship between the Fluid Systems ("design group") and other organizations within VY have been satisfactorily met using the Calculation Impact Review Page. The Calculation Impact Review Page was completed by persons in the Operations Department, System Engineering, Licensing, and various DBD owners.

Resolution:

None Needed.

7.	Methods – Was an appropriate analytical method used? Yes ☒ No ☐ N/A ☐ **Verifier Comments:** The GOTHIC code (Reference 7 & 8 of VYC-2405), Version 7.0p2 was selected for use in VYC-2405. **Resolution:** None Needed.	**Reference** Page No. Section 3 of VYC-2405 OR Paragraph No.
8.	Design Outputs – Is the output reasonable compared to the inputs? Yes ☒ No ☐ N/A ☐ **Verifier Comments:** The output is reasonable compared to the inputs. Previous, similar Drywell SBO analyses are familiar with the preparer and reviewer of this SBO calculation and thus the output given in VYC-2405 was reasonable for the various changes and modifications made to the previous input. **Resolution:** None Needed.	**Reference** Page No. OR Paragraph No.
9.	Acceptance Criteria – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that design requirements have been satisfactorily accomplished? Yes ☒ No ☐ N/A ☐ **Verifier Comments:** Section 2.1 was added to include the Acceptance Criteria. **Resolution:** None Needed.	**Reference** Page No. Section 2.1 of VYC-2405 OR Paragraph No.

10.	**Records and Documentation** – Are requirements for record preparation, review, approval, retention, etc., adequately specified? Are all documents prepared in a clear legible manner suitable for microfilming and/or other documentation storage method? Have all impacted documents been identified for update? Yes ☒ No ☐ N/A ☐	Reference Page No. Section 4.2 of VYC-2405 OR Paragraph No.
	Verifier Comments: VYC-2405 was prepared in a clear legible manner suitable for microfilming and/or other documentation storage method. All impacted documents (Design Output) have been identified for update in Section 4.2 of VYC-2405 and in LO-VTYLO-2005-00135 CA01. **Resolution:** LO-VTYLO-2005-00135 CA01 has been issued to track these affected documents. If any other documents are identified during the Calculation Impact Review process, other commitments will be generated.	
11.	**Software Quality Assurance**- For a calculation that utilized software applications (e.g., GOTHIC, SYMCORD), was it properly verified and validated in accordance with ENN IT-104 or previous site SQA Program? Yes ☒ No ☐ N/A ☐	Reference Page No. Section 3 of VYC-2405 OR Paragraph No.
	Verifier Comments: The GOTHIC code (Reference 7 & 8 of VYC-2405), Version 7.0p2 was selected for use in VYC-2405. This code was used in similar SBO analysis (References 1 of VYC-2405). This specific version of the code has been installed and complies with the ENVY SQA procedures ENN-IT-104 (replaced VY procedure AP-6030) as documented in calculation VYC-2208 (Reference 8 of VYC-2405). **Resolution:** None Needed.	

OTHER COMMENTS

See Attached list of General comments from review of VYC-2405

RESOLUTIONS

Attached General comments have been made to reviewer's satisfaction.

All comments for "NO" answers have been resolved satisfactorily.

General Comments from Alan L. Robertshaw from Review of VYC-2405
(Attached to Calculation Design Verification Checklist)

- In Section 2.0, Add addition Section (2.1) entitled "Acceptance Criteria" and add appropriate acceptance criteria.

Done

- In Section 3.0, discussion of GOTHIC code and V&V calculation need appropriate references.

Done

- In Section 4.0:

1. For Assumption #4, please correct the units for density (value is correct).
2. For Assumption #9, add that 61 gpm is from Reference 3.
3. Add VYC-2306 to Reference (from Drywell Free Volume of Table 3).

Added

- In Section 5.0:

1. In Section 5.3.1, show in more detail how total Heater #5 loads are calculated.

Done

2. In Section 5.4, recommend addition of "simple" drawing of Drywell

Done

3. In Section 5.4 show that the total Surface Area adds up to the Value obtained from OPL-4a (i.e., Table A Total = 15246.06 ft^2, RRUs = 1272.8 ft^2, Vent Pipes = 2885.7 ft^2, thus Total = 19405 ft^2).

Added

4. Add to description of Item 8 "Side of Drywell Head."
5. Add to description of Item 9 "Top of Drywell Head."

Done, both items

6. Is RRU area Reference 11 or 12 or other? Please correct if needed.

Both, added

7. Flow Path 21 Forward and Reverse loss coefficients should reference CRANE (or similar), data not found in steam table. Need to add CRANE to references

Done

8. Please add additional information on new valve added (vacuum breaker, Valve #5. e.g., size, type, etc.).

Done

9. Also for Valve discussion, note that the valve area is different from the line area used in Flow Path 21

Added

10. Initial Temperatures of the Thermal Conductors are not given (and reference).

Added

11. Please further explain why a loss coefficient of 3.964 was used instead of the calculated value of 3.93 for the vacuum breaker flow path. Any impact on analysis?

I added this discussion in the document, I also said that the difference is less than 1% and will make no difference on the analysis. Anyway, was corrected in Case 5.

- In Section 6.0:

1. List Five case individually to add clarity.

Done

2. See minor grammatical / spelling concerns noted in marked-up calc draft

Done

3. Section 6.2.1 please add info on Flow Path 21 (Leakage) area change.

Done

- In Section 8.0, Reference Section:

1. Need to add Reference for ASME Steam Tables and one for CRANE Technical Paper (if needed)

Added

2. Are References 11 and 13 used?

Yes, Reference 11 and 12 are RRU references and 13 is for the paint (added some more discussion about the paint)

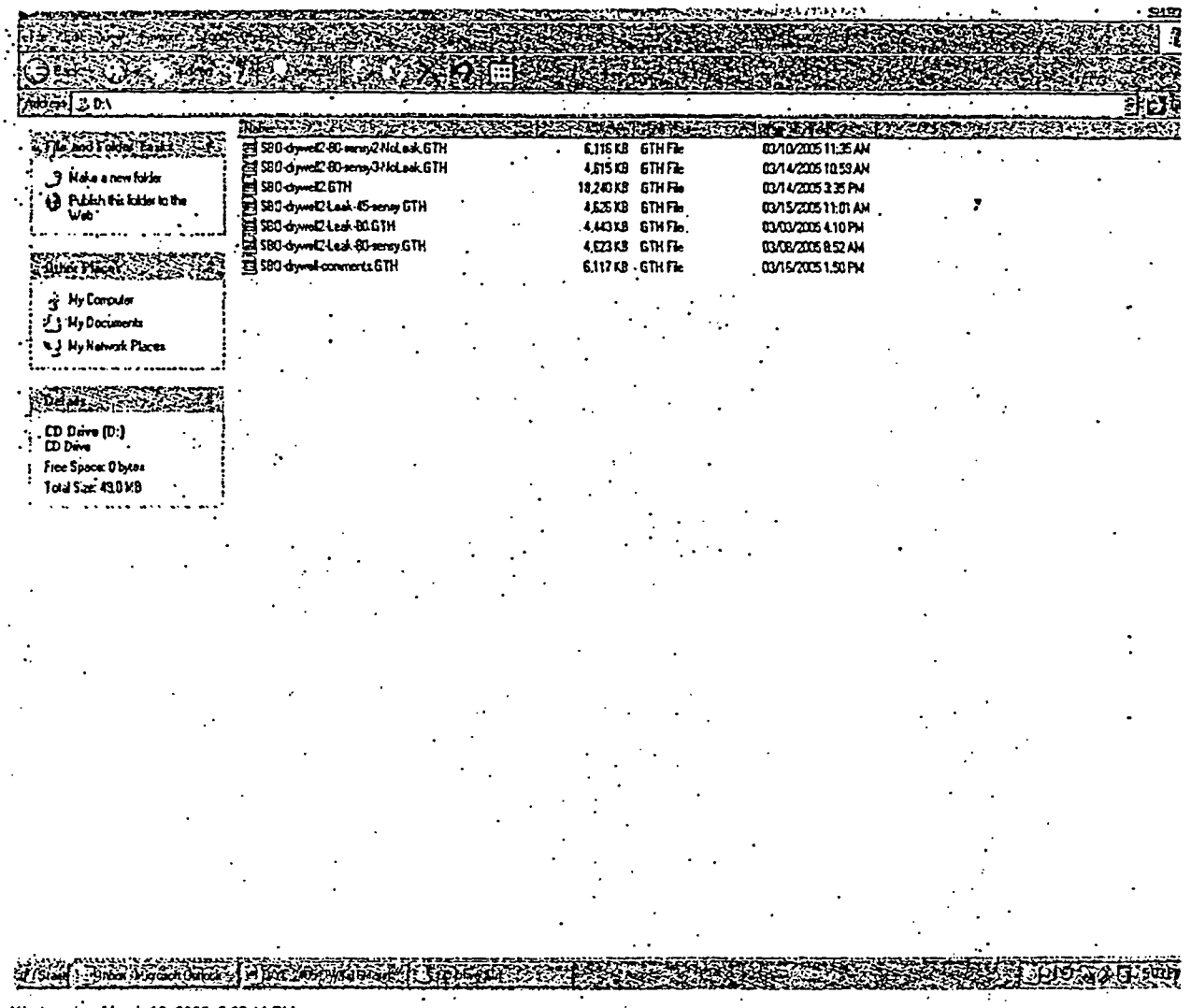
- In the GOTHIC Input Deck, Thermal Conductor #16, Concrete Shield, a surface area value of 2108 ft^2 was used. A value of 2068 ft^2 was given in the text of VYC-2405 (Section 5.4). Both of these numbers are found on page 35 of VYC-1850, Rev. 1 for OPL-4A preparation. The larger value (2108 ft^2) is for total surface area, the smaller value (2068 ft^2) subtracts the "Slots." The value used in VYC-1850, Rev. 1 CCN-01 (OPL-4A, Resolved for Analysis) uses the 2068 ft^2 value. Please discuss this in the analysis and determine which value to use, any sensitivities, etc.

Case 5 addresses this.

- In Attachment A, it appears that Figure on page A14 is a duplicate figure and should be removed.

Removed

Files on CD



Wednesday, March 16, 2005 5:03:11 PM

BVY 05-072
Docket No. 50-271

Exhibit SPSB-C-52-5

Vermont Yankee Nuclear Power Station

Proposed Technical Specification Change No. 263 – Supplement No. 30

Extended Power Uprate

Response to Request for Additional Information

Calculation VYC-2279, Rev.0

Total number of pages in this Exhibit (excluding this cover sheet) is 14.

(1)

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VY CALCULATION TITLE PAGE

VYC-2279	0	N/A	N/A
VY Calculation Number	Revision Number	Vendor Calculation Number	Revision Number

Title: **Evaluation of EPU impact on Ambient Space Temperatures During Normal Operation**

QA Status: ☒ SC ☐ NNS ☐ OQA Operating Cycle Number* N/A

* The Operating Cycle Number should only be entered here if the results of the calculation only apply during a specific operating cycle otherwise enter "N/A".

Calculation Supports A Design Change/Specification? ☒ Yes ☐ No VYDC 2003-008 ____ VYDC/MM/TM/Spec No.

Implementation Required? ☒ Yes ☐ No Calculation Done as a Study Only? ☐ Yes ☒ No

Safety Evaluation Number: N/A

Superseded Calculation Number, Title and Revision: N/A

For Revisions: List CCNs, IIJs, or SAs incorporated/superseded by this revision: N/A

Computer Code(s): None used

Are there open items in this calculation/revision? ☒ Yes ☐ No

Review and Approval: (Print and Sign Name)

Preparer: Gene O'Brien _____ Date: 8/26/03

Interdiscipline (Heat Balance, Att. B only) Preparer(s): N. Zervos _____ Date: 8/26/03

Interdiscipline (Heat Balance, Att. B only) Reviewer(s): R. Srinivasan _____ Date: 8/26/03

Independent Reviewers(s): Mansour Mojibian _____ Date: 8/26/03

Approved: DAN YASI _____ Date: 8/26/03

Accepted (only for AP 0017 calculations performed by vendors) ☐ N/A

Ed Duda _____ Date: 8/27/2003

Final Turnover to DCC (Section 2):

1) All open items, if any, have been closed.

2) Implementation Confirmation (Section 2.3.4)

Total No. Pages in Package 64 (including all attachments)

☐ Calculation accurately reflects existing plant configuration, (confirmation method indicated below)

☐ Walkdown ☐ As-Built input review ☐ Discussion with _____ (Print Name)

OR

☐ N/A, calculation does not reflect existing plant configuration

3) Resolution of documents identified in the Design Output Documents Section of VYAPF 0017.07 has been initiated as required (Section 2.3.6, 2.3.7)

_____ / _____ / _____

Printed Name Signature Date

Page 1 of 28 Pages*

* For calculations performed using AP 0017 this is the number of pages in the body of the calculation. For vendor calculations, this is the number of pages of AP 0017 forms added. (Title page, review forms, data sheets, 50.59, etc.)

2

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3

1 Calculation

1.1 Objective

The purpose of this calculation is to evaluate ambient temperature increases in several plant spaces following the increase in reactor power level to 102% of 120%, hereafter referred to as Extended Power Uprate (EPU). The EPU will increase core thermal power from the current licensed level of 1593 MWt to 1912 MWt. For bounding purposes, the 122% (1950.9 MWt) heat balances are used for EPU HVAC evaluations.

This calculation evaluates the EPU impact on ambient air temperature in the following buildings or areas during normal plant operation:

Reactor Building
- Drywell
- Steam Tunnel
- Other Reactor Building Areas

Turbine Building
- Reactor Feed Pump Room
- Condensate Pump Room
- HP Heater Area (including steam line shelf containing main steam lines)
- LP Heater Area

Note: Comments to this calculation provided by letters PUPVY-03-208 dated 7/16/03 and PUPVY-03-212 dated 7/18/03 have been reviewed and incorporated (see Attachment D).

Increases in area heat gain and ambient air temperatures, as a result of EPU, are predominately caused by increases in operating temperature of piping systems, and equipment, and air-cooled motors operating under increased loads. The preuprate piping system temperatures are selected or extrapolated from a PEPSE Heat Balance that is tuned to match preuprate (current) plant data. The EPU piping system temperatures are selected or extrapolated from a PEPSE Heat Balance that provides the most conservative results.

Affected areas are evaluated to determine the temperature gain due to increases in heat loss from piping and mechanical equipment.

1.2 Summary of Results

The results of this calculation show the effects of the EPU in terms of increased ambient temperature and heat load are due to increased feedwater temperature, as well as increased horsepower from the condensate and feedwater pumps. The ambient temperature increases are specified in Section 1.6 (Results).

(4)

1.3. Method of Solution

This calculation evaluates the temperature increase in a specified area using current fluid and ambient air temperatures and EPU fluid temperatures to predict the EPU ambient air temperature and corresponding temperature rise. PEPSE Heat Balances at 100% CTP and EPU at 122% CTP (References 7 and 8) are used to obtain preuprate and EPU piping temperatures. The increase in heat loss from piping is determined by comparing the ratio of "temperature differential between EPU pipe and area air temperatures" to "differential temperature between pre-uprate pipe and pre-uprate area ambient air".

The basis for using this scaling approach to determine increased heat loss from piping and equipment can be obtained by referencing the ASHRAE Fundamental Handbook (Reference 12) Section 20.

Formula (9) - ASHRAE 20.9 is used for flat surfaces

$q_s = (t_{is} - t_{os})/R$

Formula (10) -ASHRAE 20.9 is used for cylindrical flat surfaces

$q_s = (t_{is} - t_{os}) / [r_s \ln (r_1/r_i)]/k_1 + [r_s \ln (r_s/r_1)]/k_2$

Formula (11) -ASHRAE 20.9 for determining heat flow per area of pipe surface

$q_o = q_s (r_s/t_i)$

Where

q_s = rate of heat transfer per unit area of outer surface of insulation

q_o = rate of heat flow per unit area of pipe surface, Btu/(hr)(ft^2)

R = surface to surface thermal resistance

k = thermal conductivity of insulation at calculated mean temperature.

t_{is} = Temperature of inner surface

t_{os} = Temperature of outer surface

r_i = inner radius of insulation

r_1, r_2 = outer radius of intermediate insulation

r_s = outer radius of insulation

ln = natural or Napernian logarithm

For the purposes of this calculation it can be assumed that there is one layer of insulation, therefore Formula 10 can be simplified as follows:

$q_s = (t_{is} - t_{os}) / [r_s \ln (r_1/r_i)]/k_1$

The increase or delta in heat transfer per unit area of insulation can be stated as follows:

Δq =EPU $[(t_{is} - t_{os}) / [r_s \ln (r_1/r_i)]/k_1]$ / pre-EPU$[(t_{is} - t_{os}) / [r_s \ln (r_1/r_i)]/k_1]$

There is no change in either: r_i, r_s, or r_1,.

Based on the predicted temperature increases in the various process streams it can be assumed that there is no appreciable change between the preuprate and EPU values for k.

Therefore

$\Delta q = EPU\ [(t_{is} - t_{os}) / pre\text{-}EPU[(t_{is} - t_{os})$

Present station operating ambient air temperatures are used in the evaluation. If operating data is not available, plant design area temperatures are used. An iterative process using an Excel spreadsheet is utilized. First, an EPU ambient air temperature is estimated. Next, the EPU area heat gain multiplier is obtained using the ratio of the EPU pipe / ambient air temperature difference to the preuprate (current) pipe / ambient air temperature difference as shown below:

$$\frac{\text{(EPU pipe temperature – EPU ambient air temperature)}}{\text{(preuprate pipe temperature – preuprate ambient air temperature)}} = \text{EPU Area Heat Gain Multiplier}$$

The EPU factor is obtained by subtracting 1 from the EPU heat gain multiplier.

The EPU factor is then multiplied by the preuprate temperature difference between the air in and out of a particular air handling unit to calculate the estimated EPU temperature rise. The temperature rise is then compared to the difference of estimated EPU and preuprate ambient air temperatures. If required, a new EPU ambient air temperature is estimated and the process repeated until the temperature rise is equal to the difference of estimated EPU and preuprate ambient air temperatures.

For Feedwater and Condensate pumps, flows from preuprate and EPU PEPSE Heat Balances along with appropriate pump curves will be used to determine horsepower changes in the respective pump motors to determine the heat gain increase to the room. The percentage increase in heat gain to the room will be utilized with the temperature rise of ventilating/cooling air currently being supplied to the room or area being evaluated.

The heat load from the condensate and feedwater pumps is evaluated by calculating brake horsepower (BHP) at preuprate and EPU flows. BHP is calculated using the following equation from page B-9 of Reference 14:

$Bhp\ (hp) = Q(gpm)*H(ft)*\ \rho(lb_m/ft^3) / [247{,}000 *$ pump efficiency$]$

The flow, Q, is calculated from the mass flow rate specified on the heat balance using the fluid density, ρ, calculated at the average of pump inlet and outlet temperatures. The pump head, H, and efficiency are obtained from the pump curve.

The heat generated is due to pump motor inefficiency and is calculated using Chapter 26, Equation 21 from Reference 12:
$q\ (BTU/hr) = BHP\ (hp)*2545\ (BTU/hr\ hp) *[100-\%\ efficiency]/\ \%\ efficiency$

The heat load due to the pump motor inefficiency is calculated for preuprate and EPU conditions. The overall heat removal capability of the coolers at preuprate conditions is determined and the sensible heat load due to piping is obtained by subtracting pump heat load from cooler heat removal capacity. The piping heat load at EPU is scaled due to the increase in fluid temperature and added to the EPU pump heat load to obtain total heat load for the room. The temperature increase across the coolers is calculated using Equation 39.6(b) from Reference 13:

6

[Tin - Tout]°F = q (Btu/hr) / [cfm * 1.08 (Btu min/(ft^3 hr °F))]

Both the feedwater and condensate pump rooms are evaluated in this manner.

1.4 Inputs and Assumptions

1.4.1 Inputs

The inputs for this evaluation are the fluid temperature in system piping and ambient room temperature of the areas considered. The pre EPU fluid temperatures are obtained from a PEPSE heat balance based upon current plant operating data adjusted to 5.00" Hg. condenser backpressure to obtain maximum fluid temperatures (Reference 7). For those cases where the fluid temperature is not explicitly listed, the temperature is obtained based upon the pressure and enthalpy listed using ASME steam tables (Reference 9). The EPU fluid temperatures are obtained from the 122% heat balance with a condenser pressure of 5.00" Hg (Reference 8) which provided the highest, and therefore conservative, temperatures.

The current ambient steam tunnel and pump room temperatures are obtained from HVAC system design criteria (Reference 5). The main steam tunnel design temperature is 130°F, the reactor feedwater pump room and condensate pump room design temperatures are 105°F. The current HP and LP heater area temperatures are 125°F as taken from the Environmental Qualification Program Manual (Reference 6, page 11). The 20°F Pre-EPU Vent/Cooling Air ΔT contained in the Table below for the HP and LP heater area spaces is based upon transfer air at 105°F.

The design conditions for the air handling units are obtained from Reference 4, except for TRU-5 and TSF1A/1B, which have their design conditions specified in Reference 19.

Table 1.4-1

Area	Equip. ID	Flow, cfm	Tin(°F)	Tout(°F)	ΔT
Reactor Feedwater Pump Room	TRU-1,-2,-3,-4	16,750	105	85	20
Condensate Pump Room	TRU-5	21,400	105	85	20
Condensate Pump Room	TSF-1A/1B	5,000	90	105	15
Drywell	RRU-1,-2,-3,-4	16,000	135	97	38
Main Steam Tunnel	RRU-17A, -17B*	5000	130	105	25

*Per Reference 18, the coils for these coolers are incorrectly piped as parallel flow rather than counter flow

The design inputs for piping are summarized in the table below:

Table 1.4-2

	Pre-EPU pipe Temp °F (Ref. 7)	EPU pipe Temp °F (Ref. 8)	Pre-EPU ambient air Temp °F	Pre-EPU Vent/Clg Air ΔT °F
HP Heater Area				
ESS to FWH1	383.3	403.7	125.0	20.0
FWH1 Shell	383.3	403.7	125.0	20.0
FW to FWH1	330.7	346.4	125.0	20.0
FW lvg FWH1	374.4	392.6	125.0	20.0
Drains lvg FWH1	343.6	356.9	125.0	20.0

(7)

	Pre-EPU pipe Temp °F (Ref. 7)	EPU pipe Temp °F (Ref. 8)	Pre-EPU ambient air Temp °F	Pre-EPU Vent/Clg Air ΔT °F
ESS to FWH2	338.0	358.1	125.0	20.0
FWH2 Shell	338.0	358.1	125.0	20.0
FW to FWH2	299.3	312.5	125.0	20.0
FW lvg FWH2	330.7	346.4	125.0	20.0
Drains lvg FWH2	309.7	322.6	125.0	20.0
LP Heater Area				
ESS to FWH3	305.4	321.2	125.0	20.0
FWH3 Shell	305.4	321.2	125.0	20.0
CND to FWH3	227.6	238.4	125.0	20.0
CND lvg FWH3	296.6	309.8	125.0	20.0
Drains lvg FWH3	235.0	247.4	125.0	20.0
ESS to FWH4	239.0	252.1	125.0	20.0
FWH4 Shell	239.0	252.1	125.0	20.0
CND to FWH4	167.9	180.9	125.0	20.0
CND lvg FWH4	227.6	238.4	125.0	20.0
Drains lvg FWH4	175.1	189.1	125.0	20.0
ESS to FWH5	173.9	181.8	125.0	20.0
FWH5 Shell	173.9	181.8	125.0	20.0
CND to FWH5	135.1	134.7	125.0	20.0
CND lvg FWH5	167.9	180.9	125.0	20.0
Drains lvg FWH5	145.1	141.8	125.0	20.0
CND Pump Room				
CND to CNP	133.8	133.8	105.0	20.0

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	Pre-EPU pipe Temp °F (Ref. 7)	EPU pipe Temp °F (Ref. 8)	Pre-EPU ambient air Temp °F	Pre-EPU Vent/Clg Air ΔT °F
CND lvg CNP	133.1	133.1	105.0	20.0
RFW Pump Room				
CND to RFP	296.6	309.8	105.0	20.0
FW lvg RFP	299.3	312.5	105.0	20.0
Main Steam Tunnel				
FW lvg FW111	374.4	392.6	130.0	25.0
Main Steam	547.6	547.6	130.0	25.0

Pump information:

Reactor Feedwater Pumps

Table 1.4-3

	Preuprate (Reference 7)		EPU (Reference 8)	
Flow	6407526	lb/hr	8048044	lb/hr
# of RFPs	2		3	
per pump	3203763	lb/hr	2682681	lb/hr
Tin	296.6	°F	309.8	°F
Tout	299.3	°F	312.5	°F

Condensate Pumps

Table 1.4-4

	Preuprate (Reference 7)		EPU (Reference 8)	
Flow	6437526	lb/hr	8076444	lb/hr
# of CNPs	3		3	
per pump	2145842	lb/hr	2692148	lb/hr
Tin	133.8	°F	133.8	°F
Tout	133.1	°F	133.1	°F

Drywell information (Reference 17):

Drywell Cooling Load Summary*

Table 1.4-5

Component		Btu/hr
Reactor Pressure Vessel		459,000
Recirc. Pumps, Valves, and Pipe		278,000
Feedwater Pipe & Valves		124,000
Steam Pipe & Valves		212,000
Condensate & Instrument Lead Lines		82,000

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Component		Btu/hr
Control Rod Drive Pipe		50,400
Control Rod Drive Pipe	569,000**	
Clean-up Demineralizer Pipe & Valves		17,800
Shutdown Supply Pipe		8,100
Steam Safety/Relief Valves		206,600
Biological Shield (Gamma Heating)		16,400
Safeguards system Piping (RCIC, LPCI, HPCI, and core spray)		82,000
	Sensible Heat Gain Total, Normal Operation	1,536,300
Steam Leak, Valves	155,000	
	Latent Heat Gain Total, Normal Operation	155,000
	Total Cooling Load, Normal Operation	1,691,300

* Excluding allowance for drywell cooler motors

** Temporary initial load immediately following scram

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1.4.2 Assumptions

For the piping in the main steam tunnel, it is assumed the feedwater piping contributes 1/3 to the total heat gain and the main steam piping contributes 2/3 due to their respective surface areas. This is based upon the fact there are four 18" main steam lines and two 16" feedwater lines. From Reference 14, the external surface area of four 18" pipes is 4 * 4.712 ft^2 per foot of pipe = 18.848 ft^2 per foot of pipe and the external surface area of two 16" pipes is 2 * 4.189 ft^2 per foot of pipe = 8.378 ft^2 per foot of pipe. No confirmation is required.

It is assumed there is no appreciable change between the preuprate and EPU values for the thermal conductivity, k, of the pipe insulation based on the predicted temperature increases in the various process streams.

1.5 Calculation

Piping:
A sample calculation for the estimated temperature rise from the feedwater piping in the steam tunnel is shown below.

Preuprate pipe temp. (°F)	374.4	Reference 7
EPU pipe temp. (°F)	392.6	Reference 8
Preuprate ambient air temp. (°F)	130	Reference 5
Preuprate Air Handling Unit (AHU) ΔT (°F)	25	Reference 4 (RRU-17A, 130 - 105 = 25)

The EPU ambient air temperature is initially estimated at 131 °F. [used for initial iteration and checked later]

The EPU Area Heat Gain Multiplier is obtained using the equation in Section 1.3.

$$\text{EPU Area Heat Gain Multiplier} = \frac{(\text{EPU pipe temperature} - \text{EPU ambient air temperature})}{(\text{preuprate pipe temperature} - \text{preuprate ambient air temperature})}$$

$$\text{EPU Area Heat Gain Multiplier} = \frac{(392.6 - 131)\,°F}{(374.4 - 130)\,°F}$$

EPU Area Heat Gain Multiplier = 1.070

The EPU factor is obtained by subtracting 1 from the EPU Area Heat Gain Multiplier:
EPU factor = 1.070 -1 = 0.070

From Assumptions section, the feedwater piping contributes 1/3 to the total heat gain in the main steam tunnel, so the EPU factor becomes:
EPU factor = 0.070 *1/3
EPU factor = 0.023

The temperature rise is then calculated by multiplying the EPU factor by the AHU temperature differential.
Temp. rise = 0.023 * 25.0 °F = 0.586

The difference between estimated EPU and preuprate ambient air temperatures is:
131 - 130 = 1 (this is not close enough to the calculated temperature rise of 0.586 °F)

Try a different EPU ambient air temperature of 130.6 and repeat the process.

Preuprate pipe temp. (°F)	374.4	Reference 7
EPU pipe temp. (°F)	392.6	Reference 8
Preuprate ambient air temp. (°F)	130	Reference 5
Preuprate AHU ΔT (°F)	25	Reference 4 (RRU-17A, 130 - 105 = 25)

The EPU ambient air temperature is estimated at 130.6 °F.

The EPU Area Heat Gain Multiplier is obtained using the equation in Section 1.3.

$$\text{EPU Area Heat Gain Multiplier} = \frac{(\text{EPU pipe temperature} - \text{EPU ambient air temperature})}{(\text{preuprate pipe temperature} - \text{preuprate ambient air temperature})}$$

$$\text{EPU Area Heat Gain Multiplier} = \frac{(392.6 - 130.6)}{(374.4 - 130)}$$

EPU Area Heat Gain Multiplier = 1.072

The EPU factor is obtained by subtracting 1 from the EPU Area Heat Gain Multiplier:
EPU factor = 1.072 -1 = 0.072

From Assumptions section, the feedwater piping contributes 1/3 to the total heat gain in the main steam tunnel, so the EPU factor becomes:
EPU factor = 0.072 *1/3
EPU factor = 0.024

The temperature rise is then calculated by multiplying the EPU factor by the AHU temperature differential.
Temp. rise = 0.024 * 25.0 °F = 0.6 °F

The difference between estimated EPU and preuprate ambient air temperatures is:
130.6 - 130 = 0.6 (this equals the calculated temperature rise of 0.6 °F)

The temperature rises for the remainder of the pipelines was calculated using the same method using an Excel spreadsheet.

The results are shown in Table 1.5-1.

Table 1.5-1 - Design Temperature Differential

$$\frac{\text{EPU pipe temperature} - \text{EPU ambient temperature}^{*}}{\text{pre/pre pipe temperature} - \text{pre/pre ambient temperature}} \times \text{EPU Area \& Heat Gain Multiplier}$$

	Pre EPU pipe Temp °F (Note 1)	EPU pipe Temp °F (Note 2)	Pre EPU ambient air temp °F (Note 3)	EPU ambient air temp °F (Note 4)	EPU Heat Gain Multiplier	Pipe's percentage of total area heat gain	Weighted Factor	Pre EPU Vent/Clg Air ΔT °F (Note 5)	Discrete EPU Temperature Increase for Specified Item °F	Bulk EPU Temperature Increase for Area °F	Predicted EPU Area Temperature °F	Comments
HP Heater Area												
ESS to FWH1	383.3	403.7	125.0	126.5	1.073	See Comment	0.073	20.0	1.5			
FWH1 Shell	383.3	403.7	125.0	126.5	1.073	See Comment	0.073	20.0	1.5			
FW to FWH1	330.7	346.4	125.0	126.4	1.070	See Comment	0.070	20.0	1.4			
FW kg FWH1	374.4	392.6	125.0	126.4	1.068	See Comment	0.068	20.0	1.4			Determination of what percentage each pipe section contributes to the area heat gain was not performed. Bulk air temperature increase of 1.7°F conservatively based greatest discrete temperature increase
Drains kg FWH1	343.6	358.9	125.0	126.1	1.056	See Comment	0.046	20.0	1.1	1.7	126.7	
ESS to FWH2	338.0	358.1	125.0	126.7	1.087	See Comment	0.087	20.0	1.7			
FWH2 Shell	338.0	358.1	125.0	126.7	1.087	See Comment	0.087	20.0	1.7			
FW to FWH2	299.3	312.5	125.0	126.4	1.068	See Comment	0.068	20.0	1.4			
FW kg FWH2	330.7	346.4	125.0	126.4	1.070	See Comment	0.070	20.0	1.4			
Drains kg FWH2	309.7	322.8	125.0	126.3	1.063	See Comment	0.063	20.0	1.3			
LP Heater Area												
ESS to FWH3	305.4	321.2	125.0	126.8	1.079	See Comment	0.079	20.0	1.6			
FWH3 Shell	305.4	321.2	125.0	126.8	1.079	See Comment	0.079	20.0	1.6			
CND to FWH3	227.6	238.4	125.0	126.8	1.088	See Comment	0.088	20.0	1.8			
CND kg FWH3	256.6	309.8	125.0	126.4	1.069	See Comment	0.069	20.0	1.4			
Drains kg FWH3	235.0	247.4	125.0	126.9	1.096	See Comment	0.096	20.0	1.9			
ESS to FWH4	239.0	252.1	125.0	126.9	1.097	See Comment	0.097	20.0	1.9			
FWH4 Shell	239.0	252.1	125.0	126.9	1.097	See Comment	0.097	20.0	1.9			Determination of what percentage each pipe section contributes to the area heat gain was not performed. Bulk air temperature increase of 4.1°F conservatively based greatest discrete temperature increase
CND to FWH4	167.9	180.9	125.0	129.1	1.207	See Comment	0.207	20.0	4.1	4.1	129.1	
CND kg FWH4	227.6	238.4	125.0	126.8	1.099	See Comment	0.099	20.0	1.8			
Drains kg FWH4	175.1	189.1	125.0	129.0	1.201	See Comment	0.201	20.0	4.0			
ESS to FWH5	173.9	181.8	125.0	127.3	1.116	See Comment	0.116	20.0	2.3			
FWH5 Shell	173.9	181.8	125.0	127.3	1.116	See Comment	0.116	20.0	2.3			
CND to FWH5	135.1	134.7	125.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
CND kg FWH5	167.9	180.9	125.0	129.1	1.207	See Comment	0.207	20.0	4.1			
Drains kg FWH5	145.1	141.0	125.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
RFW Pump Room												
CND to RFP	296.6	319.8	105.0	106.2	1.062	See Comment	0.062	20.0	1.2	N/A	N/A	See Section 1.5 for temperature increase due to pump motors and piping
FW kg RFP	299.3	312.5	105.0	106.2	1.062	See Comment	0.062	20.0	1.2	N/A	N/A	
CND Pump Room												
CND to CNP	133.8	133.8	105.0	105.0	1.000	See Comment	0.000	20.0	0.0	N/A	N/A	See Section 1.5 for temperature increase due to pump motors and piping
CND kg CNP	133.1	133.1	105.0	105.0	1.000	See Comment	0.000	20.0	0.0	N/A	N/A	
Main Steam Tunnel												
FW kg FWH1	374.4	392.6	130.0	130.6	1.072	0.333	0.024	25.0	0.6	0.8	130.8	Determination of 0.8°F temperature rise in tunnel assumed surface area of FW lines represent 33% of Heat Gain
Main Steam	547.8	547.8	130.0	130.0	1.000	0.666	0.000	25.0	0.0			

NOTES:

1 - Pre EPU Pipe temperatures based upon VY PEPSE Heat Balance 59079-HB(0)-103, Rev 0 5/21/03 (See Attachment B)

2 - Post EPU Pipe temperatures based upon VY PEPSE Heat Balance 59079-HB(1)-203 Rev 0 3/18/03

3 - Pre-uprate ambient air temperatures were taken from EBASCO Summary of HVAC Design Criteria and Calculation Data, transmitted by EBASCO letter dated 3/25/76. For areas not specified in the letter, the avg temp from EQ manual

4 - EPU ambient temperature is obtained by manual iteration by simply using pre-uprate ambient air temperature in the numerator of the formula

5 - Pre uprate temperature rise of vented air/cooling air was obtained by taking the difference between area ambient air temperature and based on the HVAC Flow Diagrams one of the following temperatures: outside air, transfer air, or leaving air from area cooler. Referenced EBASCO Summary of HVAC Design Criteria and Calculation Data, transmitted by EBASCO letter dated 3/25/76

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The Total Cooling Load for Normal EPU Operation is: 1,700,675 Btu/hr

The ratio of cooling loads to differential temperatures is:
$q_{epu} / q_{pre} = \Delta T_{epu} / \Delta T_{pre}$
$\Delta T_{epu} = (q_{epu} * \Delta T_{pre}) / q_{pre}$ = (1,700,675 Btu/hr * (135 - 97)°F) / 1,691,300 BTU/hr
ΔT_{epu} = 38.21 °F
Since ΔT_{pre} = 135 - 97 = 38°F
The increase in drywell temperature due to the higher feedwater temperature is:
$\Delta T = \Delta T_{epu} - \Delta T_{pre}$ = 38.2 °F - 38°F
ΔT = 0.2 °F
The ambient drywell temperature at EPU is 135 °F + 0.2 °F = **135.2 °F**

Main Steam Tunnel (RRU-17A, -17B)
q (Btu/hr) = cfm * 1.08 (Btu min/ft^3 hr °F) * [Tin - Tout]°F
q = 5000 cfm * 1.08 (Btu min/ft^3 hr °F) * [130 - 105]°F
q = 1.35 x 10^5 Btu/hr

The main steam tunnel piping is evaluated using the Excel spreadsheet described above. As stated in the assumption section, the temperature rise from the feedwater piping is "weighted" at 33% based upon its surface area ratio when compared to main steam piping. The increased feedwater temperature will result in an ambient temperature increase of approximately **0.6°F** to **130.6°F**. As previously noted, the service water to RRU-17A&B is piped backwards, such that there is parallel flow rather than counter flow (Reference 18). Because of this, both coils are in continuous operation rather than the initial design of one in operation and the other as a back-up. The minimal increase in ambient temperature due to EPU will not adversely affect current operation due to the fact the current peak allowable temperature in the tunnel is 150°F (Reference 6, pg. 10). Also, per Reference 6, Section 7.5.2.5, the high space temperature alarm set point is 160°F and the MSIV close/scram set point is 200°F.

Reactor Feedwater Pump Room (TRU-1,-2,-3,-4)
The heat removal capability of the reactor feedwater pump room is:
q (Btu/hr) = cfm * 1.08 (Btu min/ft^3 hr °F) * [Tin - Tout]°F
q = 4 * 16750 cfm * 1.08 (Btu min/ft^3 hr °F) * [105 - 85]°F
q = 1.45 x 10^6 Btu/hr

From above, the preuprate heat load due to two pumps operating is 0.97 x 10^6 Btu/hr and the EPU heat load due to three pumps operating is 1.47 x 10^6 Btu/hr.

Using the heat removal capability with all four coolers running, the preuprate heat load due to the piping is:
1.45 x 10^6 Btu/hr - 0.97 x 10^6 Btu/hr = 0.50 x 10^6 Btu/hr

The temperature scaling method using the preuprate and EPU heat balances shows the ambient temperature will increase 1.2°F.

The EPU increase in piping heat load due to higher feedwater temperature can be approximated using:
$q_{pre} = mC_p\Delta T_{pre}$ and $q_{epu} = mC_p\Delta T_{epu}$
Since mC_p is the same preuprate and EPU,
$q_{epu} / q_{pre} = \Delta T_{epu} / \Delta T_{pre}$ or
$q_{epu} = q_{pre} * (\Delta T_{epu} / \Delta T_{pre})$

The areas that contain condensate and feedwater piping are the only areas that will experience an ambient temperature increase during normal operation due to EPU. The following systems will not experience an ambient temperature increase during normal operation due to EPU: Reactor Recirculation (RRS), Reactor Core Isolation Cooling (RCIC), Residual Heat Removal (RHR), Reactor Water Clean Up (RWCU), High Pressure Coolant Injection (HPCI) and Core Spray (CS) (References 20 through 25).

Reactor Building open areas
Temperatures in the open areas of the reactor building will not increase during normal operation as a result of EPU (Reference 26).

Control Room
As shown in Calculation VYC-1502 (Reference 28), Section 2.1, heat sources in the control room are from electrical equipment, ambient outside air temperature, and personnel. None of these sources will increase at EPU. Therefore, the Control Room HVAC system's ability to provide appropriate temperature and humidity conditions for personnel and equipment during all modes of operation and emergency condition is not impacted by EPU.

1.6 Results

The results of this calculation are shown in Table 1.6-1 below.

Table 1.6-1

Area	EPU Ambient Temperature Increase (°F)
Drywell	0.2
Main Steam Tunnel	0.6
LP Heater Area	4.1
HP Heater Area	1.7
Feedwater Pump Room	7.6
Condensate Pump Room	3.5

~~The increase in drywell ambient temperature due to the higher EPU feedwater temperature is 0.2 °F to 135.2 °F.~~

The increase in main steam tunnel ambient temperature due to the higher EPU feedwater temperature is 0.6 °F to 130.6 °F.

The results of the piping evaluation are shown in Table 1.5-1. At normal operating EPU conditions, the ambient temperature in the LP heater area will increase approximately 4.1°F to 129.1°F and the HP heater area will increase 1.7°F to 126.7°F.

The increase in feedwater pump room ambient temperature due to the higher EPU feedwater temperature is 7.6 °F to 112.6 °F. This result was achieved using both design and empirical information.

The increase in condensate pump room ambient temperature due to the higher EPU feedwater temperature is 3.5 °F. The ambient temperature in the condensate pump room at EPU based upon design information is 113.2 °F and 122.5°F based upon empirical data.

It is noted that the temperatures obtained in this calculation are conservative maximum temperatures for the purposes of obtaining bounding temperature increases within the subject areas. Actual EPU maximum temperatures are anticipated to be lower than those calculated.