MONTICELLO NUCLEAR GENERATING PLANT		3494
TITLE:	CALCULATION COVER SHEET	Revision 4
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CALCULATION COVER SHEET

Title RHR Room Temp Response to General Electric Letters GLN-97-017 and GLN-97-019

CA-97-157 Add. 0

Vendor NSP

Associated Reference CA-96-113 CA-97-074

Assigned Personnel

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Record of Issues

Rev	Description	Total No. of Sheets	Last Sheet No.	Preparer	Verifier	Verifier	Approval	Approval Date
0	Initial Issue	9	9	RPJ	DW		SH	6/13/97

☐ NA Verification/Approval in Document

References/Filing Locations

1. ESW Re-Rate file
2. Calc. CA-96-113
3. Calc. CA-97-079

Associated Subjects/Component - RHR Room Temperature

3087 (DOCUMENT CHANGE, HOLD AND COMMENT FORM) incorporated: 97-0759				
FOR ADMINISTRATIVE USE ONLY	Resp Supv: GSE-NGS	Assoc Ref: AWI-05.01.25	SR: N	Freq: 0 yrs
	ARMS: 3494	Doc Type: 3042	Admin initials: cjo	Date: 4/8/97

M/trb

MONTICELLO NUCLEAR GENERATING PLANT		3495
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Place initial by items verified.

CA- 97 - 157
Attachment ______
Page 1 of ______

REVIEW			Verified
1.	Inputs correctly selected.	~~See Comments~~ DSW	DSW
2.	Assumptions described and reasonable.	~~See Comments~~ DSW	DSW
3.	Applicable codes, standards and regulations identified and met.		DSW
4.	Appropriate method used.		DSW
5.	Applicable construction and operating experience considered.		DSW
6.	Applicable structure(s), system(s), and component(s) listed.		DSW
7.	Formulas and equations documented, unusual symbols defined.		DSW
8.	Detailed to allow verification without recourse to preparer.		DSW
9.	Neat and legible, pages all correctly numbered.		DSW
10.	Signed by preparer.		DSW
11.	Interface requirements identified and satisfied.		DSW
12.	Acceptance criteria identified, adequate and satisfied.		DSW
13.	Result reasonable compared to inputs.		DSW

ALTERNATE CALCULATION		
14.	Alternate calc results consistent with original.	N/A
15.	Items 1-4 above verified. (Required by ANSI N.45.2.11)	N/A.

TESTING		
16.	Testing requirements fully described and adequate.	N/A
17.	Shows adequacy of tested feature @ worst case conditions.	N/A
18.	If test is for overall design adequacy, all operating modes considered in determining test conditions.	N/A
19.	If model test, scaling laws and error analysis established.	N/A
20.	Results meet acceptance criteria, or documentation of acceptable resolution is attached.	N/A

OTHER (Explain) ______________________________

FINAL DOCUMENTATION (Verify applicable items included)

21.	Alternate or check calcs	N/A
22.	Summary of test results.	N/A
23.	Comments (errors, discrepancies, recommendations). Recommendations incorporated in calculation	DSW
24.	Method of resolution of comments. - incorporated into calculation	DSW

Completed By: Daniel [signature] Date: 6/13/97

3087 (DOCUMENT CHANGE, HOLD AND COMMENT FORM) incorporated: 97-0761				
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M/trb

RHR ROOM HEAT UP RESPONSE TO GLN-97-017 & GLN-97-019
RESPONSE TO VERIFIERS COMMENTS

COMMENT 1: Correct Lotus input tables for water response to agree with General Electric Letters GLN-97-017/019. It appears the temperature values are off set one time step up to about 25 hours.

RESPONSE: Incorporated the following statement in the results portion of the calculation:

The Lotus Vlookup tables in the RHR Room Heat Up calculations off set General Electric torus water response with respect to time one time step quicker from zero time until the peak is reached after which no off set is made. This keeps the heat input into the room above the GE curve which is conservative.

COMMENT 2: Place statement in assumptions that calculation is based on RHR Room with the greater heat input which bounds the other RHR Room.

RESPONSE: Incorporated the following statement in the results portion of the calculation:

This calculation models the B-RHR Room. It is conservative for the A-RHR Room as explained in Calculation CA-96-113, Methodology and Results portion.

COMMENT 3: State flow requirements to ECCS Pump Motor Cooler.

RESPONSE: 2 gpm was indicated in the Summary Section. A reference for the relationship between 2 gpm and 4960 BTU's/hr was indicated in the analyses portion.

COMMENT 4: Place statement in text acknowledging typographical error in table heading of GLN-97-019 of Ref 6.

RESPONSE: In the reference section for Ref 6, indicated 18800 MWT should read 1880 MWT of the heading.

By: Robert P. Jones 6-13-97 — Robert P. Jones, Preparer

Daniel S. Whitcomb 6/13/97 — Daniel S. Whitcomb, Verifier

TEMPERATURE OF RHR ROOMS DURING DBA LOCA, TORUS WATER TEMP PROFILE PER GENERAL ELECTRIC LETTERS GLN-97-017 AND GLN-97-019

TABLE OF CONTENTS

TEMPERATURE OF RHR ROOMS DURING DBA LOCA, TORUS WATER TEMP PROFILE PER GENERAL ELECTRIC LETTERS GLN-97-017 AND GLN-97-019

SUMMARY:

1. In an effort to support re-rate plus to answer questions about NPSH to the ECCS pumps, NSP contracted with General Electric to provide torus water temperatures for Design Basis Accidents. In this effort, General Electric has produced GLN-97-017, Ref 5, and GLN-97-019, Ref 6.

   GLN-97-017 contains torus water temperatures for re-rate at 1880 MWT for 1 RHRSW and 1 RHR pump operation plus 2 RHRSW and 2 RHR pump operation. The peak torus water temperatures are 193.6°F and 178.9°F respectively. GLN-97-017 supersedes General Electric Report GE-NE-T2300731-1, Ref 7 of NSP calculation CA-96-113, which reported a peak torus temperature of 191°F for 1 pump/1pump operation. The major difference between the two reports is that CRD water was not flowing in GLN-97-017.

   Further, it is proposed that GLN-97-017 supersede the May-Witt decay heat curve in the USAR for LOCA-DBA Torus Water Profile approved by the NRC in 1983 for 2 pump/2 pump operation showing peak torus temperature of 182°F, Ref 1 of NSP calc CA-97-074.

2. GLN-97-019 provides torus temperature peak of 194.2°F and analysis out to 25 hours for 1 pump/ 1 pump operation. This GE analysis minimizes Net Positive Suction Head for the ECCS Pumps with result being a hotter torus water temperature as compared to GLN-97-017. After 25 hours, this NSP calculation uses the results of GLN-97-017 for 1pump/1pump operation. It is proposed this combination of GLN-97-019 and GLN-97-017 be used in the USAR for torus water temperature during 1pump/1pump operation. If GLN-97-019 is revised in the future, the torus water response should be carried out in time the same as GLN-97-107, 288.0 hours.

3. Calculations are carried out long enough in time until the lesser time of the following is obtained:

   a. Room temperature hits 140°F.

   b. Room temperature peaks.

c. 277.78 hours where room temperature stays under 140°F but does not peak. 277.78 hours is the time extent of the May-Witt decay heat curve referenced in Calculation CA-97-074, Ref 3.

4. The maximum RHR A and B Room temperature during a DBA LOCA with 2 pump/ 2 pump operation is 140°F at 25.7 hours and 139.86°F at 277.78 hours with River Service water at 90°F and at 89°F respectively with thermal power at 1880 MWT.

5. The maximum RHR A and B Room temperature during a DBA LOCA with 1 pump/ 1 pump operation is 130.84°F at 46.0 hours with thermal power at 1880 MWT and River Service Water Temperature at 90°F.

6. 26 gpm cooling flow to the A and B RHR Room coolers must be obtained. Cooling flow of 2 gpm to one ECCS Motor/room when three motors in a room are operating must be obtained. Cooling flow must be 90°F or colder.

I. PURPOSE

It is desired to obtain the temperature rise in the Residual Heat Removal (RHR) rooms during a DBA LOCA for environmental qualification of equipment. Per Ref 7, this maximum ambient temperature is 140°F.

II. METHODOLOGY

Methodology is same as that shown in Calculation CA-96-113.

III. ANALYSES

Analyses is same as that shown in Calculation CA-96-113 except for the following five changes:

1. Insulation Ki value

Ki in calculation CA-96-113, table 1, page 1, was calculated based on a "ΔT" across the thickness of insulation. Rather, Ki should be based on the mean temperature value of the insulation. See Ref 5 of Calc CA-96-113 and also attached to this calculation as Ref 8.

In the Lotus input program, the two interior nodes were given twice the load rating as compared to the two exterior nodes. Therefore, the mean temperature the Ki was based on is:

Tmean= (T2+2*T3+2*T4+T5)/6

2. Steel Kstl value

A Kstl value of 96 BTU-in/hr-ft2-F was referenced on page 7 of calculation CA-96-113. The reference given was read wrong. Instead Kstl=26 BTU/hr-ft-F * 12in/ft = 312 BTU-in/hr-ft2-F at 212 F. Ref 9.

3. Calculation CA-96-113 made reference to a preliminary calculation, Ref 16 to CA-96-113, showing the temperature response of the torus air space and the Secondary Containment Air Space to a DBA-LOCA. Since it is desired not to reference preliminary work, conservative assumptions were used for these two air space temperatures as such:

The torus air space temperature is taken as the GE torus water temperature minus 10°F, but no less than 120°F. This is considered conservative. A much larger earth heat sink, much of which is below water line, exists around the torus room as compared to no heat sink modeled around the Torus as reported in GLN-97-019, Ref 6.

The Secondary Containment Air Space above the RHR room was taken as a constant 130°F throughout the accident. With Standby Gas Treatment drawing in about 2700 CFM 90°F or colder atmospheric air and large heat sources insulated from the air space above the RHR Rooms such as Primary Containment and the Steam Chase, 130°F is a conservative high temperature to use.

Again, as stated in CA-96-113, the 3 foot thick concrete wall between the torus room and the RHR rooms and the 1'9" thick concrete ceiling between the 935' elevation of the Reactor Room Secondary Containment and RHR Room acts to insulate the RHR Room. Therefore, these room temperatures only have a small impact on the RHR room temperature.

4. This calculation takes credit for one motor cooler rather than two. Therefore, the amount of electrical heat load into the room is reduced by 4960 BTU's/hr rather than 9920 BTU/hr as indicated in Calculation CA-96-113 (electric heat load is increased by 4960 BTU's/hr in this calculation because of the deletion of one motor cooler). 2 gpm of cooling flow to a ECCS Motor cooler corresponds to 4960 BTU's/hr per calculation CA-96-113.

   No motor coolers are taken credit for in the 1 pump/1 pump operation.

5. Analyses for obtaining Cmin/Cmax and ε for 1 RHRSW and 1 RHR pump operating is from Calc CA-97-074 (Ref 3) and is as such:

   RHR heat Exchanger K Value = 143.1 BTU/sec-F

Shell side=4000gpm*60min/hr*8.05lbs/gal(@195F)=1.93E6 lbs/hr (1 RHRSW pumps)
Tube side=3500gpm*60min/hr*8.304lbs/gal(@90)= 1.75E6 lbs/hr (1 RHR pumps)

Cs=1.93E6 BTU/hr-F=Cmax
Ct=1.75E6 BTU/hr-F=Cmin

K=143.1*3600=5.15E5 BTU/hr-F

Per Ref 4,

Cmin/Cmax=.904 |
|→ ε=.21
NTUmax= 5.15E5/1.75E6=.29 |

IV. RESULTS

The maximum RHR A and B Room temperature during a DBA LOCA with 2 pump/ 2 pump operation is 140°F at 25.7 hours, and 139.86°F at 277.78 hours, with River Service water at 90°F, and 89°F respectively with thermal power at 1880 MWT.

The maximum RHR A and B Room temperature during a DBA LOCA with 1 pump/ 1 pump operation is 130.84°F at 46 hours with thermal power at 1880 MWT and River Service Water Temperature at 90°F.

TEMPERATURE OF RHR ROOMS DURING DBA LOCA, TORUS WATER TEMP PROFILE PER GENERAL ELECTRIC LETTERS GLN-97-017 AND GLN-97-019

See following pages of attached production runs:

1. Page 13 of 19 of 90°F River, 2 pump/2 pump operation.

2. Page 76 of 82 of 89°F River, 2 pump/2 pump operation.

3. Page 23 of 33 of 90°F River, 1 pump/1 pump operation.

It will be reported the temperature of the room will stay at 140°F or less during the DBA-LOCA. There are a number of conservatisms in this calculation from which this conclusion can be reached. They are listed below.

1. Conservatisms listed in the Methodology portion of Calculation CA-96-113 are applicable.

2. Conservative Torus room and Secondary Containment temperature assumptions were made which will tend to drive the RHR Air Room temperature a little higher than is the case.

3. It is unlikely that the two RHR motors and the one Core Spray motor in a RHR room will be running at a full 600 H.P. and 800 H.P. rating respectively for 25.7 hours at 90°F River water temperature or 11 1/2 days at 89°F River Water temperature as this calculation models.

4. The river temperature does drop at night but is ignored in this calculation. Constant maximum river temperature for 277.78 hours is not likely.

5. GE calculated torus water temperatures of References 5 and 6 assumed River Water Temperature of 90°F. This is conservative for the one run in this calculation that used 89°F River Water temperature for the Room Cooler, motor cooler and RHR Room Piping Temperatures that are a function of River Water Temperature.

6. Operator action maybe relied upon to shut one of the two RHR pumps down in order to limit room temperature after 25.7 hours into the accident. The temperature of the RHR room has stayed under 140°F long enough to drop the torus temperature to less than 165°F which is well below the design value of 194.2°F, peak temperature of GLN-97-019, Ref 6.

7. Reference 5 indicated the room temperature should not exceed 140°F at a relative humidity of 100%. This calculation used dry air properties. As explained in Calculation CA-96-113, this is conservative (meaning a higher room temperature will be obtained in this calculation than is actually the case) relative to the surface convection heat transfer coefficients. Further, it is also conservative in that the Specific Heat of moist air is higher than dry air. This means more heat input into a RHR room to raise it a degree is needed if the RHR room has moist air in it as compared to dry air.

8. The Lotus Vlookup tables in the RHR Room Heat Up calculations off set General Electric torus water response with respect to time one time step quicker from zero time until the peak is reached after which no off set is made. This keeps the heat input into the room above the GE curve which is conservative.

9. This calculation models the B-RHR Room. It is conservative for the A-RHR Room as explained in Calculation CA-96-113, Methodology and Results portion.

V. REFERENCES

Reference #1

"Heat Transfer" by J.P. Holman, Sixth Edition

Reference #2

Calculation CA-96-113, Rev 0, Temperature of RHR Rooms During DBA LOCA

Reference #3

Calculation CA-97-074, Rev 0, RHR Room Temp Response to USAR Rev 2, 10/83, Torus Water Temperature Profile

Reference #4

"Heat Transfer" by J.P. Holman, Sixth Edition, page 552 — Attached

TEMPERATURE OF RHR ROOMS DURING DBA LOCA, TORUS WATER TEMP PROFILE PER GENERAL ELECTRIC LETTERS GLN-97-017 AND GLN-97-019

<u>Reference #5</u>

General Electric letter GLN-97-017 dated 3-14-97, Revised Suppression Pool Temperature and Wetwell Pressure History Data For DBA-LOCA (Task 6.0)	Attached

<u>Reference #6</u>

General Electric letter GLN-97-019 dated 5-9-97, Revised Analysis of Suppression Pool Temperature and Wetwell Pressure for Limiting Long-term LOCA event for NPSH (Task 6.0).	Attached

A typographical mistake is acknowledged in the heading of Att B, Case 2 Table. 18800 MWT should read 1880 MWT.

<u>Reference #7</u>

Monticello USAR, Rev 14, Page 4 of 39	Attached

<u>Reference #8</u>

ASTM C-533-72, Calcium Silicate Block and Pipe Thermal Insulation	Attached

<u>Reference #9</u>

Mechanical Engineer's Review Manual, Seventh Edition, Lindeburg, PE, Page 10-21	Attached

ADDITIONAL INFORMATION ON MODELLING

acts to insulate the RHR room. Therefore, these room temperatures only have a small impact on the RHR room temperature.

The RHR room temperature will be solved for by thermal resistance and capacity formulation as described in Section 4-7 of Reference 17. Heat transfer is by convection from surface to air and by radiation from surface to surface. The equations are formulated on the "LOTUS" software. The resulting program is called RHR. Development, required inputs and running instructions are covered in Appendix A to this calculation. Verification is covered in Appendix B.

Per Ref 17, page 360, the nominal calculated convection heat transfer coefficients may vary by ± 25%. It will be conservative to use .75 of nominal on all heat convecting surfaces. This will tend to subtract from wall heat sink capability to keep the room temperature down. Lower coefficients on the hot pipe and equipment will tend to lower room temperature, but since the area of the walls are so much larger, the overall effect of lower coefficients is conservative higher room temperature. A 1.25 X Nom for the pipe hot surfaces and .75 X Nom for the walls will not be considered. The biggest factor in determining h is the amount of moisture in the air as compared to the shape of components. The shape factor is a weak or no influence in the convection equation. With this observation, all h values will tend to go one way or the other.

The convection heat transfer coefficients were calculated using dry air properties of Ref 18. In actuality, there will be moisture in the air which will tend to raise the convection heat transfer coefficients. Using dry air coefficients is conservative.

The following modeling techniques which are either conservative or equivalent for predicting how hot the RHR Room will get are used in modeing the RHR Room:

A. Radial heat transfer out the edges of the RHR Room and the volume of this concrete to act as a dampening restriction on the rise of the RHR Room temperature will be ignored which is conservative.

B. Each pipe and the RHR Heat Exchanger is approximated to transfer all of its radiant energy to the inside surfaces of the exterior walls, floor and ceiling. The amount appropriated to each surface is in proportion to its area/total RHR inside surface area.

C. Pipe insulation thermal conductivity, air to surface convection heat transfer coefficients, and air density are automatically corrected for temperature.

D. The extra dampening capacity of the steel and re-bar buried in the concrete walls to restrict heat rise with respect to time is neglected. This is conservative.

E. The model showing the flow of heat from the concrete walls to the Radwaste Building and to the water table through soil is shown in Figure 1. This heat flow model is based on Ref 19 showing heat flow around corners following a circular path. From the Re-Rate RHR run output data, for initial steady state conditions, the model of figure #1 gives a temperature of [87.4°F] (W2-T7s/1c) and [100.0°F] (W3-T7s/1c) on the outside of the concrete walls between water level and grade. If these values are compared to Ref 20 that shows an average temperature range of 62°F to 34°F, then figure #1 is extremely conservative. It is from this conservatism that an average of 62°F and 34°F up to ten feet down will be used as the design temperature of soil below water level at 28 feet below grade. 48°F will be used as design temperature below water level.

F. Per Table 7-1 of Ref 42, a C value of .56 will be used for calculating Convection Heat Transfer Coefficients for both vertical (C=.59) and horizontal pipe (C=.53) pipe as a simplification rather then separating the two.

G. Temperature data will be saved about once every 1.89 hours which is 10 calculations across the LOTUS spread sheet.

III. <u>ANALYSIS</u>

The analysis will involve obtaining input variables for RHR of Appendix A. Variables that are not discussed here are shown in Table #1.

1. Summer time steady state temperatures, before accident, of the RHR Room and adjacent surroundings is as such:

    a. Torus Compartment: 104F Ref 21

    b. Reactor Building Secondary Containment at 935' Elev, Radwaste Rooms, and RHR Room: 100 F Ref 21

these motors by the thrust bearing water coolers. #11 and #12 RHR motors do not have bearing water coolers. Therefore, the amount of bearing heat removed when all three ECCS motors are operating in a room is 2 * 4960 = 9920 BTU/hr. It will conservatively be taken as 4960 BTU/hr when one RHR pump in a room is operating.

IV. RESULTS

RHR B Room was modeled to obtain hottest room temperature during a DBA LOCA for three scenarios; Non-rerate with 3 motors running, Re-rate with 3 motors running, and Re-rate with 1 Core Spray and 1 RHR motor operating. The room hottest temperatures were 139.53 F, 141.56 F, and 130.55 F respectively as shown in the attached production runs.

The two motor operation at re-rate bounds non-rerate for two motor operation.

The slight rise in room temperature at about 280 hours on the Non-rerate production curve is due to the transition between the NEDO curve of Ref 35 and the digitized printout of Ref 7.

The length of time of the runs was long enough to show a definite peak of room temperature, the reported hottest room temperature.

For the B room, the flow rate to the room cooler must be 26 gpm.

For each rroom, there must be flow to two of the ECCS motor bearing coolers if all three pumps are operating or flow to one if two of the pumps are operating.

The A room was not modeled, but it is very similar in its heat generation/sink characteristics as the B room. Relative to each room, the main heat contributors are the ECCS motors, heat exchanger surface, and torus water temperature. The latter two are identical and the ECCS motor input will be less in the A room. The main heat sinks are the coolers and to a lesser extent the the surrounding environment temperatures. The coolers are identical and the environment temperatures are slightly cooler for the A room. It would have 90 F atmospheric air on the surface outside rather than 130 F Radwaste building air modeled for the B Room. Based on this reasoning, 26 gpm cooling flow the the A Room cooler will also be specified.