HPCI Room Thermal Response With Loss of HPCI Room Cooler at Dresden Station

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1. Introduction

The purpose of this calculation is to document the thermal response of the HPCI room to events in which the heat removal capability of the room cooler subsystem is unavailable. This condition could occur if the normal service water cooling path is lost due to a loss of offsite power. Assuming a loss of cooling function concurrent with maximum estimated heat load to the HPCI room, the HPCI room would experience increasing temperatures, moderated only by heat transfer to the structures. The room heatup would continue until the HPCI steam line isolation setpoints were reached, at which time the function of the HPCI system would be lost. This analysis quantifies the time required to reach this point and demonstrates that this time is large compared to the maximum expected operating time of the HPCI system.

Two cases are presented in this calculation. The first case is the thermal heatup of the HPCI room based on conservatively selected heat loads and heat transfer coefficients, and represents the design basis case. The second case is presented for information, and represents the thermal response of the HPCI room in the event of extended operation with gland condenser failure and significant steam leakage to the room. Both cases demonstrate that significant time exists for operation of the HPCI system in the event that cooling water is lost to the room cooler.

This report is intended to become the analysis of record for this event, and supercedes previous HPCI room heatup calculations [References 1, 2, and 3]. It is based on changes and improvements in methodology developed in the process of regulatory review.

2. Description of Analysis

All analyses represented in this report were performed with the RELAP 4 Mod 6 computer code as installed on the CECo computer system. This version of the code contains an equation of state for air and has the ability to transport air between nodes. The code has a default minimum heat transfer coefficient of 5.0 BTU/HR/FT2-F, which necessitates adjustment of the geometry of the heat slabs to simulate alternative convection coefficients. The validity of the computer code and attendant methodology is demonstrated in Reference 4.

2.1 General Input Assumptions Utilized

The analyses presented in this report are dependent on several key assumptions, controllable by station personnel, to ensure validity in application to plant operation. They are:

1. The room cooler is assumed to be functioning as a fan, with a flow rate of 4750 cfm. The cooling water is assumed to be unavailable throughout the event. This assumption guarantees that the mixing of air in the room is good, and justifies the use of the lumped parameter, average room temperature treatment performed here.

2. The initial temperature of the room is assumed to be 120 F or less during normal operation. A sensitivity on the initial temperature of the room is included to demonstrate that operability is assured even when performing HPCI surveillance testing that potentially could lead to temperatures between 120 and 130 F.

3. The HPCI room temperature isolation setpoint is nominally set at 180 F, with an uncertainty of less than 5 F. A maximum temperature of 175 F is assumed to be the lowest temperature that would result in isolation of the HPCI steam lines.

Additionally, the following assumptions were utilized in the performance of these calculations:

1. The operation of the HPCI system (and therefore the applied heat load) is continuous. The heat load is assumed to be equal to the designed capacity of the room cooler at 200,000 BTU/HR

2. The thermal properties of the concrete walls are:

Conductivity	1.05 BTU/HR-FT-F
Heat Capacity	30.24 BTU/FT3-F

3. The thermal capacity of the steel structures inside the HPCI room are neglected for conservatism.

4. The soil temperature is assumed to be 65 F. The effective heat transfer coefficient from the concrete to the soil is dependent on semi-infinite slab dynamic calculations presented in the Appendix.

5. The temperature of adjacent rooms is assumed to be constant at the EQ zone map temperatures. This is 104 F for all rooms in this analysis

2.2 HPCI Room Heatup with Detailed Wall Models

The original analyses were based on the use of the simple model depicted in Figure 1. This model relied on limiting heat transfer through the walls to guarantee conservatism. In this analysis a more refined model was utilized, subdividing the heat structures representing the walls, floor and ceiling of the HPCI room into six separate heat structures. This model is shown in Figure 2. The walls were explicitly modeled to their actual thickness (3 feet for walls and ceiling, 4 feet for the floor) and two sided conduction was modeled. Heat transfer to the soil was allowed, although at a greatly reduced heat transfer coefficient (0.3 BTU/HR/FT2-F). The other surfaces used overall heat transfer coefficients determined as the combination of natural convection and grey gas radiation components. A detailed description of the calculation of these overall coefficients is provided in the Appendix. These coefficients ranged from 0.5 for the floor to 1.0 for the ceiling. The wall heat transfer coefficient was 0.91 BTU/HR/FT2-F.

2.3 HPCI Room Heatup with Postulated Gland Seal Leakage

An additional case was run to provide insight into the room heatup behavior resulting from postulated leakage of gland seal steam. It is noted that this case yields heat loads beyond those for which the room coolers were originally designed to accomodate, and is reported here to support the current EQ classification of the gland exhaust fan and condenser (eg. not qualified to elevated temperatures). A review of the UFSAR (Section 6.2.5.3.3.5) indicated that for a fully pressurized turbine casing with a locked turbine rotor, the gland condenser would over pressurize due to loss of cooling water and seal steam would be released to the room. The leakage for this case is 2160 lb/hr, and the HPCI system is assumed to isolate on high room temperature within 15 minutes.[Reference 5] Figure 3 provides a diagram of the gland seal system.

In this scenario, the turbine is assumed to be continuously operating, and cooling water would be supplied to the gland exhaust condenser. The gland exhaust fan is not currently on the EQ list and could be postulated to fail eventually due to elevated room temperatures. In the event of gland exhaust fan failure, the removal of non-condensable from the condenser would be impaired, which would lead to a degradation of the condensation heat transfer. For the purposes of this evaluation, a constant value of seal leakage to the HPCI room of 10% of the locked rotor scenario was analyzed.

Since significant steam leakage was postulated in this case, the use of a condensing coefficient for the heat transfer slabs is warranted. Several values were utilized ranging from the overall coefficients used in the above analysis to 2.0 BTU/HR/FT2-F (the default minimum Uchida correlation value for high air/water ratios) to 5.0 BTU/HR/FT2-F (judged to be the most reasonable average value over time). [Reference 6]

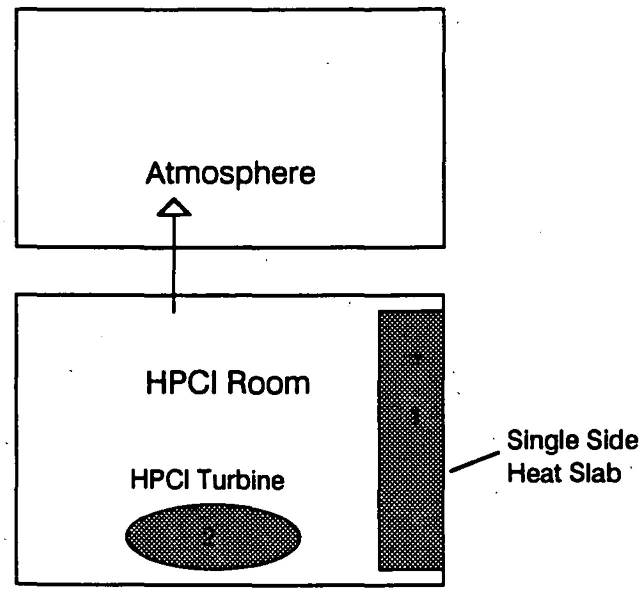


Figure 1 Original HPCI Room Model

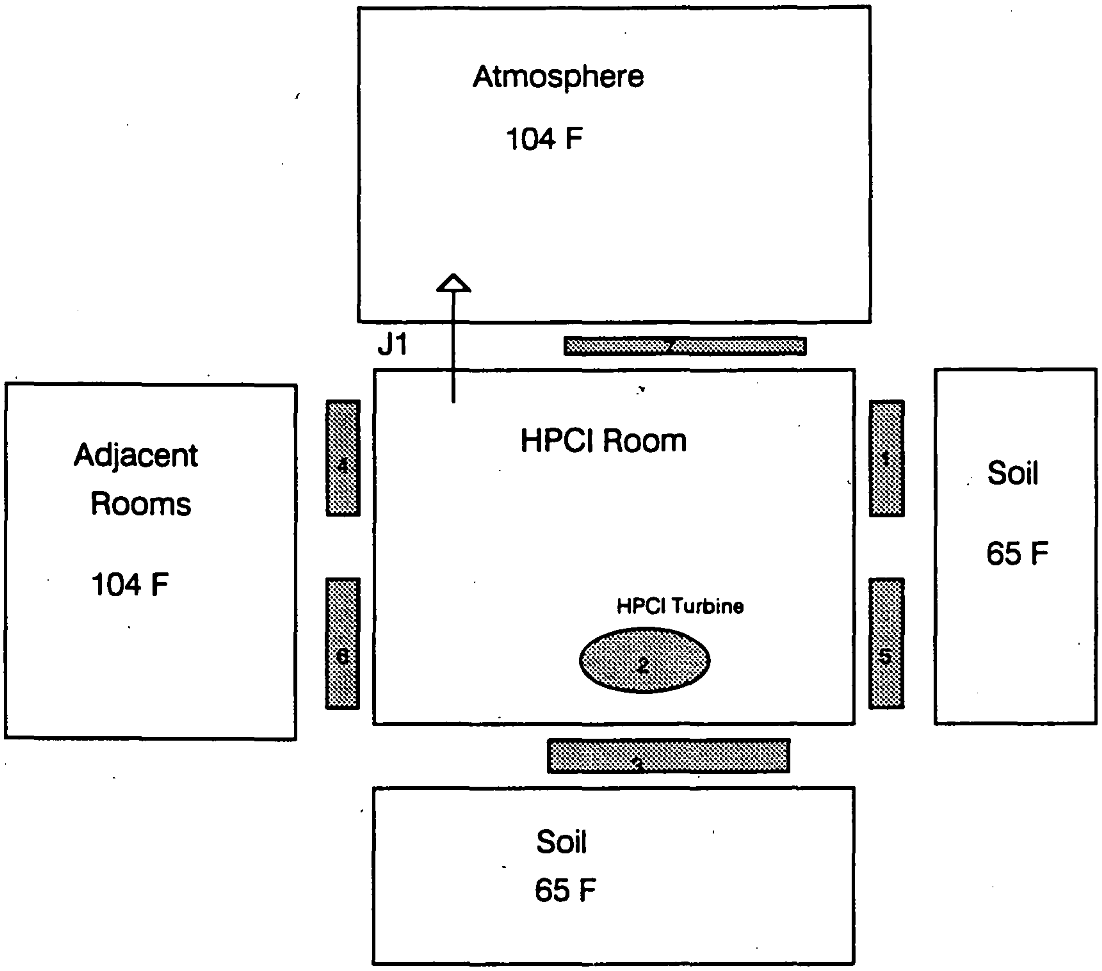


Figure 2 Diagram of Revised HPCI Room Model

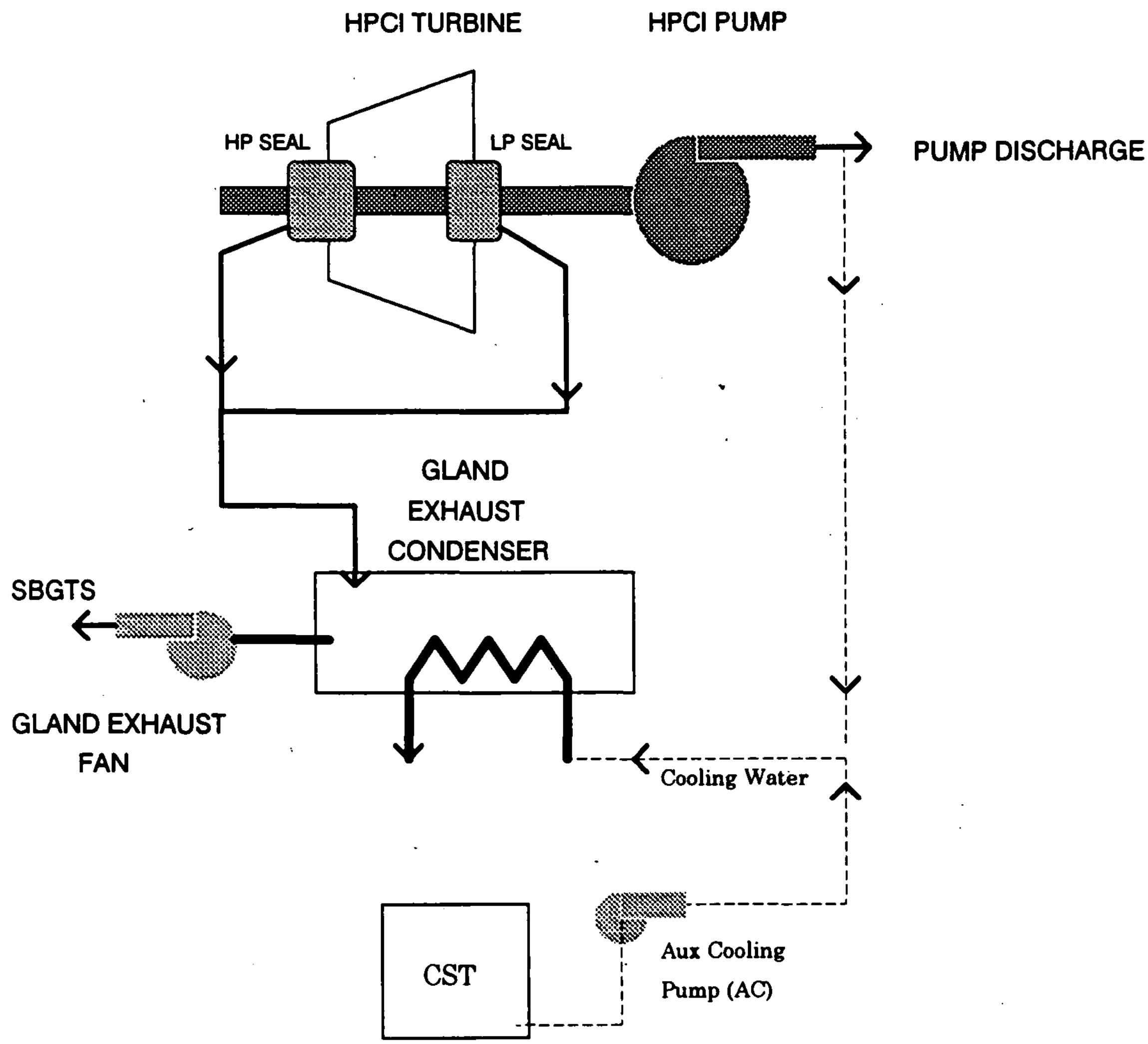


Figure 3 Gland Seal System Flowpaths

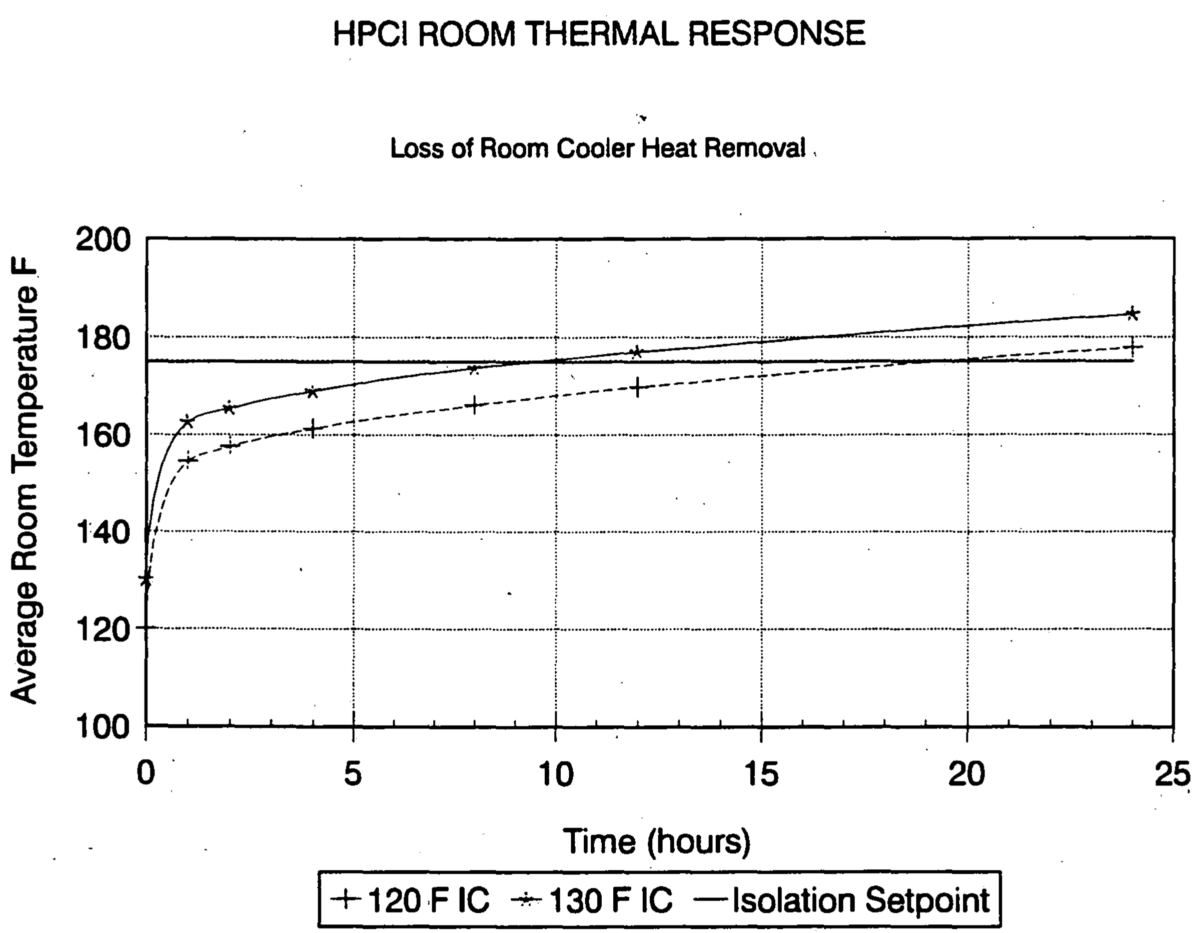
3.0 Results of Calculations

3.1 HPCI Room Heatup with Detailed Wall Models

Two cases were run covering a range of initial temperatures from 120 F (normal maximum anticipated) to 130 F (Elevated room temperature due to surveillance testing). The results of this calculation demonstrate that the heatup of the room from 120 F to 175 F would take over nineteen hours. Starting at elevated room temperature would reduce this time to nine hours. It should be noted that this time reduction is overpredicted, since the methodology assumes that the concrete walls are in equilibrium with the elevated temperature. The duration of surveillance is generally far too short to accomplish this equilibrium condition. The results are shown in Figure 4.

3.3 HPCI Room Heatup with Postulated Gland Seal Leakage

This case builds on the previous case to include the effects of the seal steam leakage into the room following postulated loss of the gland exhaust fan. For this calculation, a seal leakage of 216 lb/hr was assumed, representing 10% of the locked rotor steam leakage rate for a faulted condenser and limiting pressure at both ends of the turbine casing. Since steam addition would lead to condensation on structures, the Uchida correlation was utilized to determine appropriate values of heat transfer coefficients on the internal HPCI room surfaces. Two cases were run, one using the default minimum value of the Uchida correlation (h=2.0), and the other using a nominal value based on the air steam mass ratios existing (h=5.0) . The results of these cases are shown in Figure 5. These results clearly demonstrate that significant time (8-16 hours) is required to reach the isolation limits, even with a high rate of steam leakage to the room.



Minimum Temperature limit (with uncertainty)

Figure 4. HPCI Room Thermal Response

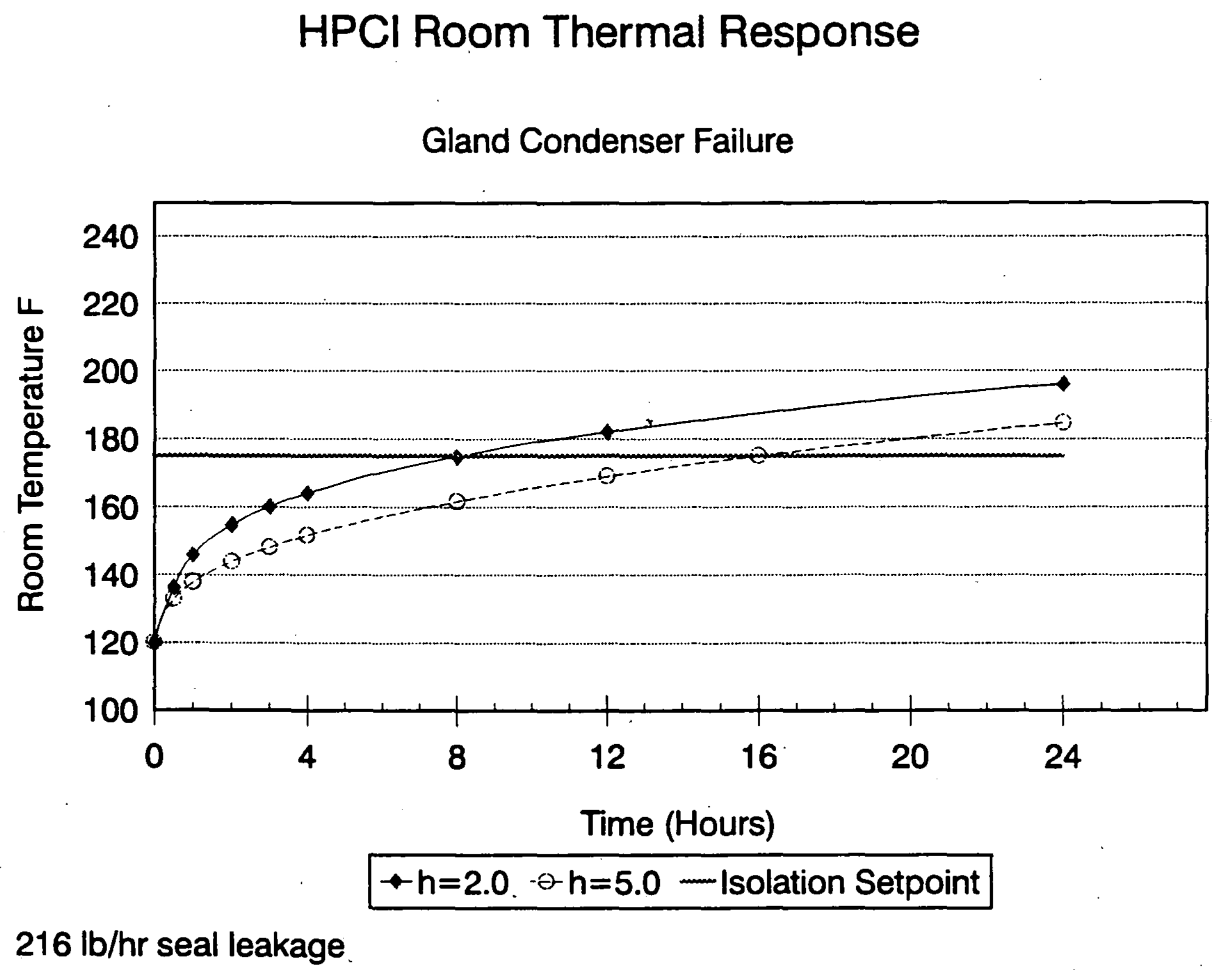


Figure 5. HPCI Room Response to Gland Seal Condenser Leakage

4.0 Conclusions

The HPCI room thermal response has been determined for a range of postulated conditions. The more detailed consideration of heat transfer structures illustrates that HPCI operation without ventilation or room coolers could continue for extended periods of time, well beyond anticipated operational requirements (less than four hours). These calculations have been performed in a conservative fashion, and assume continuous HPCI operation with heat load to the room constant at the capacity of the room cooler. In the seal steam leakage case, constant seal leakage from start of the HPCI was assumed, ignoring both the anticipated cyclic operation of the HPCI and the time required to achieve degradation of condensation in the gland exhaust condenser. This clearly bounds the manner in which HPCI would operate in transient and accident scenarios, and demonstrates that operation of the HPCI without room coolers does not compromise the operability of the HPCI system.

References

1. "ECCS Pump Room Transient Response to Loss of Room Cooler for Dresden Station Units 2 and 3" , RSA-D-89-01.

2. "ECCS Pump Room Transient Response to Loss of Room Cooler for Dresden Station Units 2 and 3" , RSA-D-90-01.

3. "An Evaluation of Loss of HPCI Room Cooler at Dresden Station", RSA-D-92-04.

4. "Validation of Loss of HPCI Room Cooler Analysis at Dresden Station", RSA-D-92-05.

5. Dresden UFSAR, current to 8/92.

6. "CONTEMPT 4/Mod5: An Improvement to CONTEMPT 4/Mod4 Multicompartment Containment System Analysis Program for Ice Containment Analysis" , NUREG/CR-4001, BNL-NUREG-51824, C. C. Lin. Section 3.9.1.2.2

Listing of Computer Cases

Job Identifier	Job Number	Case Description
NFSKR1	JO 9804	Base Case with Reduced HT Initial Temp=120F
NFSKR2	JO 9823	Base Case with Reduced HT Initial Temp=130F
NFSKRC	JO 3980	Revised model with seal leak HTC=2.0 BTU/HR/FT2-F
NFSKRD	JO 9739	Revised model with seal leak HTC=5.0 BTU/HR/FT2-F

Appendix

The following pages provide detailed description of the calculation of the surface heat transfer coefficients used in the analysis.

Calculation of Overall Heat Transfer Coefficients

This calculation provides the basis for the selection of overall heat transfer coefficients used in the HPCI room heatup RELAP calculations. The overall heat transfer coefficient is based on the sum of the turbulent natural convection coefficient and the equivalent gas radiation heat transfer to the walls. Both of these components is dependent on the temperature difference between the air and the wall surface. Therefore the first step is to determine an appropriate value of temperature difference, based on the heat load and the heat transfer area.

$Heatload := 200000$

$Area := 2 \cdot (1274 + 1300 + 612.5)$

$\frac{Heatload}{Area} = 31.382$ Btu/hr-ft2

Given this value of heat flux needed, and an assumed overall coefficient of heat transfer U, the temperature difference can be estimated.

$U := 1.0$

$TD := \frac{Heatload}{Area \cdot U}$

$TD = 31.382$

We will use a value of TD=30F for determining the heat transfer coefficients

Calculation of Radiative Heat Transfer From Gas to Walls

(Based on CONTEMPT 4 Mod5 Grey gas/grey wall model)
This calculation is performed in SI units and converted to British units for use in RELAP

$T := 120, 130 .. 150$

Gas Temperature (K) **Wall Temperature (K)**

$TG(T) := (T + 30 - 32)\cdot\frac{5}{9} + 273$ $TW(T) := (T - 32)\cdot\frac{5}{9} + 273$

TW(T)
321.889
327.444
333
338.556

$\tau(T) := \frac{TG(T)}{1000}$

$V := 3.185\cdot10^{4}\cdot28317$ HPCI ROOM VOLUME (cm3)

$A := 2\cdot(1274 + 1300 + 612.5)\cdot929$ HPCI ROOM SURFACE AREA (cm2)

$L := 3.4\cdot\frac{V}{A}$ $L = 517.936$ Hemispheric beam length cm

The vapor pressure is psat for T=120F times .95, the relative humidity times a correction to yield the appropriate vapor pressure following heatup.. Note that this conservatively assumes that the HPCI system operates with zero steam leakage

$Pv(T) := 1.6927\cdot0.0689\cdot0.95\cdot\frac{TG(T)}{321.9}$

$\beta(T) := \log(Pv(T)\cdot L)$

$a0(T) := -2.2118 - 1.1987\cdot\tau(T) + 0.035596\cdot\tau(T)^2$

$a1(T) := 0.85667 + 0.93048\cdot\tau(T) - 1.4391\cdot\tau(T)^2$

$a2(T) := -0.10838 - 0.17156\cdot\tau(T) + 0.045915\cdot\tau(T)^2$

$\varepsilon Tref(T) := e^{\left[a0(T) + a1(T)\cdot\beta(T) + a2(T)\cdot\beta(T)^{(2)}\right]}$ emissivity at reference conditions, 1 atm Pv=0

εTref(T)	T
0.264	120
0.262	130
0.26	140
0.259	150

$Pt := 14.7\cdot0.0689$

$Pe(T) := Pt\cdot\left(1 + 4.9\cdot\sqrt{\frac{273}{TG(T)}}\cdot\frac{Pv(T)}{Pt}\right)$

$\beta m(T) := \log\left(13.2\cdot\tau(T)^2\right)$

Correction factor cw to get the emissivity at the design conditions of T and P

$cw(T) := (1.149 - 0.412\cdot\tau(T))\cdot(\log(Pe(T)))\cdot e^{(0.5\cdot(\beta m(T) - \beta(T)))} + 1.0$

$\varepsilon t(T) := cw(T)\cdot\varepsilon Tref(T)$

εt(T)	cw(T)
0.286	1.083
0.284	1.084
0.282	1.084
0.281	1.085

Now develop absorptivity of water vapor, using the Hottel method described in the Contempt4-M5 manual on page 69

$$\tau(T) := \frac{TW(T)}{1000}$$

$$\beta(T) := \log\left(Pv(T)\cdot L\cdot\frac{TW(T)}{TG(T)}\right)$$

$$a0(T) := -2.2118 - 1.1987\cdot\tau(T) + 0.035596\cdot\tau(T)^2$$

$$a1(T) := 0.85667 + 0.93048\cdot\tau(T) - 1.4391\cdot\tau(T)^2$$

$$a2(T) := -0.10838 - 0.17156\cdot\tau(T) + 0.045915\cdot\tau(T)^2$$

$$\varepsilon Trefw(T) := e^{\left[a0(T) + a1(T)\cdot\beta(T) + a2(T)\cdot\beta(T)^{(2)}\right]}$$

εTrefw(T)
0.269
0.267
0.266
0.264

$$Pt := 14.7\cdot 0.0689$$

$$Pe(T) := Pt\cdot\left(1 + 4.9\cdot\sqrt{\frac{273}{TG(T)}}\cdot\frac{Pv(T)}{Pt}\right)$$

$$\beta m(T) := \log\left(13.2\cdot\tau(T)^2\right)$$

$$cw(T) := (1.149 - 0.412\cdot\tau(T))\cdot(\log(Pe(T)))\cdot e^{(0.5\cdot(\beta m(T) - \beta(T)))} + 1$$

$$\varepsilon tw(T) := cw(T)\cdot\varepsilon Trefw(T)$$

εtw(T)
0.291
0.289
0.288
0.286

cw(T)
1.083
1.083
1.084
1.085

$$\alpha T(T) := \varepsilon tw(T)\cdot\left(\frac{TG(T)}{TW(T)}\right)^{0.45}$$

αT(T)
0.298
0.296
0.294
0.293

absorptivity of vapor

$\varepsilon w := 0.95$

$\sigma := 5.67 \cdot 10^{-12}$

$Q(T) := \sigma \cdot A \cdot \varepsilon w \cdot \left(\varepsilon t(T) \cdot TG(T)^4 - \alpha T(T) \cdot TW(T)^4\right)$

Q(T)
$1.788 \cdot 10^4$
$1.856 \cdot 10^4$
$1.925 \cdot 10^4$
$1.993 \cdot 10^4$

Note Q is in units of watts
now converting to BTU/HR yields a total radiant heat transfer for a 30 F delta t

$QR(T) := Q(T) \cdot 3.412$

QR(T)
$6.1 \cdot 10^4$
$6.333 \cdot 10^4$
$6.567 \cdot 10^4$
$6.802 \cdot 10^4$

Radiant heat transfer (BTU/HR)

$Area = 6.373 \cdot 10^3$ ft2

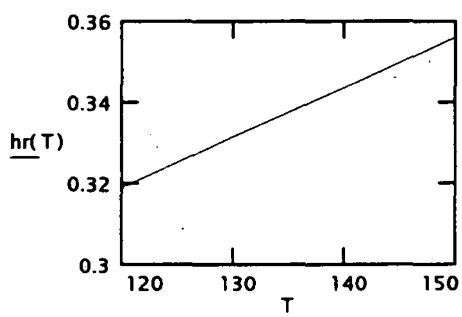
$DT := 30$

temperature difference

$hr(T) := \frac{QR(T)}{Area \cdot DT}$

equivalent radiation "heat transfer coefficient" (BTU/HR-FT2-F)

hr(T)	T
0.319	120
0.331	130
0.344	140
0.356	150



Note that in the application to the HPCI room heatup calculations, the room temperatures typically range from 120 initially to over 175 F at the conclusion of the calculation. For conservatism the radiation component will be based on the value at 120 F.

Calculation of Natural Convection Heat Transfer Coefficients

Heat transfer coefficients will be calculated for the interior and exterior surfaces of the HPCI room. The interior coefficients are based on a 30 degree delta T, while the exterior surfaces utilize a delta T of 10 F. The formulas used are from McAdams and use coefficients consistent with the properties of air at elevated temperatures (200 F) which is conservative in this calculation.

Vertical Walls

Internal Surface $\Delta T := 30$

$$h := 0.19 \cdot \Delta T^{\frac{1}{3}}$$

$h = 0.59$

$UW(T) := h + hr(T)$ Add the radiative and convective components to get overall coefficient

UW(T) Btu/Hr-FT2-F

0.909
0.922
0.934
0.946

External Surface $\Delta T1 := 10$

$$HWALL1 := 0.19 \cdot \Delta T1^{\frac{1}{3}}$$

$HWALL1 = 0.409$ This coefficient is for the outside wall surfaces and is based on a delta T of 10 F.

Ceiling

Internal Surface

$h := 0.22 \cdot \Delta T^{\frac{1}{3}}$

$h = 0.684$

$UC(T) := h + hr(T)$

UC(T)

1.003
1.015
1.027
1.039

Btu/Hr-FT2-F

External Surface

$HCEIL1 := 0.22 \cdot \Delta T1^{\frac{1}{3}}$

$HCEIL1 = 0.474$

This coefficient is for the outside ceiling surface and is based on 10 F delta T and no radiation HT

Floor

$h := 0.13 \cdot \left(\frac{\Delta T}{8.44}\right)^{.25}$

$h = 0.178$

$UF(T) := h + hr(T)$

UF(T) Btu/Hr-FT2-F

0.498
0.51
0.522
0.534

DRESDEN HPCI ROOM GEOMETRY

The HPCI room will be modeled as a rectangular shaped room. The sump volume will be ignored for conservatism.

Reference drawings B-627, B-628

$Height := 25$

$Width := 24.5$

$Depth := 52$

$Vol := Height \cdot Width \cdot Depth$

$Vol = 3.185 \cdot 10^4$

Calculate wall areas

The walls are 3 foot thick concrete(steel reinforced)
The ceiling is also 3 foot thick
The floor is 4 foot thick slab

Will need six slabs to model heat transfer

Floor/Ceiling Slabs

$Area := Depth \cdot Width$

$Area = 1.274 \cdot 10^3$

$tc := 3$ $tf := 4$

$Volf := Area \cdot tf$

$Volc := Area \cdot tc$

$Volf = 5.096 \cdot 10^3$

$Volc = 3.822 \cdot 10^3$

Wall Slabs
will model as four slabs
East West walls
one wall faces other HPCI room other connects to soil

$Area12 := Depth \cdot Height$

$Area12 = 1.3 \cdot 10^3$

$tw := 3$

$Volw12 := Area12 \cdot tw$

$Volw12 = 3.9 \cdot 10^3$

North South Walls
One wall will face torus room, other ends in soil

$Area := Height \cdot Width$

$Area = 612.5$ $tw := 3$

$Volw34 := Area \cdot tw$

$Volw34 = 1.838 \cdot 10^{3}$

HEAT SLAB INPUT PARAMETERS
Since RELAP defaults to 5.0 HTC , we need to adjust the areas accordingly to simulate different values of HTC. Minimal values of radiative plus convective HTCs will be applied in the model.

$HWALL := UW(120)$ $HWALL = 0.909$ $HRELAP := 5.0$

$HFLOOR := UF(120)$ $HFLOOR = 0.498$

$HCEIL := UC(120)$ $HCEIL = 1.003$

$HCEIL1 = 0.474$ $HWALL1 = 0.409$

$HSOIL := 0.3$

$AWALLNS := 612.5$

$AWALLEW := 1300$

$AFLOOR := 1274$

North Wall (RELAP Model Slab 6)

$AHTL := \frac{HWALL}{HRELAP} \cdot AWALLNS$ $AHTL = 111.406$

$AHTR := \frac{HWALL1}{HRELAP} \cdot AWALLNS$ $AHTR = 50.144$

South Wall (RELAP Model Slab 5)

$AHTL := \frac{HWALL}{HRELAP} \cdot AWALLNS$ $AHTL = 111.406$

$AHTR := \frac{HSOIL}{HRELAP} \cdot AWALLNS$ $AHTR = 36.75$

East Wall (RELAP MODEL Slab 1)

$$AHTL := \frac{HWALL}{HRELAP} \cdot AWALLEW$$ AHTL = 236.453

$$AHTR := \frac{HSOIL}{HRELAP} \cdot AWALLEW$$ AHTR = 78

West Wall (RELAP Model Slab 4)

$$AHTL := \frac{HWALL}{HRELAP} \cdot AWALLEW$$ AHTL = 236.453

$$AHTR := \frac{HWALL1}{HRELAP} \cdot AWALLEW$$ AHTR = 106.429

Floor (RELAP Model Slab 3)

$$AHTL := \frac{HFLOOR}{HRELAP} \cdot AFLOOR$$ AHTL = 126.778

$$AHTR := \frac{HSOIL}{HRELAP} \cdot AFLOOR$$ AHTR = 76.44

Ceiling (RELAP Model Slab 7)

$$AHTL := \frac{HCEIL}{HRELAP} \cdot AFLOOR$$ AHTL = 255.476

$$AHTR := \frac{HCEIL1}{HRELAP} \cdot AFLOOR$$ AHTR = 120.769

Determination of Soil Effective Heat Transfer Coefficient

To facilitate the calculation of through wall heat transfer to the soil, a surface heat transfer coefficient representing the flow of heat from the wall into the soil is desired. This is determined as follows:

HEAT Flow=hA(Tw-Tsoil)=kA/x(Tw-Tsoil)

where Tw=temperature at outside of wall
Tsoil=temperature at a distance x into the soil

This reduces to h=k/x

and the difficulty is then to define an appropriate value for x.
This can be done by treating the soil as a semi-infinite slab and solving for the thermal penetration as a function of time. From Incropera,

$\rho := 2050 \cdot .062428$ $\rho = 127.977$

$k := 0.52 \cdot 0.57782$ $k = 0.3$

$cp := 1840 \cdot 2.3886 \cdot 10^{-4}$ $cp = 0.44$

$\alpha := \frac{k}{\rho \cdot cp}$ $\alpha = 0.005$

$\eta := 1, 1.1 .. 2$

$T(\eta) := \text{erf}(\eta)$

T is a dimensionless temperature ratio, and erf is the gaussian error function integral.

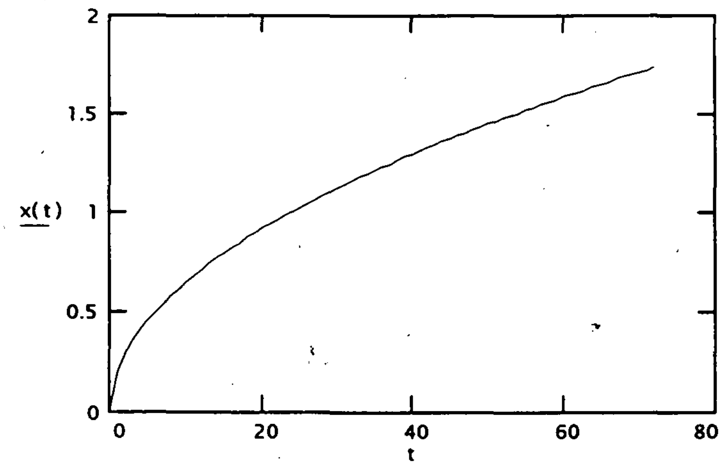
$T(\eta)$	η
0.843	1
0.88	1.1
0.91	1.2
0.934	1.3
0.952	1.4
0.966	1.5
0.976	1.6
0.984	1.7
0.989	1.8
0.993	1.9
0.995	2

This demonstrates that at a value of eta equal to 1.4, the temperature at some distance into the soil would increase to 95% of its final steady state value. Therefore solving the relationship for this value of eta will yield the time and affected distance into the soil.

$t := 0, 1 .. 72$

$\eta := 1.4$

$x(t) := \eta \cdot 2 \cdot \sqrt{\alpha \cdot t}$



The HPCI Room heatup calculations typically occur over a span of approximately 24 hours, therefore the value of x at 24 hours will be used.

$x(24) = 1.003$

$$h := \frac{k}{x(24)}$$

$h = 0.3$ Btu/hr-ft2-F

Use of this value for the external surface of the HPCI room walls is conservative, since the actual value would be a function of time and start large and become smaller with time. Since a constant single value selected at the end of an interval desired is being used, this approach is conservative.

ENCLOSURE 2
CECo Calculation RSA-D-92-07

LPCI Room Temperature Response Due to Loss of Room Cooler at Dresden Station

LPCI Room Temperature Response due to Loss of Room Cooler at Dresden Station

Document Number RSA-D-92-07

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Abstract

This calcnote documents analysis performed to demonstrate the operability of the LPCI system is not compromised by the loss of heat removal capability of the room coolers. This condition could occur if the normal service water is lost due to a loss of offsite power. The temperature response in the LPCI room due to a loss of room cooler concurrent with a LOCA was calculated conservatively. It shows that the EQ temperature is not exceeded during extended LPCI system operation without the room coolers. The analysis incorporates methods discussed with the NRC reviewers in recent meetings. This calcnote provides final documentation in support of room cooler operation as related to LPCI system operability and is intended to supersede the results of previous analyses.

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List of Illustrations

1.0 Introduction

The purpose of this calculation is to document the thermal response of the LPCI room to events in which the heat removal capability of the room cooler subsystem is unavailable. This condition could occur if the normal service water cooling path is lost due to a loss of offsite power. Assuming a loss of cooling function concurrent with maximum estimated heat load to the LPCI room, the LPCI room would experience increasing temperatures, moderated only by heat and mass transfer out of the room. In the unlikely event of a LOCA, the room heatup must not exceed the EQ (equipment qualification) temperature of the essential mechanical, electrical and structural components located within the room for an extended period of time. This analysis conservatively calculates the temperature response and demonstrates that the EQ temperature is not exceeded.

This report is intended to be the analysis of record for this event, and supersedes the results of previous LPCI room heatup calculations (References 1, 2 and 3). It is based on changes and improvements in methodology developed in the process of regulatory review.

2.0 Method of Analysis

The LPCI room temperature response was calculated by a RELAP4 system model. The following sections describe the transient, computer code, model and the assumptions used in the analysis.

2.1 Description of Transient

The analysis assumes a LOCA concurrent with the loss of heat removal capability of the room coolers. This condition could occur if the normal service water path is lost due to a loss of offsite power. The normal ventilation to the LPCI pump room is also lost. Upon the initiation of the LPCI system to mitigate the consequences of the LOCA, the pump room temperature would start to increase due to the heat generated by the running pump. The pump is assumed to run continuously.

2.2 Computer Code

The RELAP4/MOD6 (Reference 4) computer code was used in this analysis. RELAP4 is a computer code written to model system fluid conditions including flow, pressure, temperature, mass inventory, fluid quality, and heat transfer. It is primarily applied in the study of system transient response to postulated perturbations. This version of the code contains an equation of state for air and has the ability to transport air between nodes. The code was installed in the CECo computer system in accordance with approved Company procedures and requirements for design application computer codes. The name of the current CECo load module is M2720 with site ID of RELAP/IO6 02/23/78 (Reference 5).

2.3 Analytical Model

The limiting case that would result in the highest LPCI room temperature is when both ECCS trains are running because both pump rooms share the same heat sinks in the reactor building and the torus room. For this case, both pump room temperature responses are identical or symmetrical. Therefore, only one pump room and one half of the volume and heat sink areas in the reactor building and torus room are used in the analytical model.

The analytical model is shown in Figure 1. It consists of three volume nodes representing the LPCI pump room, the reactor building floors above Elevation 517, and the torus room. Five additional nodes are used to model the outdoor air, soil adjacent to the building walls, soil underneath the floors, the turbine building and the reactor building of the sister unit. A time dependent volume is used to prescribe the post-LOCA torus water temperature.

Heat transfer to walls, ceilings and floors is modelled with fourteen heat slabs. The heat load in the pump room is modelled by a heat slab with constant power generation. The heat slab dimensions are listed in Table 1.

As the room heats up, the room would act like a chimney by drawing air from the torus room through openings in the wall and discharging the air to the reactor building. After passing through the reactor building, the air is returned to the torus room through openings between the reactor building and the torus room. Thus an air circulation path is formed that would contribute to the heat removal in the pump room. This air circulation path is modelled by three flow junctions. Since the amount of air circulated affects the room temperature, LPCI room 2A which has the smallest opening was modelled. The results of References 1 and 2 confirm this selection.

2.4 Input Assumptions and Parameters

The following input assumptions and parameters were used in the analysis.

1. The pump room air temperature is assumed to be uniform and no significant stratification exist within the room. Data from the Quad Cities test (Reference 6) shows all sensor readings fall within a 2 degree band around the average room temperature during a 90 minute run of the RHR pumps without room coolers. This is due to the thorough mixing of air caused by the ECCS pump motor fan and the room cooler fans. Measured data from Dresden shows that the exhaust air flow from each of the three pump motors is approximately 48,000 cfm

(Reference 7). Since the room volume is approximately 25,000 cu ft, thorough mixing of air can be assumed.

2. The initial pump room and torus room conditions are 14.7 psia, 104 deg F and 95% relative humidity. The torus water temperature history is taken from the LOCA analysis which assumed the operation of one RHR cooling loop with one RHR pump, two RHR service water pumps and one RHR heat exchanger. This assumption resulted in higher torus water temperature as compared to two RHR loop operation. The temperature history is given in Figure 5.2.19 (Case d) of the Quad Cities UFSAR and is reproduced in Figure 2.

3. The initial reactor building conditions are 14.7 psia, 104 deg F and 95% relative humidity. This is the conditions that would exist following a LOCA as listed in the EQ zone maps (Reference 8). The temperature of the turbine building and the reactor building of the sister unit is assumed to be constant at 104 deg F throughout the transient.

4. Normal pump room ventilation is assumed to be off throughout the transient.

5. The heat load in the LPCI room was taken from Reference 9. It consists of two components, a fixed component and a variable component. The heat load from room lighting, two LPCI pumps, one CS pump and fan motors is fixed at 431,022 Btu/hr. The heat load from piping and LPCI heat exchanger shell is variable depending on the surface and room temperatures and was calculated in Reference 9 by assuming surface temperatures of 170 and 165 deg F, respectively. It varies from 81,446 Btu/hr to zero for room temperatures of 120 and 170 deg F, respectively.

   The operation of the LPCI/CS system is assumed continuous. The piping and the shell side of the LPCI heat exchanger contain water from the suppression pool. Therefore, the heat load from these sources becomes zero when the room temperature equals the torus water temperature. Although the piping and heat exchanger become heat sinks when the room temperature exceeds the torus water temperature, they are not modelled as heat sinks. Since a temperature dependent heat load can not be modelled with the RELAP4 code, the maximum heat load of 512,500 Btu/hr was assumed in the analysis for room temperature below 170 deg F. After the room temperature reached 170 deg F, the fixed heat load value of 431,500 Btu/hr was used.

6. All steel structures are not considered as heat sinks for conservatism.

7. The mechanism of heat transfer between air and the heat sinks in the pump room is a combination of natural, forced and radiative heat transfer. Based on the test data obtained in the Quad Cities RHR2B room in 1986, the combined heat transfer coefficient was determined to be 6.5 Btu/hr-sq ft-F (Reference 6). A value of 5.0 Btu/hr-sq ft-F was used in the analysis.

8. The mechanism of heat transfer between air and the heat sinks in the other rooms is assumed to be a combination of natural and radiative heat transfer. The RELAP4 code has a default heat transfer coefficient of 5 Btu/hr-sq ft-F, which requires the adjustment of the heat slab surface area to yield the correct heat transfer rate. The actual and adjusted heat slab areas are listed in Table 1. The natural convection heat transfer coefficients were calculated using correlations found in heat transfer textbooks such as Kreith (Reference 10) or McAdams (Reference 11). The radiative heat transfer coefficient is derived by considering the heat transfer between air and the gray walls. It is defined as the heat transfer rate per unit area divided by the temperature difference. The heat transfer rate is calculated using gas emissivity value given by Hottel (Reference 11) or Leckner (Reference 12) and gas absorptivity value calculated by Hottel's method (Reference 11). The methodology of calculating the radiative heat transfer coefficient is identical to the one used in the CONTEMPT4 code (Reference 12).

9. The thermal conductivity of concrete is assumed to be 1.05 Btu/hr-ft-F and the volumetric heat capacity is 30.24 Btu/hr-cu ft-F.

10. The soil temperatures are assumed to be 55 and 65 deg F for soil under the floor and adjacent to walls, respectively. In the Chicago area, the ground water temperature at depths of 30 to 60 feet is relatively constant at 52 deg year round (Reference 13). The soil temperature under the floor is assumed to be equal to the ground water temperature and a value of 55 deg F is used for conservatism. The soil temperature adjacent to the wall is assumed to be equal to the mean of the temperatures at depths of 4 inches and 30 feet. The

maximum annual soil temperature at a depth of 4 inches is estimated to be about 77 deg F using data given in Reference 14 (page 25.6).

11. Heat transfer between concrete and soil is modelled by using an effective heat transfer coefficient which is defined by the soil thermal conductivity divided by a heat diffusion length. The diffusion length is determined from semi-infinite heat slab solution methods. The detailed procedure is described in the Appendix.

3.0 Results

The LPCI room temperature response as a result of a loss of room cooler heat removal capability concurrent with a LOCA is shown in Figure 3. The room temperature at the end of 11.7 days is 178.0 deg F.

Because the RELAP4 code has a transient time limitation of 11.7 days (1E+6 sec), the temperature at the end of 30 days was estimated. After 11 days, the room temperature is increasing, but the rate of increase is decreasing. The torus water which acts as a heat sink is cooling down resulting in lower torus room temperature. Thus, cooler air will circulate through the LPCI room. It is estimated that the temperature would reach a peak of 178.6 deg F in four more days and beyond that time it would be less than or equal to 178.6 deg F.

The calculated LPCI room temperature response shows an abrupt change after it has reached 170 deg F. This is the result of the change in heat load as explained in Item 5 of the input assumptions. If the heat load were allowed to vary with room temperature, the temperature response would be smooth. The temperature response shown as a dotted line in Figure 3 was obtained with a constant heat load equal to the fixed heat load of 431,500 Btu/hr. Therefore, it represents the lower bound of the temperature response while the solid curve represents the upper bound.

The dotted curve in Figure 3 provides an insight to the mechanisms of heat removal for the LPCI room. The temperature increased 54.5 deg from 104 to approximately 165 deg F during the first 12 hours but added only 6 degrees in the next 12 hours.. During the first 12 hours, the major contributor to heat removal is heat transfer through the LPCI room surfaces. As the room air and surface temperatures increase, the heat removal through the walls decreases but the "chimney effect" air circulation increases. The increased air circulation carries a major portion of the heat load out of the LPCI room which slows down the temperature increase. At the end of 6 days the room temperature added another 10.6 deg to 175.2 deg F. From this point on, the room temperature starts to level off and would reach a temperature of 177.9 deg F after 11.7 days.

4.0 Conclusion

The temperature response in the LPCI room as a result of loss of room cooler function concurrent with a LOCA has been determined. The results show that the EQ temperature limit of 185 deg F is not exceeded for an extended period of time. Therefore, operation of the LPCI system without room coolers does not compromise the operability of the LPCI system. The temperature response shows that it takes 6 days for the temperature to reach 175 deg. This would allow enough time to restore the room coolers. The calculations have been performed in a conservative manner by assuming both ECCS trains are running to maximize the room heat load. The torus area temperature was maximized by using the torus water temperature for LOCA with one ECCS train as the forcing function.

5.0 References

1. "ECCS Pump Room Transient Response to Loss of Room Cooler for Dresden Station Units 2 and 3," RSA Calcnote RSA-D-89-01, August 15, 1989.

2. "ECCS Pump Room Transient Response to Loss of Room Cooler for Dresden Station Units 2 and 3," RSA Calcnote RSA-D-90-01, April 12, 1990.

3. "An Alternate Method of ECCS Pump Room Transient Response for Dresden and Quad Cities Stations," RSA Calcnote RSA-D-92-02, August 6, 1992.

4. "RELAP4/MOD6 - A Computer Program for Transient Thermal-Hydraulic Analysis of Nuclear Reactor and Related Systems," EG&G Idaho Inc., CDAP TR 003, January 1978.

5. "RELAP4/MOD6 Certification," RSA Calcnote RSA-M-85-01, February 28, 1985.

6. "Study of Thermodynamic Characteristics of Quad Cities ECCS Pump Rooms," RSA Calcnote RSA-Q-86-01, October 14, 1986.

7. "Air Flow Measurements on LPCI and Core Spray Pumps", Documentation of Telephone Conversation between K. Ramsden and S. Rhee, October 30, 1992.

8. "Response to IE Bulletin 79-01 B Procedure for Use of Environmental Zone Maps for DNPS Units 2 and 3," Rev. 3, October 21, 1988.

9. "Dresden Maximum Corner Pump Room (CS/LPCI) Temperatures," Bechtel Calc DR-721-M-001, October 19, 1992.

10. Kreith, F., Principles of Heat Transfer, Second Edition, International Textbook Company, 1965.

11. McAdams, W. H., Heat Transmission, Third edition, McGraw-Hill Book Company, 1954.

12. "CONTEMPT4/MOD4 A Multicompartment System Analysis Program," NUREG/CR-3716, page 69.

13. Todd, D. K., Ground Water Hydrology, page 195, John Wiley & Sons, Inc., 1959.

14. ASHRAE Handbook 1981 Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1981.

15. "HPCI Room Thermal Response with Loss of HPCI Room Cooler at Dresden Station," RSA Calcnote RSA-D-92-06.

Table 1: Heat Slab Parameters

Slab	Description	Volume Number		Area, sq ft	Heat Transfer Coeff Btu/hr sq ft F		Temp Diff, F [1]		Adjusted Area, sq ft		Thick, ft	Vol, cu ft
		Left	Right		Left	Right	Left	Right	Left	Right		
1	Pump room outside wall	1	4	1480	5	0.106			1480	31	3	4440
2	Pump	0	1	100					0	100		100
3	Pump room outside wall	1	4	1480	5	0.106			1480	31	3	4440
4	Pump room inside wall	1	3	2080	5	0.68		10	2080	283	3.5	7280
5	Pump room ceiling	1	2	640	5	0.37		5	640	47	2	1280
6	Pump room floor	1	7	685	5	0.106			685	15	4	2740
7	Torus room floor	3	7	6515	0.43	0.106	20		560	138	4	26060
8	Torus room ceiling	3	2	6515	0.74	0.37	10	5	964	482	2	13030
9	Torus room outside wall	3	4	2280	0.79	0.106	20		360	48	3	6840
10	Rx bldg outside wall	2	6	11367	0.58	4	5	[2]	1319	9094	3	34101
11	Rx bldg interior floors	2	2	19348	0.64	0.37	5	5	2477	1432	2	38696
12	Torus shell	5	3	16137	5	1.46		[3]	16137	4712	0.042	673
13	Rx bldg roof	2	6	7770	0.74	4	10	[2]	1150	6216	0.29	2266
14	Wall bet U2/U3 Rx bldg	2	8	11367	0.58	0.58	5	5	1319	1319	3	34101
15	Wall bet torus rm & turb bldg	3	8	2280	0.79	0.79	20	20	360	360	3	6840

Notes:

1. Temperature difference assumed in calculating the combined natural convection and radiation heat transfer coefficient.
2. Heat transfer coefficient for wind velocity of 7.5 mph (Reference 14, page 23.12).
3. Heat transfer coefficient for non-reflective vertical surface (Reference 14, page 23.12)

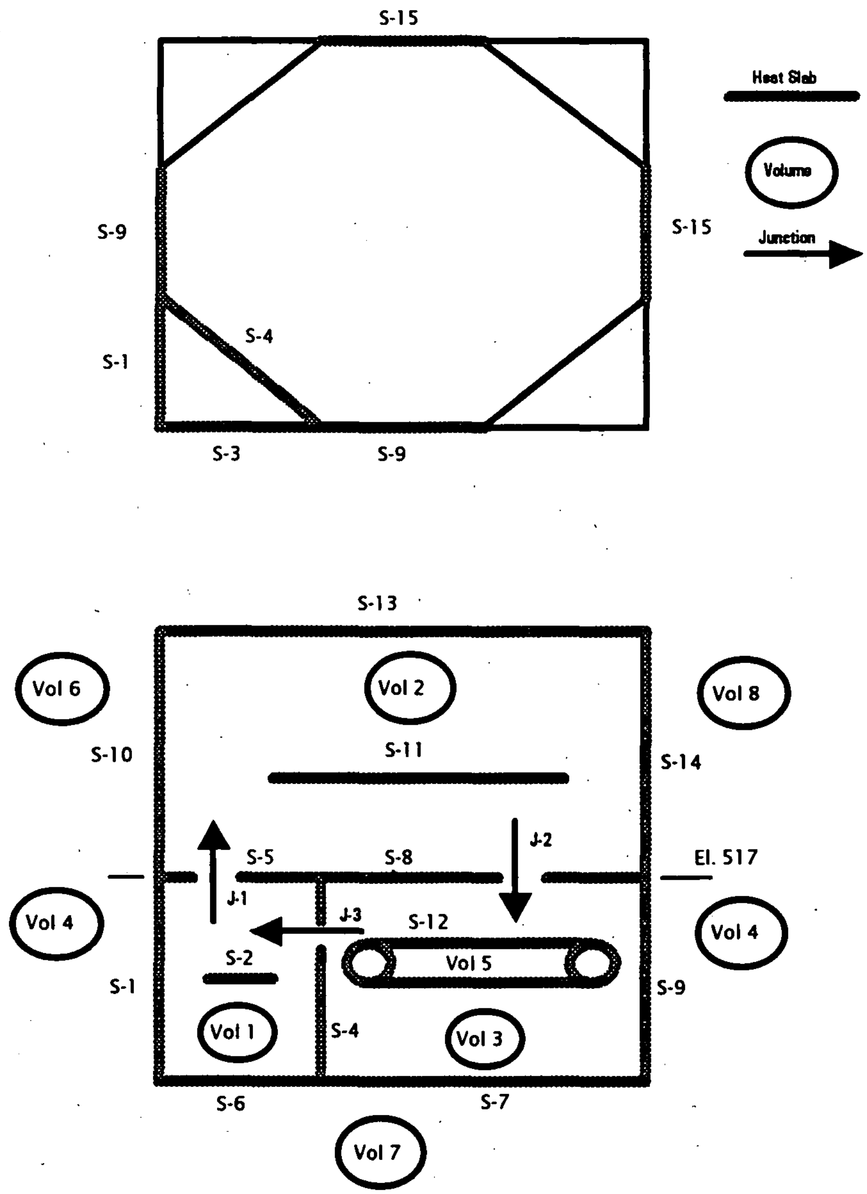

Figure 1: RELAP4 Model Schematic

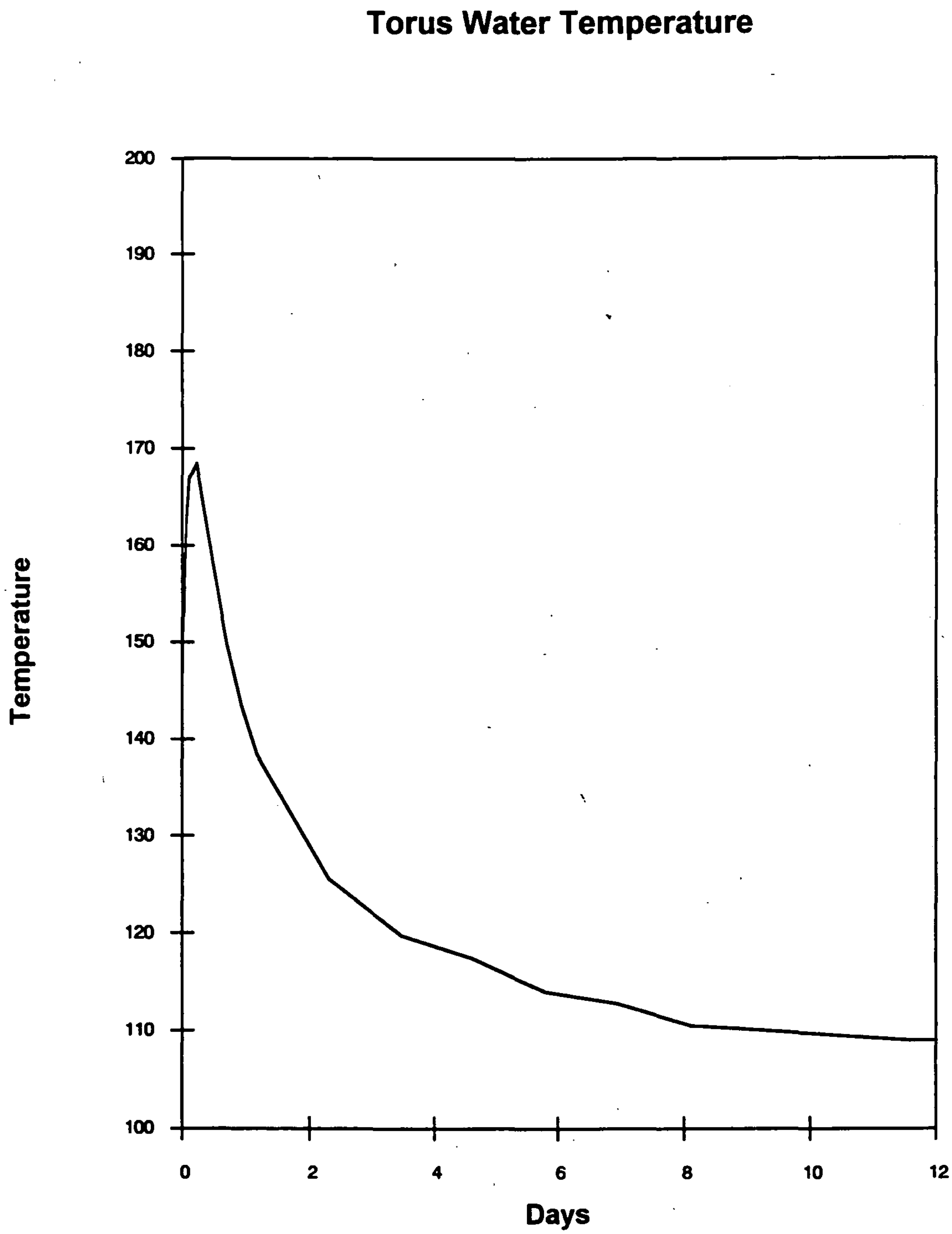

Figure 2: Torus Water Temperature

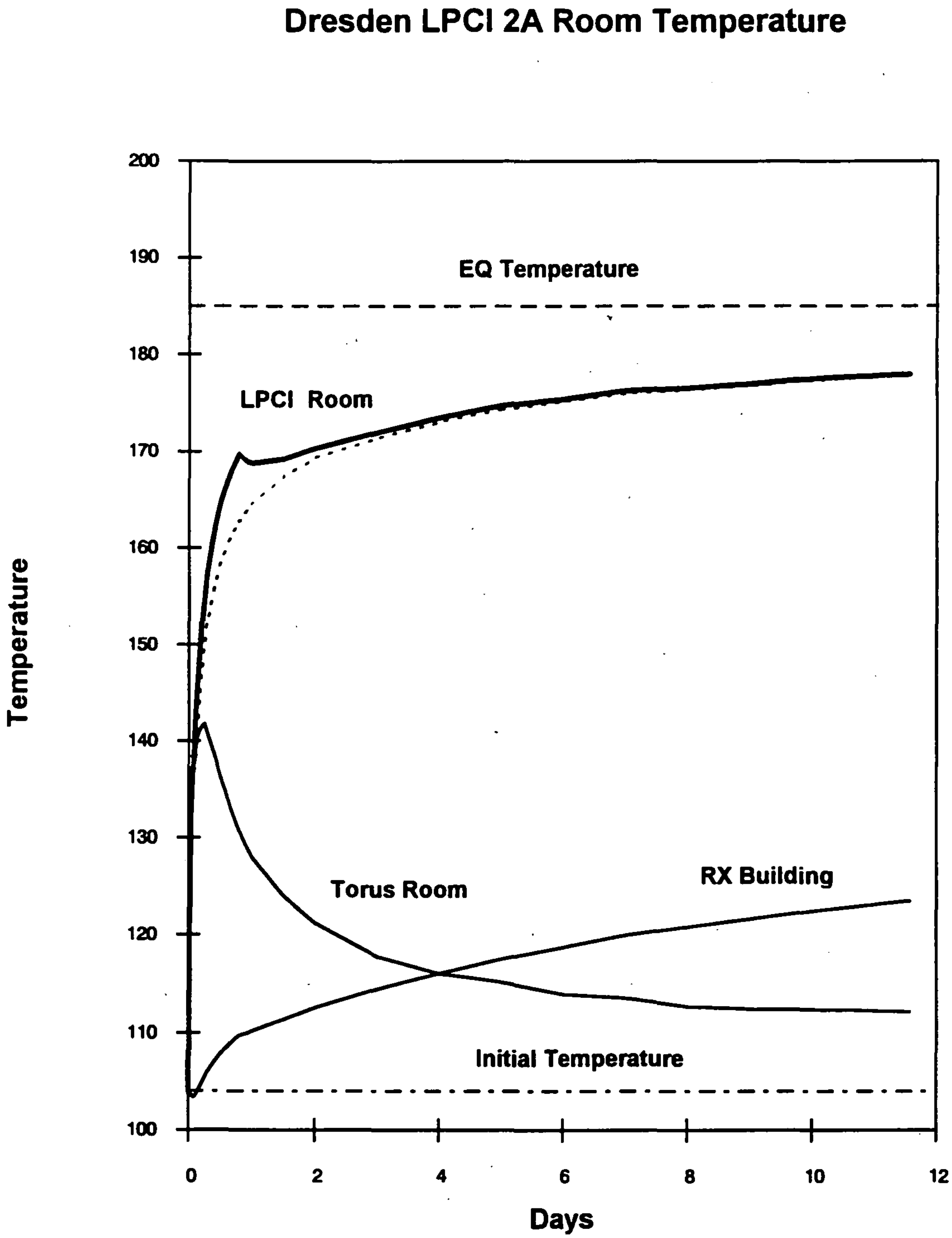

Figure 3: LPCI room temperature response due to loss of room cooler.

Listing Of Computer Runs

Job ID	Description
NFSPKB(J0789)	Change from total heat load to fixed heat load at t = 69000 sec.
NFSPKC(J1846)	Fixed heat load only.
NFSPKF(J9608)	Change interior floor thickness to 1 ft.

Appendix

Contents

Calculation of Combined Heat Transfer Coefficient

Heat transfer to heat slab is calculated in RELAP by:

$$q = h A \Delta T$$

where h is a combined natural convection and radiation HTC (heat transfer coeff)

$$h = h_{conv} + h_{rad}$$

Radiation HTC

Heat transfer between gas and a gray wall is given by

$$q = \sigma A \varepsilon'_{wall} \left(\varepsilon_g T_g^4 - \alpha_g T_w^4 \right)$$

Since

$$q = h_{rad} A \left(T_g - T_w \right)$$

$$\therefore h_{rad} = \frac{\sigma \varepsilon'_{wall} \left(\varepsilon_g T_g^4 - \alpha_g T_w^4 \right)}{\left(T_g - T_w \right)}$$

where $\varepsilon'_{wall} = \dfrac{1 + \varepsilon_{wall}}{2}$ for $\varepsilon_{wall} \geq 0.9$

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Combined HTC (p.2)

ε_g and α_g can be calculated using steps described in the CONTEMPT4 User Manual (Ref. 12). Details of calculation are given in the following spreadsheet.

In the calculation of ε_g, a beam length of 17 ft was used. This is the beam length calculated for the HPCI room (Ref. 15). It is judged that the HPCI room dimensions are representative of the compartment dimensions in the Rx bldg. Larger dimensions would yield a larger beam length and therefore a larger radiation HTC. Although the Rx bldg is modelled as one node, it is not appropriate to use the lumped volume and surface area to calculate the beam length. (This would yield a higher HTC.) A beam length of 17 feet is used for the torus room for the same reason.

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Combined HTC (p. 3)

Formulas used are from Kreith or McAdams (Ref 10 and 11):

(a) Wall

$$h_{conv} = 0.19\,(\Delta T)^{1/3}$$

(b) Ceiling

$$h_{conv} = 0.22\,(\Delta T)^{\frac{1}{3}}$$

(c) Floor

$$h_{conv} = 0.13\left(\frac{\Delta T}{L}\right)^{\frac{1}{4}}$$

Heat transfer on all surfaces is turbulent. Eqs (a) and (b) are correlations for turbulent flow while Eq (c) is for laminar flow. Since heat transfer to the floor is turbulent, and turbulent flow correlation is not available, the transition length is used in Eq (c). This yields a lower bound on the turbulent heat transfer coeff. For a film temperature of 150°F and $\Delta T = 20$, the transition length is about 8.4 ft. This value was used in the calc.

	Prepared by:		Checked by:		Reviewed by:		
tg, F	150	160	170	180	125	115	110
tw, F	120	130	140	150	105	105	105
Dt	30	30	30	30	20	10	5
Tg, K	338.7056	344.2611	349.8167	355.3722	324.8167	319.2611	316.4833
Tw, K	322.0389	327.5944	333.15	338.7056	313.7056	313.7056	313.7056
L, ft	17	17	17	17	17	17	17
L, cm	518.16	518.16	518.16	518.16	518.16	518.16	518.16
tref	120	120	120	120	105	105	105
psat, ref p	1.6933	1.6933	1.6933	1.6933	1.1016	1.1016	1.1016
Rel hum	0.95	0.95	0.95	0.95	0.95	0.95	0.95
pv	1.691888	1.719639	1.747389	1.77514	1.083587	1.065053	1.055787
pv, bar	0.116652	0.118565	0.120478	0.122392	0.074711	0.073433	0.072794
pt	14.7	14.7	14.7	14.7	14.7	14.7	14.7
pt, bar	1.013529	1.013529	1.013529	1.013529	1.013529	1.013529	1.013529
Calculate emmisivity							
tau	0.338706	0.344261	0.349817	0.355372	0.324817	0.319261	0.316483
beta	1.781354	1.78842	1.795373	1.802216	1.587846	1.580354	1.576559
a0	-2.61372	-2.62025	-2.62677	-2.63329	-2.5974	-2.59087	-2.5876
a1	1.006733	1.006442	1.006062	1.005594	1.007072	1.007052	1.007009
a2	-0.16122	-0.162	-0.16278	-0.16355	-0.15926	-0.15847	-0.15808
eps,t,ref	0.263958	0.262251	0.260488	0.258671	0.24663	0.247794	0.248354
pe	1.526694	1.530885	1.535043	1.539168	1.349144	1.346261	1.344811
beta,max	0.180219	0.19435	0.208255	0.221941	0.143851	0.128866	0.121276
cw	1.083298	1.083944	1.08458	1.085207	1.064139	1.063585	1.063306
eps	0.285946	0.284265	0.28252	0.280712	0.262449	0.26355	0.264076
Calculate absorptivity							
tau1	0.322039	0.327594	0.33315	0.338706	0.313706	0.313706	0.313706
beta1	1.75944	1.766869	1.774172	1.781354	1.57273	1.57273	1.57273
a0	-2.59414	-2.60067	-2.6072	-2.61372	-2.58434	-2.58434	-2.58434
a1	1.007073	1.007049	1.006935	1.006733	1.006943	1.006943	1.006943
a2	-0.15887	-0.15965	-0.16044	-0.16122	-0.15768	-0.15768	-0.15768
eps,t,ref	0.268731	0.2672	0.265608	0.263958	0.2489	0.2489	0.2489
pe	1.539805	1.543883	1.547929	1.551945	1.355036	1.349195	1.346274
beta,max	0.136391	0.151247	0.165854	0.180219	0.113618	0.113618	0.113618
cw	1.082951	1.08361	1.08426	1.0849	1.063943	1.063486	1.063256
alpha	0.297706	0.296079	0.294385	0.292626	0.268995	0.2668	0.265696
Calculate Radiation coeff							
eps,w	0.95	0.95	0.95	0.95	0.95	0.95	0.95
q"	9.740629	10.11287	10.48611	10.85968	5.488458	2.675487	1.320663
hr	0.324688	0.337096	0.349537	0.361989	0.274423	0.267549	0.264133
Calculate combined heat transfer coeff							
wall							
hc	0.590374	0.590374	0.590374	0.590374	0.515739	0.409343	0.324895
h=hr + h	0.915062	0.92747	0.939911	0.952364	0.790162	0.676891	0.589028
ceiling							
hc	0.683591	0.683591	0.683591	0.683591	0.597172	0.473976	0.376195
h=hr + h	1.008279	1.020687	1.033128	1.045581	0.871595	0.741524	0.640327
floor							
L	8.44	8.44	8.44	8.44	8.44	8.44	8.44
hc	0.1785	0.1785	0.1785	0.1785	0.161293	0.135631	0.114051
h=hr + h	0.503188	0.515596	0.528037	0.540489	0.435716	0.403179	0.378184

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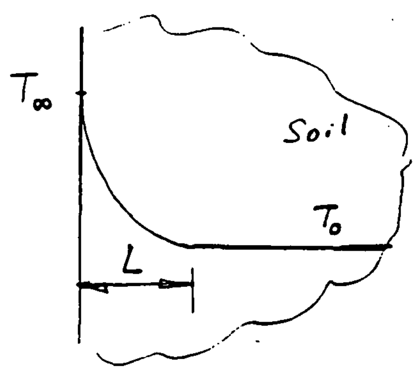
Determination of Soil Effective Heat Transfer Coefficient

To facilitate the calculation of heat transfer to the soil, a surface heat transfer coefficient is used. It is determined as follows:



$$q = \frac{k_s A}{L}(T_\infty - T_0) \quad (1)$$

$$= h A (T_\infty - T_0) \quad (2)$$

$$\therefore h = \frac{k_s}{L} \quad (3)$$

where L is a heat diffusion length. It can be determined from the solution of heat conduction in a semi-infinite slab (Ref 10, p. 158):

$$q = \frac{k_s A}{\sqrt{\pi \alpha t}}(T_\infty - T_0) \quad (4)$$

Comparing Eqs (1) and (4):

$$L = \sqrt{\pi \alpha t} \quad (5)$$

Soil HTC (p. 2)

The total heat transfer for the time interval Δt is:

$$Q = 2 k_s A (T_\infty - T_0) \sqrt{\frac{\Delta t}{\pi \alpha}} \qquad (6)$$

∴ The average heat transfer rate is

$$\bar{q} = 2 k_s A (T_\infty - T_0) \sqrt{\frac{1}{\pi \alpha \Delta t}}$$

and the average heat transfer coefficient is

$$\bar{h} = \frac{2 k_s}{\sqrt{\pi \alpha \Delta t}}$$

the average heat diffusion length is

$$\bar{L} = \frac{\sqrt{\pi \alpha \Delta t}}{2}$$

Using soil properties from "Incropera and De Witt, Introduction to Heat Transfer, John Wiley & Sons, 1985, p. 680":

$$\rho = 2050 \text{ kg/m}^3 \times 0.062428 = 128 \text{ lb/ft}^3$$

$$k = 0.52 \text{ W/m-K} \times 0.57782 = 0.3 \text{ Btu/hr-ft-°F}$$

$$C_p = 1840 \text{ J/kg-K} \times 2.3886 \times 10^{-4} = 0.4395 \text{ Btu/lb-°F}$$

$$\alpha = \frac{k}{\rho C_p} = \frac{0.3}{128 \times 0.4395} = 0.005327 \text{ ft}^2/\text{hr}$$

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Soil HTC (p 3)

For $\Delta t = 768$ hrs (32 days)

$$\bar{L} = \frac{\sqrt{\pi \alpha \Delta t}}{2}$$

$$= \frac{\sqrt{\pi \times 0.005327 \times 768}}{2} = 1.793 \text{ ft}$$

$$\bar{h} = \frac{k_s}{\bar{L}} = \frac{0.3}{1.793} = 0.167 \text{ Btu/hr-ft}^2\text{-°F}$$

Note that $\bar{h}$ varies inversely with time.
A value of 0.106 was used previously and
was not changed in the current calc.
Since the heat transfer varies directly with h,
the use of a lower value of h is
conservative.

Heat Slab Dimensions*

1. Heat Slab 1 - Pump Room Outside Wall

   $A = 38.5 \times 38 = 1463\ ft^2$

   $t = 3\ ft$

   $V = 4389\ ft^3$

   Ref: Dwg B-187

2. Heat Slab 2 - Pump

   Use $A = 100\ ft^2$

3. Heat Slab 3 - Pump Room Outside Wall

   Same dimensions as Heat Slab 1

4. Heat Slab 4 - Pump Room Inside Wall

   $A = 53.75 \times 38 = 2042.5\ ft^2$

   $t = 3.5\ ft$

   $V = 7145\ ft^3$

   Ref: Dwg B-187

   alt. method - KBR $\frac{A_1}{\cos 45} = \frac{1463}{.707} = 2069$

---

* Some of the dimensions are slightly different from the code input values. The effect on the results is minimal.

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

CALCULATION NUMBER RSA-D-92-07 FILE ______ PAGE ____ OF ____

SUBJECT ______

PREPARED BY P. L. KONG PK CHECKED BY ______ REVIEWED BY KBR

Heat Slab Dimensions (p 2)

5. Heat Slab 5 -- Pump Room Ceiling

$A = \frac{1}{2}(38.5 \times 37.5) = 722 \ ft^2$

Assume 10% occupied by equipment on other side

$A_{net} = 0.9 \times 722 = 650 \ ft^2$

$t = 2 \ ft$ (Assumed)*

$V = 1300 \ ft^3$

* The value of t does not affect the long-Term solution. See results of computer run NPSPKF (J9608).

6. Heat Slab 6 - Pump Room Floor

$A = \frac{1}{2}(38.5 \times 37.5) = 722 \ ft^2$

Assume 10% occupied by equipment

$A_{net} = 0.9 \times 722 = 650 \ ft^2$

$t = 4 \ ft$

$V = 2600 \ ft^3$

Ref: Dwg B-190

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

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SUBJECT ______

PREPARED BY P. L. KONG P.K. CHECKED BY ______ REVIEWED BY KBR

Heat Slab Dimensions (p. 3)

7. Heat Slab 7 - Torus Room Floor

$A = 13030\ ft^2$ (See p 9)

Limiting case is 2 trains of RHR running simultaneously. Therefore, only half of the torus area can be credited

$A_{net} = 0.5 \times A = 6515\ ft^2$

$t = 4\ ft$

$V = 6515 \times 4 = 26{,}060\ ft^3$

Ref: Dwg B-190

8. Heat Slab 8 - Torus Room Ceiling

$A_{net} = A_{net}$ of Heat Slab 7

$= 6515\ ft^2$

$t = 2\ ft$ (Assumed)*

$V = 6515 \times 2 = 13{,}030\ ft^3$

* The value of t does not affect the long term solution. See results of computer run NFSPKF (J 9608).

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

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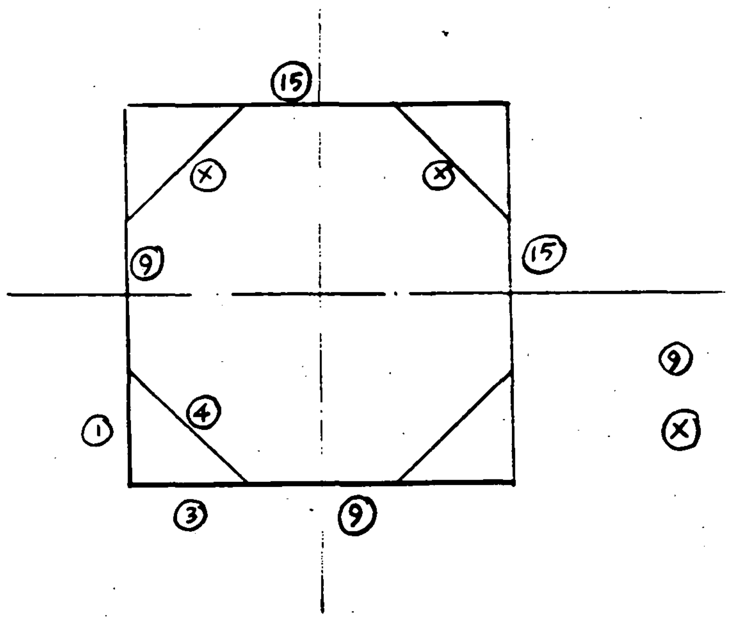
SUBJECT ______

PREPARED BY P. L KONG PK CHECKED BY ______ REVIEWED BY KBL

Heat Slab Dimensions (p. 4)

9. Heat Slab 9 - Torus Room Outside Wall



(9) Heat Slab Number

(x) Not credited

$A = 2 \times 60 \times 38 = 4560\ ft^2$

For limiting case:

$A_{net} = \frac{1}{2} A = 2280\ ft^2$

$t = 3\ ft$

$V = 6840\ ft^3$

Ref: Dwg B-187

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NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

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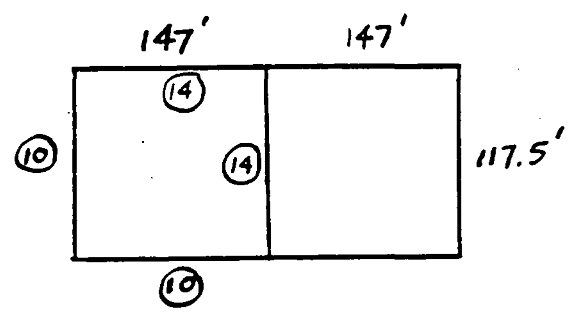
SUBJECT ______

PREPARED BY P. L. KONG PK CHECKED BY ______ REVIEWED BY [signature]

Heat Slab Dimensions (p. 5)

10. Heat Slab 10 - Rx Bldg Outside Walls

This heat slab represents the outside walls from Elev 517.5 to El. 613' (Refueling floor). The metal siding is not credited in the calc. Conservative KBR.



$h = 613 - 517.5$

$= 95.5$ ft

$A = (147 + 117.5) \times 95.5$

$= 25260$

For the limiting case and assuming 10% obstruction

$A_{net} = 0.5 \times 0.9 A = 11367 \ ft^2$

$t = 3$ ft

$V = 34,101 \ ft^3$

Ref Dwg B-185

COMMONWEALTH EDISON COMPANY

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SUBJECT ______

PREPARED BY P. L. KONG P.K. CHECKED BY ______ REVIEWED BY KBR

Heat Slab Dimensions (p. 6)

11. Heat Slab 11 – Rx Bldg Interior Floors.
(see pp 11 thru 14)

Elev	Area
545'6"	11185
570'0"	10387
589'	10624
613'	17273
total	49469

For the limiting case and assuming 20% occupied by equipment

$A_{net} = 0.5 \times 0.8 \times A = 19{,}788 \ ft^2$

$t = 2 \ ft$ (Assumed)*

$V = 39575 \ ft^3$

$A_{net} = 19{,}348 \ ft^2$ and $V = 38{,}696 \ ft^3$ were used as input.

* The value of t does not affect the long term solution. See results of computer run NFSPKF (J9608).

Review note: slight differences on internal wall dimensions will not affect long term steady state soln. KBR

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

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SUBJECT ______

PREPARED BY P. L. KONG PK CHECKED BY ______ REVIEWED BY KBL

Heat Slab Dimensions (p. 7)

12. Heat Slab 12 — Torus Shell

(see p 9)

$A = 32273.6$

For the limiting case

$A_{net} = 0.5 \times A = 16,137\ ft^2$

$t = \frac{1}{2}''$

$V = 673\ ft^3$

13. Heat Slab 13 — Rx Bldg Roof

See Diagram for Slab 10

$A = 117.5 \times 147 = 17272.5\ ft^2$

For the limiting case and assuming 10% obstruction

$A_{net} = 0.5 \times 0.9 \times A = 7773\ ft^2$

Determine thickness:

From Dwg B-433

Top of steel = El 657'6"

Low Point of roof: El 657' 9½"

High Point of roof El 658' 6½"

Assume t = 3.5"

$V = \frac{3.5}{12} \times 7773 = 2267\ ft^3$

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NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

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SUBJECT ______

PREPARED BY P. L KONG PK CHECKED BY ______ REVIEWED BY KBR

Heat Slab Dimensions (p. 8)

14. Heat Slab 14 - Wall between U2/U3 Rx Bldg, Wall bet. Rx and Turbine Bldgs.

From Diagram for Heat Slab 10

A_{net} = A_{net} for Slab 10

= 11367 ft^2

t = 3 ft

V = 34,101 ft^3

Ref: Dwg B-185

15. Heat Slab 15 - Wall between Torus room and turbine bldg

From Diagram for Heat Slab 9

A = 2 × 60 × 38 = 4560 ft^2

For limiting case

A_{net} = 0.5 × A = 2280 ft^2

t = 3 ft

V = 6840 ft^3

Ref: Dwg B-189

note - includes wall to other torus room too
KBR

COMMONWEALTH EDISON COMPANY

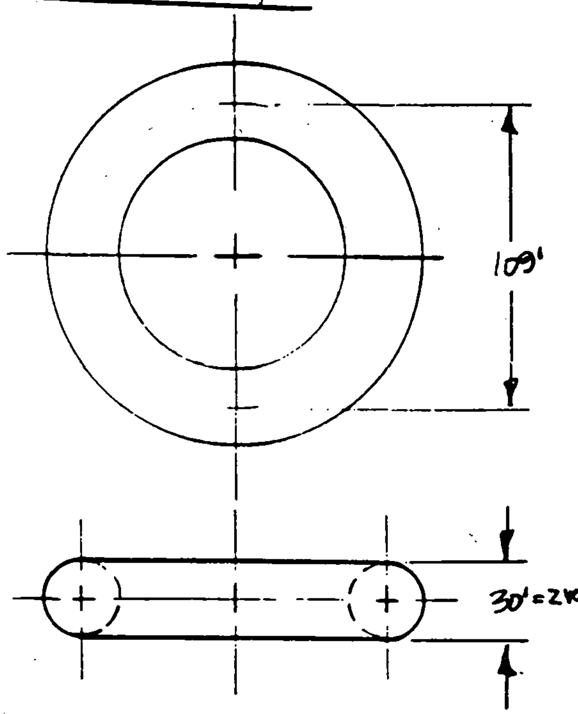
NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 4-22-87

CALCULATION NUMBER ______ FILE LORC PAGE ____ OF ____

SUBJECT EVALUATION OF HEAT TRANSFER COEFFICIENTS AND AREAS FOR TORUS ROOM AND 517.5' LEVEL FOR THE HPCI LINE BREAK CONDITIONS

PREPARED BY J.M.F. CHECKED BY ______ REVIEWED BY KBR

Heat Slabs (p. 9) TORUS DIMENSIONS [1];



WATER VOLUME = 112203 ft^3
GROSS VOLUME = 247000 ft^3
TORUS MAJOR DIA = 109 ft
TORUS MINOR DIA = 30 ft.
FREE AIR VOLUME = 117245 ft^3

$FLOWA_S = (\sim 30)(\sim 30) \approx 900 ft^2$ (APPROXIMATE)

ASSUME TORUS VERTICALLY CENTERED, ELEV = $\frac{40-30}{2}$ = 5.0 ft

SURFACE AREA = $4\pi^2 Rr$ (CIRCULAR TORUS)

VOLUME = $2\pi^2 Rr^2$ (CIRCULAR TORUS)

$$S = 4\pi^2\left(\frac{109}{2}\right)\left(\frac{30}{2}\right) = 32273.6 \ ft^2 \checkmark$$

$$V = 2\pi^2\left(\frac{109}{2}\right)\left(\frac{30}{2}\right)^2 = 242052 \ ft^3$$

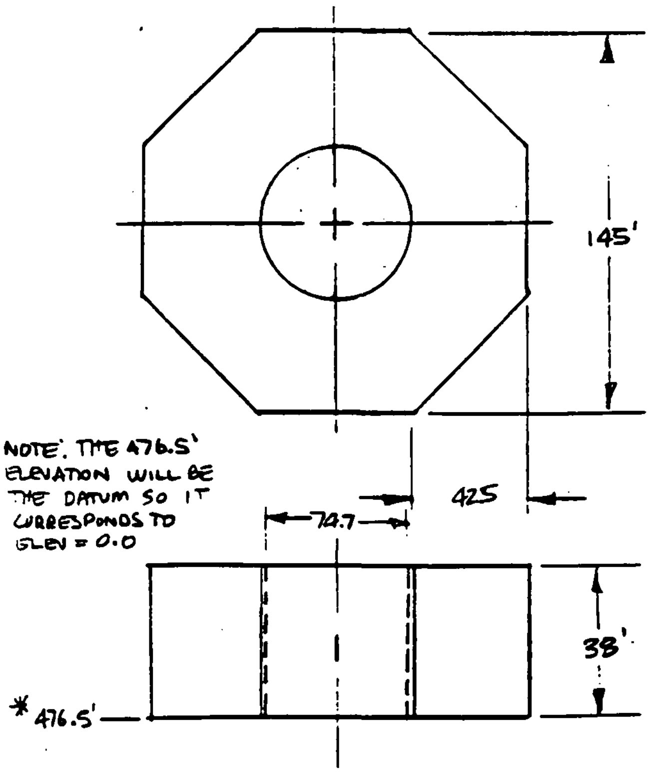
(THIS AGREES WITH FSAR DATA) AS A CHECK

$V_{STRUCTURAL\ MATERIAL} = 14,400 \ ft^3$ [1]

$V_{SUPPRESSION\ POOL} = 247000 - 14400 = 232600 \ ft^3 = V_S$

FOR TORUS LEVEL $ZM_{TORUS} = \left(\frac{112203}{112203+117245}\right)30 = 14.669$ ft

TORUS ROOM DIMENSIONS;



145 FEET ACROSS [2]
42.5 FEET CORNERS [3]
74.7 FEET INSIDE DIA [5]
38 FEET TALL [2]

$$S_{VERT\ WALLS} = 38\left[4(60) + 4(42.5)(\sqrt{2}) + \pi(74.7)\right]$$

$$= 27173.5 \ ft^2 \checkmark$$

$$S_{TOP} = 145^2 - 4\left(\tfrac{1}{2}\right)(42.5)^2 - \frac{\pi}{4}(74.7)^2$$

$$= 13029.9 \ ft^2, \quad FLOWA_3 \approx 10{,}000 \ ft^2$$

$$S_{TOTAL} = 40203.4 \ ft^2$$

$$V_{TOTAL} = 13029.9 \ ft^2 (38 \ ft) - 247000$$

$$= 248136.2 \ ft^3 = V_3$$

$$V_{WITHOUT\ TORUS} = 495136.2 \ ft^3$$

* NOTE: THE 476.5' ELEVATION WILL BE THE DATUM SO IT CORRESPONDS TO ELEV = 0.0

ELEV = 0.0, ZVOL$_3$ ≈ 40' FOR CONSERVATISM

COMMONWEALTH EDISON COMPANY

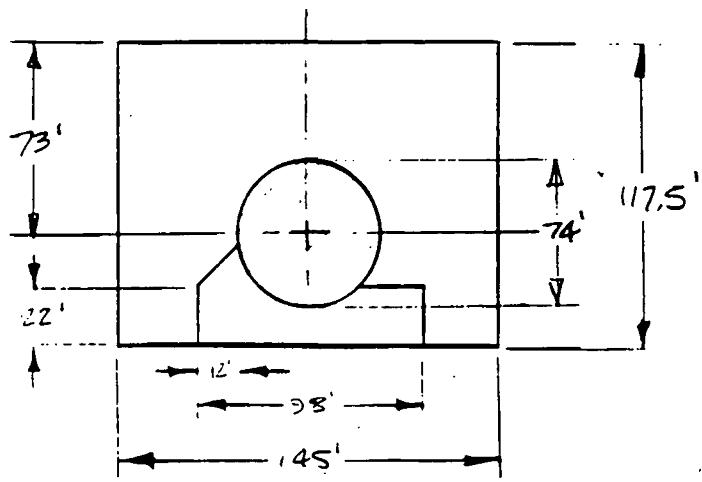
NUCLEAR FUEL SERVICES DEPARTMENT   PROJECT DRESDEN   DATE 4-22-87

CALCULATION NUMBER ________   FILE LORC   PAGE ____ OF ____

SUBJECT EVALUATION OF HEAT TRANSFER COEFFICIENTS AND AREAS FOR TORUS ROOM AND 517.5 LEVEL FOR HPCI LINE BREAK CONDITIONS

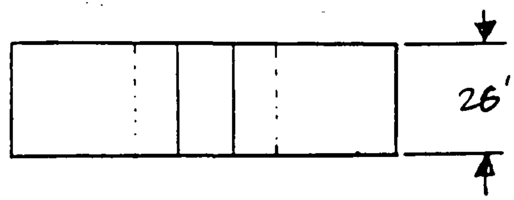
PREPARED BY J.M.F.   CHECKED BY ________   REVIEWED BY KBR

Heat Slabs (p 10)   517.5 LEVEL DIMENSIONS:



145 Ft ACROSS [4]
74 Ft INSIDE DIA [4]

117.5 ft WIDE [5]
26.0 ft TALL [6]
℄ TO WALL IS ~73 ft [5]
DISTANCE ACROSS ~98 ft [5]
DEPTH OF ROOM ~22 ft [5]
ANGULAR PORTION ~12' ft [5]



$545.5 - 517.5 - 2 = 26'$

$S_{VERTICAL\ WALL} = 26\left[2(117.5) + 2(145) - 98.0 + 2\left[22 + \sqrt{2}(12)\right] + \frac{3}{4}\pi(74)\right]$

$= 17661.8 ft^2$ ✓

$S_{TOP} = (117.5)(145) - \frac{\pi}{4}(74)^2 - 98(22) - \frac{1}{2}(12)^2$

$= 10508.7 ft^2$ ✓

$V_{TOTAL} = 10508.7 ft^2 (26) = 273226.2 ft^3$ ✓

$S_{TOTAL} = 28170.5 ft^2$

COMMONWEALTH EDISON COMPANY

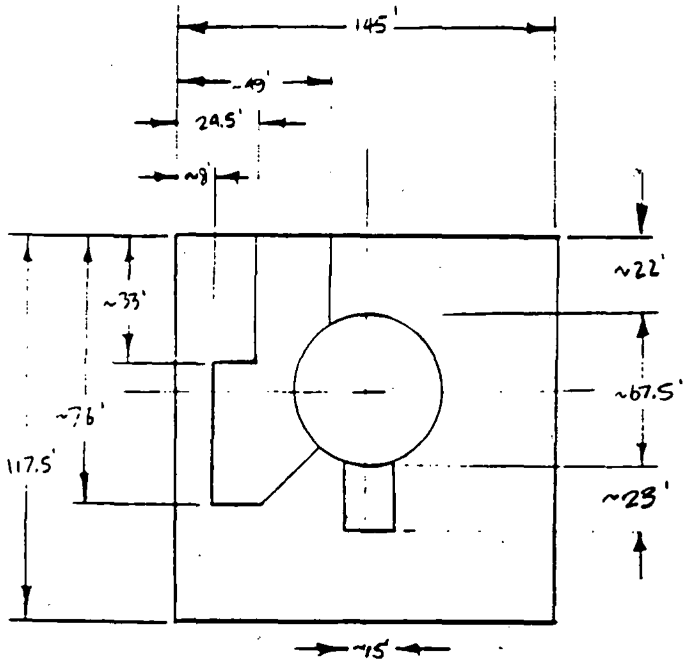
NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 9-8-87

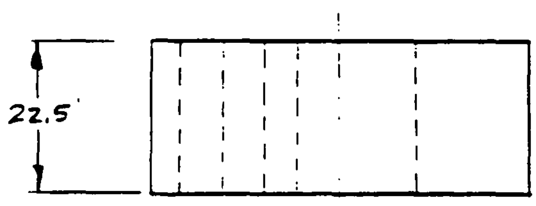
CALCULATION NUMBER ______ FILE LORC/HELB PAGE ____ OF ____

SUBJECT LORC DURING A HPCI STEAM LINE BREAK IN THE TORUS ROOM

PREPARED BY J.M.F. CHECKED BY ______ REVIEWED BY KBR

Heat Slabs (p 11) 545.5' LEVEL DIMENSIONS: [7][6]





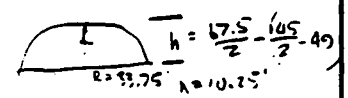
$570 - 545.5 - 2 = 22.5\ ft$

$$S_{\text{vertical walls}} = \Big[2(117.5) + 2(145) - (49-24.5) + 33 + 2[24.5-8] + (76-33) + \sqrt{2}(49-24.5) + 22 + \tfrac{3}{4}\pi(67.5) + 2(23) + 15\Big](22.5)$$

$$= 19939.306\ ft^2 \quad ✓$$

$$S_{\text{top}} = (117.5)(145) - \frac{\pi}{4}(67.5)^2 - (49-24.5)(76) + \tfrac{1}{2}(49-24.5)^2 - (24.5-8)(76-33) + A_{\text{segment}} - (15)(23)$$

$$= 10842.655 + A_{\text{segment}} \quad ✓$$



[8]

$$A_{\text{segment}} = 33.75^2 \cos^{-1}\left(\frac{33.75-10.25}{33.75}\right) - (33.75 - 10.25)\sqrt{2(33.75)(10.25) - (10 \ldots}$$

$$A_{\text{segment}} = 342.632\ ft^2$$

$$S_{\text{top}} = 10842.655 + 342.632 = 11185.287\ ft^2 \qquad V_{\text{total}} = 11185.287(22.5) = 251,668.958$$

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 9-9-87

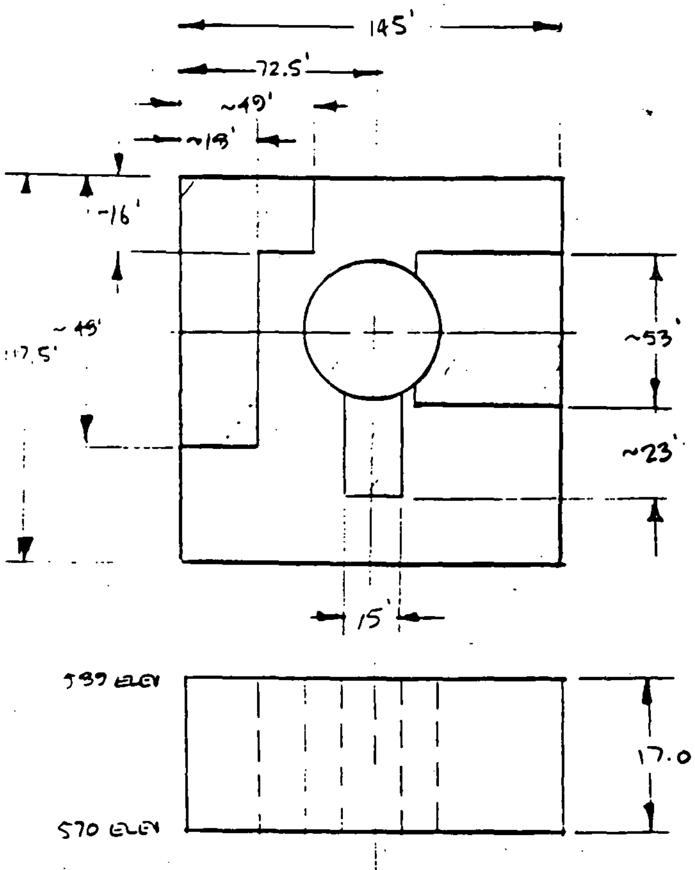
CALCULATION NUMBER ______ FILE LORC/HELB PAGE ____ OF ____

SUBJECT LORC DURING A HPCI STEAM LINE BREAK IN THE TORUS ROOM

PREPARED BY J.M.F. CHECKED BY ______ REVIEWED BY [signature]

Heat Slabs (p12)

570.0' LEVEL DIMENSIONS: [9]



589 − 570 − 2 = 17.0 ft

$$S_{\text{VERTICAL WALLS}} = (17.0)\left[2(117.5) + 2(145) - 53 + 2(72.5) + \tfrac{1}{2}\pi(53) + 2(23) + 15\right]$$

$$= 12941.287\ ft^2 \quad ✓$$

$$S_{TOP} = (117.5)(145) - \left(\tfrac{1}{2}\right)\tfrac{\pi}{4}(53)^2 - (53)(72.5) - (23)(15) - (48)(18) - (16)(49-18)$$

$$= 10386.908\ ft^2 \quad ✓$$

$$V_{TOTAL} = 10386.908(17.0\ ft) = 176577.436\ ft^3 \quad ✓$$

COMMONWEALTH EDISON COMPANY

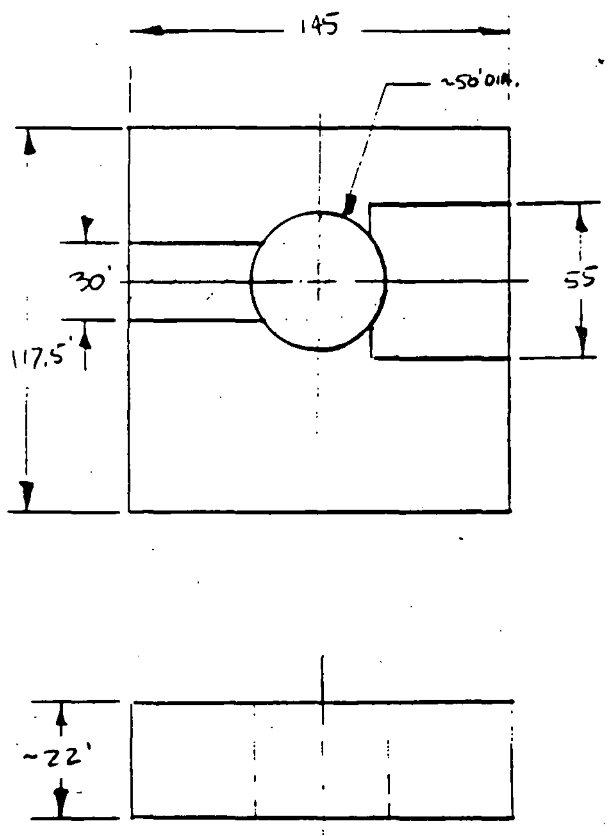
NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 9-9-87

CALCULATION NUMBER ______ FILE LORC/HELB PAGE ____ OF ____

SUBJECT LORC DURING A HPCI STEAMLINE BREAK IN THE TORUS ROOM

PREPARED BY J.M.F. CHECKED BY ______ REVIEWED BY KBR

Heat Slabs (p13) 589' LEVEL DIMENSIONS: [10]



613 - 589 - 2 = 22.0 ft ELEV

$$S_{VERTICAL\ WALLS} \cong [4(145) + 2(117.5) - 55 - 30](22) =$$
$$= 16060.0\ ft^2 \quad ✓$$

$$S_{TOP} = (145)(117.5) - \frac{\pi}{4}(50)^2 - (55)^2 - (30)\left(\frac{145}{2} - 25\right)$$
$$= 10624.005\ ft^2 \quad ✓$$

$$V_{TOTAL} = 10624.005\ ft^2 (22) = 233728.110\ ft^3 \quad ✓$$

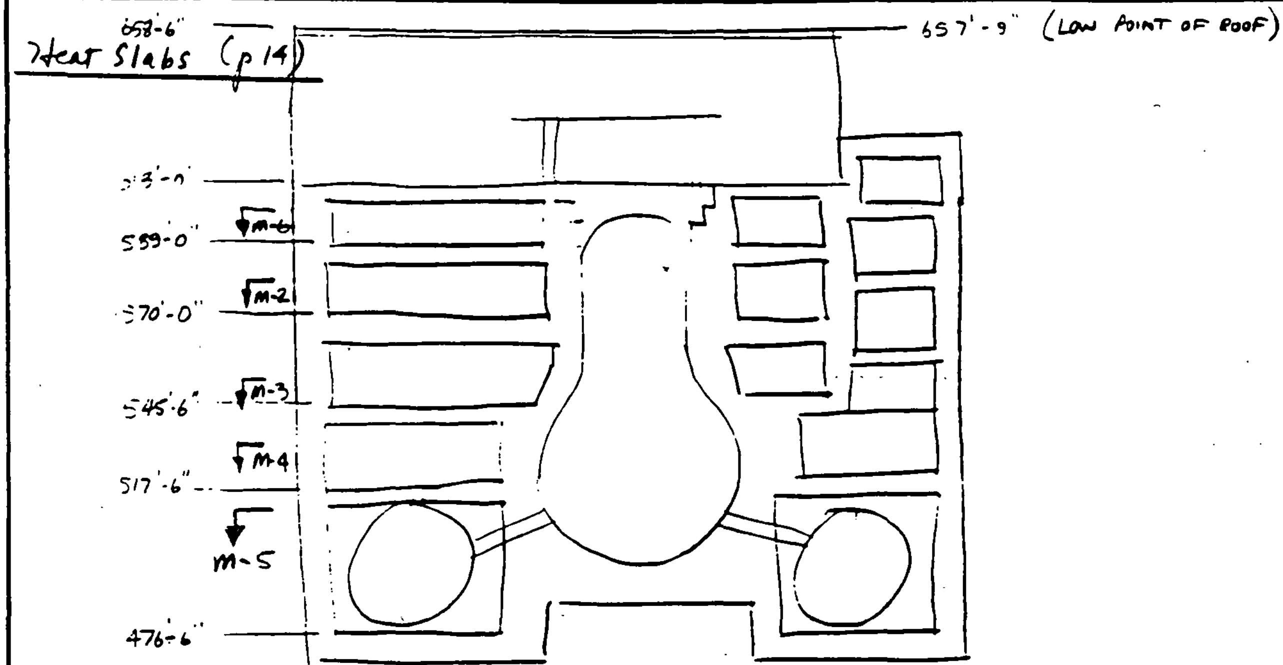
COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 9-8-87

CALCULATION NUMBER ______ FILE LORC/HELB PAGE ____ OF ____

SUBJECT LORC DURING HPCI STEAM LINE BREAK IN THE TORUS ROOM

PREPARED BY J.M.F CHECKED BY ______ REVIEWED BY KBR



SECTION B-B, M-7

DIMENSIONS 613.0' LEVEL: [10] (ENTIRE REFUELING FLOOR)

$V_{TOTAL} = (147+147)[3(22)+2(25.75)](657-613)$

$= 1519980.0\ ft^3$ {THIS ASSUMES CARRYOVER ONLY ON REFUEL FLOOR, WHICH IS VERY CONSERVATIVE.} ✓

*ADDING ALL LEVELS EXCEPT THE TORUS ROOM

1519980	613 LEVEL
233728	589 LEVEL
176577	570 LEVEL
251669	545 LEVEL
+ 273226	517 LEVEL
2 455 180 ft^3 ✓	

ASSUMING 5% OF VOLUME IS EQUIPMENT OR UNCERTAIN FOR CONSERVATISM

$V_4 = (2.455180 \times 10^6\ ft^3)(0.95) = 2.332 \times 10^6\ ft^3$ ✓

TYPICAL FLOWA_4 $\approx (117.5)(145) = 17037.5\ ft^2$, BUT ASSUME $10,000\ ft^2$ FOR CONSERVATISM

$ZVOL_4 = 657 - 517.5 + 1.5 = 141\ ft$ (FOR OVERLAP WITH VOL 1,2,3), $ELEV = 517.5 - 476.5 - 1.5 = 39.5\ ft$ (FOR OVERLAP WITH VOL 1,2,3)

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT DRESDEN DATE 4-22-87

CALCULATION NUMBER ________ FILE LORC/HELB PAGE ____ OF ____

SUBJECT LORC DURING A HPCI STEAM LINE BREAK IN THE TORUS ROOM

PREPARED BY J.M.F. CHECKED BY ________ REVIEWED BY KBR

Heat Slabs (p.15) VOLUME REFERENCES:

[1] DRESDEN FSAR, VOLUME 1, SECTION 5, P. 5.2.3-3

[2] DRESDEN NUCLEAR POWER STATION UNIT 2, P&ID M-83

[3] DRESDEN NUCLEAR POWER STATION. UNIT 2, P&ID M-71

[4] DRESDEN NUCLEAR POWER STATION UNIT 2, P&ID M-68

[5] DRESDEN NUCLEAR POWER STATION UNIT 2, P&ID M-4

[6] DRESDEN NUCLEAR POWER STATION UNITS 2&3, P&ID M-7

[7] DRESDEN NUCLEAR POWER STATION UNITS 2&3, P&ID M-3

[8] CRC STANDARD MATHEMATICAL TABLES, 26TH EDITION CRC PRESS, BOCA RATON, 1981, P.

[9] DRESDEN NUCLEAR POWER STATION UNITS 2&3 P&ID M-2

[10] DRESDEN NUCLEAR POWER STATION UNITS 2&3 P&ID M-6

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

CALCULATION NUMBER RSA-D-92-07 FILE ______ PAGE ____ OF ____

SUBJECT ______

PREPARED BY P. L. KONG PK CHECKED BY ______ REVIEWED BY KBR

Volume of Model Volumes

1. Volume 1 - LPCI

Dimensions are : triangular shaped floor 37.5 x 38.5

height = 38 ft.

$V = \frac{1}{2}(37.5 \times 38.5) \times 38 = 27,431 \ ft^3$

Assume ~10% occupied by equipment

$V_{net} = 0.9 \ V = 24,688 \ ft^3$

$V_{net} = 24,642 \ ft^3$ was used as input.

2. Volume 2 - Rx Bldg.

(see pp10-14 of "Heat Slab Dimensions")

Elev	Volume
517'6"	273226
545'6"	251669
570'	176577
589'	233728
613'	759990

total = 1,695,190

For the limiting case and assuming 15% occupied by equipment $V_{net} = 0.5 \times 0.85 \times 1695190 = 720,456.$

$V_{net} = 695,000 \ ft^3$ was used as input.

COMMONWEALTH EDISON COMPANY

NUCLEAR FUEL SERVICES DEPARTMENT PROJECT ______ DATE ______

CALCULATION NUMBER RSA-D-92-07 FILE ______ PAGE ____ OF ____

SUBJECT ______

PREPARED BY P. L KONG P.K. CHECKED BY ______ REVIEWED BY KBR

Volume of Model Volumes (p. 2)

3 Volume 3: Torus Room

(See p 9 of "Heat Slab Dimensions")

$V = 248,136 \text{ ft}^3$

For the limiting case

$V_{net} = 0.5 V = 124,068 \text{ ft}^3$ ✓

4. Volume 4 Soil

Use $V = 9 \times 10^9 \text{ ft}^3$

5. Volume 5: Torus

(see p 9 of "Heat Slab Dimensions")

$V = 2.42 \times 10^5$

Volume 5 is TDV, V is not used.

6. Volume 6: Outside Air

Use $V = 9 \times 10^9 \text{ ft}^3$ ✓

7. Volume 7 Soil

Use $V = 9 \times 10^9 \text{ ft}^3$ ✓

8. Volume 8: Rx Bldg + Turbine Bldg

Use $V = 9 \times 10^9 \text{ ft}^3$ ✓

Prepared by: [signature]		Checked by:		Reviewed by:		[signature]
P.	L. KONG					
	ESTIMATION OF LPCI ROOM TEMPERATURE AT 30 DAYS					
The temperature after 11.5 days is estimated by first examining						
the change in temperature every two hours for 32 hours						
preceding t=276 hours.						
day	hour	delta time	Temp	delta Temp		
		-34	177.511			
		-32	177.545	0.034		
		-30	177.578	0.033		
		-28	177.611	0.033		
		-26	177.643	0.032		
		-24	177.674	0.031		
		-22	177.705	0.031		
		-20	177.735	0.03		
		-18	177.764	0.029		
		-16	177.793	0.029		
		-14	177.821	0.028		
		-12	177.849	0.028		
		-10	177.876	0.027		
		-8	177.903	0.027		
		-6	177.929	0.026		
		-4	177.954	0.025		
		-2	177.979	0.025		
11.5	276	0	178.003	0.024		
The rate of change of delta Temperature is about -0.0005 deg per 2 hours.						
Estimate temp assuming this rate.						
		0	178.003	0.0240		
		2	178.027	0.0235		
		4	178.050	0.0230		
		6	178.072	0.0225		
		8	178.094	0.0220		
		10	178.116	0.0215		
		12	178.137	0.0210		
		14	178.157	0.0205		
		16	178.177	0.0200		
		18	178.197	0.0195		
		20	178.216	0.0190		
		22	178.234	0.0185		
		24	178.252	0.0180		
		26	178.270	0.0175		
		28	178.287	0.0170		
		30	178.303	0.0165		
		32	178.319	0.0160		
		34	178.335	0.0155		

Prepared by: P.K.		Checked by:		Reviewed by:		KBCC
P. L. KONG		36	178.350	0.0150		
		38	178.364	0.0145		
		40	178.378	0.0140		
		42	178.392	0.0135		
		44	178.405	0.0130		
		46	178.417	0.0125		
		48	178.429	0.0120		
		50	178.441	0.0115		
		52	178.452	0.0110		
		54	178.462	0.0105		
		56	178.472	0.0100		
		58	178.482	0.0095		
		60	178.491	0.0090		
		62	178.499	0.0085		
		64	178.507	0.0080		
		66	178.515	0.0075		
		68	178.522	0.0070		
		70	178.528	0.0065		
		72	178.534	0.0060		
		74	178.540	0.0055		
		76	178.545	0.0050		
		78	178.549	0.0045		
		80	178.553	0.0040		
		82	178.557	0.0035		
		84	178.560	0.0030		
		86	178.562	0.0025		
		88	178.564	0.0020		
		90	178.566	0.0015		
		92	178.567	0.0010		
		94	178.567	0.0005		
15.5	372	96	178.567	0.0000		
Therefore, the maximum temperature is 178.6 deg F.						
The temperature at 30 days would be less than or equal to 178.6 deg F.						

ENCLOSURE 3
CECo Calculation DSE-Q-004

Evaluation of the Impact of LOCA Combined with a Loss of Room Coolers on Performance of General Electric RHR Pump Motors, Dresden 2&3/Quad Cities 1&2

STATION/UNIT	PAGE: 1 OF
Dresden, 2&3 / Quad Cities, 1&2	

CALCULATION TITLE:

Evaluation of the Impact of LOCA Combined with a Loss of Room Coolers on Performance of General Electric RHR Pump Motors.

- [X] SAFETY RELATED
- [ ] REG. RELATED
- [ ] NON-SAFETY RELATED
- [X] ENVIRONMENTAL QUALIFICATION
- [ ] ASME SECTION III

EQUIP NUMBER(S)	GROUP	CALC NUMBER	SYSTEM
2/3-1502A-D, 1/2-1002A-D 2/3-1401A-B 1/2-1401A-B		DSE-Q-004	

REV.	CHRON #	PREPARER	DATE	REVIEWER	DATE	APPROVER	DATE
00		Boris Pikelny	10/21/92				

CALCULATION NO: DSE-Q-004	REV. 0	PAGE 2 OF

SECTIONS	DESCRIPTION	PAGES
1	CALCULATION TITLE PAGE	1
2	TABLE OF CONTENTS	2
3	HISTORICAL DATA (REQUIRED ONLY FOR REVISIONS)	—
4	CALCULATION SUMMARY SHEET	3
5	CALCULATION SHEET(S)	4,5
6	CALCULATION REVIEW CHECKLIST	6
7	COMPUTER APPLICATION REVIEW CHECKLIST	
	ATTACHMENTS	

NUCLEAR ENGINEERING DEPARTMENT
CALCULATION SUMMARY SHEET

CALCULATION NO: DSE-Q-004 REV. 0 PAGE 3 OF

PURPOSE/OBJECTIVE OF CALCULATION

Evaluation of Impact of LOCA combined with a Loss of Room Coolers on performance of GE RHR Pump motors and on the motors' qualified life.

ASSUMPTIONS/DESIGN INPUTS

REFERENCES

1. EQ Binder EQ-25D
2. EQ Binder EQ-25Q
3. Memo from J. Schrage to G. Wagner, dated 9-24-92 with attachment.
4. SQL calculation CQD-049455, Rev.01, dated 4-24-92

CONCLUSIONS

The RHR pump motors will perform its intended function during 40 years of service and 30 days of post-LOCA/LORC accident.

REMARKS	PREPARER	DATE
	Boris Pikelny	10-21-92
	REVIEWER	DATE

CALC. NO: DSE-Q-004
PAGE NO: 4 OF

The results of the subject motors thermal aging are shown at Fig. 1, References 1&2, page 30. The curve 2 of this figure shows that the motors covered by the qualification report can stand 69,000 hours at operating temperature of 140°C. The 140°C is the temperature of the motor windings and accommodates 80°C heat rise (Ref. 1&2, Tab F1, page 17), 10°C hot spot temperature and ambient temperature of 50°C. (140°C = 80°C + 50°C + 10°C)

The RHR room temperatures profiles which are result of LOCA combined with a Loss of Room Coolers are shown on pages C13 and C14 of Reference 4, and it is shown that the temperature does not reach 180°F (82.2°C) during 30 days of post-accident.

Per Ref. 1&2, Tab F1, page 17 the heat rise temperature for the installed pump motors is 50°C. So, during the post-accident the temperature of the RHR motors winding is: 82.2°C + 50°C + 10°C = 142.2°C

REVISION					
BY/DATE					
CHECKED/DATE					

CALC. NO: DSE-Q-004
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From Curve 2 (Ref. 1&2, page 30) the qualified thermal life of the motor insulation at 142.2°C & 145°C is about 45,000 hours. Per Reference 1, page C16 the duration which represent all operational modes of the subject equipment is equivalent to 11,260 hours at 136°C (for Dresden) and 27,316 hours at 136°C for Quad Cities (Ref. 2, page C18).

Comparison of the given requirements (max 27,316 hours at 136°C) and qualified life value (45,000 hours at 145°C) shows that the RHR pump motors will perform it required safety function during 30 days of post-LOCA/LORC accident and are qualified for 40 years of normal service life.

REVISION					
BY/DATE					
CHECKED/DATE					

NUCLEAR ENGINEERING DEPARTMENT
CALCULATION REVIEW CHECKLIST

CALCULATION NO: DSE-Q-004 REV 0 PAGE 6 OF

REVIEWED BY: DATE:

	YES	NO	REMARKS
1. IS THE OBJECTIVE OF THE ANALYSIS CLEARLY STATED?			
2. ARE ASSUMPTIONS AND ENGINEERING JUDGEMENTS VALID AND DOCUMENTED?			
3. ARE ANY ASSUMPTIONS THAT NEED REVERIFICATION IDENTIFIED?			
4. ARE THE REFERENCES (I.E. DRAWINGS, CODES, STANDARDS,) LISTED BY REVISION EDITION, DATE, ETC.?			
5. IS THE DESIGN METHOD CORRECT AND APPROPRIATE FOR THIS ANALYSIS?			
6. IS THE CALCULATION IN COMPLIANCE WITH DESIGN CRITERIA, CODES, STANDARDS, AND REG. GUIDES?			
7. ARE THE UNITS CLEARLY IDENTIFIED, AND EQUATIONS PROPERLY DERIVED AND APPLIED?			
8. ARE THE DESIGN INPUTS AND THEIR SOURCES IDENTIFIED AND IN COMPLIANCE WITH UFSAR, TECH SPECS?			
9. ARE THE RESULTS COMPATIBLE WITH THE INPUTS AND RECOMMENDATIONS MADE?			
10. WAS A DETAILED REVIEW PERFORMED? IF "NO" PROVIDE JUSTIFICATION FOR YOUR REVIEW METHOD.			