Arizona Nuclear Power Project

DOCUMENT NUMBER
13-MC-HA-A05

TITLE/DESCRIPTION

Transient temperature study for Containment spray pump room.

Safety related Quality class "Q"

REV	REVISION DESCRIPTION	ORIGINATOR DATE	CHECKER DATE	RS DATE	QA DATE	NEM/PEM DATE
0	Issue for Use	BECHTEL	BECHTEL	H.W.Riley 4/4/88	N/A	N/A

VALIDATION CHECK ON
CALCULATION B-MC-HJ-253

EVALUATION OF ROOM TEMPERATURE

For small time

Energy eq^n for air

$$\rho_{CV} \frac{dT}{dt} = \Phi - hA(T - z)$$

For small time assume $z \approx$ const (check later)

$$\frac{dT}{dt} = \frac{\Phi}{\rho_{CV}} - \frac{hA}{\rho_{CV}} T$$

$$\frac{dT}{dt} + \frac{hA}{\rho_{CV}} T = \frac{\Phi}{\rho_{CV}}$$

$$\frac{d}{dt}\left(e^{\frac{hA}{\rho_{CV}} t} T\right) = \frac{\Phi}{\rho_{CV}} e^{\frac{hA}{\rho_{CV}} t}$$

$$T = e^{-\frac{hA}{\rho_{CV}} t} \frac{\Phi}{\rho_{CV}} \int_0^t e^{\frac{hA}{\rho_{CV}} t}$$

$$= \frac{\Phi}{\rho_{CV}} e^{-\frac{hA}{\rho_{CV}} t} \frac{\rho_{CV}}{hA}\left[e^{\frac{hA}{\rho_{CV}} t} - 1\right)$$

$$\boxed{T = \left(\frac{\Phi}{hA}\right) \cdot \left[1 - e^{-\frac{hA}{\rho_{CV}} t}\right]} \qquad (1)$$

Energy eq^n for concrete

$$\frac{d z^2/\zeta}{dt} = \frac{4}{3} \alpha f \qquad f = \frac{h}{k}(T - z) = \frac{h}{k} T(1 - u)$$

$$d \frac{T u^2}{h/k (1-u)} = \frac{4}{3} \alpha \left(\frac{h}{k}\right)(1-u) T.$$

$$-\frac{T u^2}{(1-u)^2} \frac{\partial u}{dt} + \frac{1}{(1-u)} \frac{d T u^2}{d\zeta} = \frac{4}{3} \alpha \left(\frac{h}{k}\right)(1-u) T$$

for small u

$$\frac{d\,Tu^2}{dt} = 4/3 - \alpha (h/k)^2 T$$

$$Tu^2 = \frac{4}{3}\alpha \left(\frac{h}{ic}\right)^2 \frac{\dot{Q}}{hA}\left[t + \frac{e^{-\frac{hA}{\rho cv}t}}{\frac{hA}{\rho cv}} \cdots\right]$$

$$\Delta x = \left[\frac{4}{3}\alpha \left(\frac{h}{ic}\right)^2 \frac{\dot{Q}}{hAT}\left[t + \frac{e^{-\frac{hA}{\rho cv}t}}{hA/\rho cv} \cdots\right]\right]^{1/2} T \qquad (2)$$

$$\Delta x = \left[6.26\left[\frac{t}{60} + \frac{e^{-.24t}}{14.44} \cdots\right]\right]^{1/2} T^{1/2}$$

Control room

$Q = 1,238,275$ | $\frac{Q}{hA} = 37.24$

$A = 23,754$

$h = 1.4$, $V = 159,573$ | $\frac{hA}{\rho cV} = 14/44 \; 0.24$

$$T = 37.24\,[1 - e^{-0.24\,t}]$$

t	2	4	6	12	24
T	89.22	98.01	103	110	112.12
z	77.6	78.66	79.51	81.68	84.64

checks AA

APPROVED: HMRiley 6/22/88

ANPP CALCULATION CHANGE NOTICE (CCN)				PAGE 1 OF 3
CALCULATION NO. 13-MC-HA-A05	REV. 0	CLASS Q	AFFECTED SHEET NO(S) 11, 14	CCN NO. 1
CALCULATION TITLE TRANSIENT TEMP. STUDY FOR C.S. PUMP ROOM				CCN ISSUE DATE 5-31-88
AFFECTED PLANT CHANGES NONE			REFERENCE(S) NONE	UNITS AFFECTED ☒ UNIT 1 ☒ UNIT 2 ☒ UNIT 3 ☐ COMMON

REASON FOR CHANGE SHEET# 11-ITEM 21- To provide further justification for assumption made.
SHEET#R14- To add Item 25 - For Reference.

DESCRIPTION OF CHANGE

Delete existing sheets 11 & 14.

Insert sheets 11 & 14 as attached with this CCN.

ORIGINATOR	CHECKER	RS	QA	RS
(O. BHASIN)	5/27/88	H.W. Riley 5/27/88	N/A	N/A

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 11

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSolu	3-28-88	GWM	3-28-88						

20. For calculation of air flow due to temperature difference for the case of an open door, the room average temperature is assumed to be 140° F. For support of this average temperature, see Section VII.C, verification of average room temperature.

21. For calculation of air flow due to temperature difference for the case of open room door, the average temperature outside the room is assumed to be 90° F. The air volume in the hallway outside the CS pump room is approximately 64,000 ft^3 (References 13 and 25), which is about 6.8 times the volume of the CS pump room. The walls, ceiling and the floor in the hallway will act as a heat sink for the heat transferred to the hallway from the CS pump room. In addition, by opening the door in the hallway between HPSI pump rooms A and B, an additional 64,000 ft^3 of air volume is available for the heat transfer. Therefore, 90°F is a conservative high estimate for an average temperature outside the CS pump room after the door is open. Note: The initial temperature was 75°F (Assumptions 2 and 3). 1

22. Concrete has the following properties:

A. Density 144 lbs/ft^3 (Ref 6)
B. Thermal conductivity 0.54 (Ref 6)
C. Specific heat 0.2 $btu/lb-^oF$ (Ref 6)

15. Ingersoll-Rand Pump Manual, log N001-15.02-11, CS pump data sheet and pump curve.
16. Pump motor data sheets, log N001-11.05-7-2
17. Reliance Electric Co. drawing, log M721A-109-2
18. User's and Theoretical Manuals Verification Report, program RMHTUP-Room Heat Up, program number ME204 Rev. A1, Bechtel Power Corporation, San Francisco Power Division.
19. Final Safety Analysis Report, Palo Verde Nuclear Generating Station, Amendment 17.
20. Auxiliary Building Isometric, Drawing Number 13-P-SIF-207, Rev. 22.
21. Detailed Design Criteria, Part III, System HA, HVAC-Auxiliary building, Rev. 8.
22. Detailed Design Criteria, Part III, System SI, Safety Injection and Shutdown Cooling System, Rev. 5.
23. Detailed Design Criteria, Part III, System EC, Essential Chilled Water System, Rev. 3.
24. Auxiliary Building Base Mat, Sections and Details, Drawing Numbers 13-C-ZAS-124, Rev. 13.
25. Auxiliary Building Floor Plan at El. 40'-0", 51'-6", 70'-0" & 88'-0", drawing number 13-A-ZAD-201 Rev. 19.

INTERNAL CONTROL NO. 18601-183 -CALC-003

CALCULATION COVER SHEET

SHEET 1

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM FILE NO.

PROJECT QUALITY CLASS Q DISCIPLINE MECH.

COMPUTER PROGRAM	SCP [X] YES [ ] NO	PROGRAM NO.(S) ME 204	VERSION/RELEASE NO. A1

RECORD OF ISSUES

NO.	DESCRIPTION	TOTAL NO. OF SHEETS	LAST SHEET NO.	ORIG	CKR	GL	GS	CHEF	DATE
0	ORIGINAL ISSUE	72	72	P.S. Seth	G.V.M	—	TSS	—	APPR. 3-28-86 FILM
									APPR. FILM
									APPR. FILM
									APPR. FILM
									APPR. FILM
									APPR. FILM

INFORMATION ENTERED IN THIS SPACE:

- SHOW PROFESSIONAL ENGINEER STAMP, IF REQUIRED.
- ENTER REFERENCE TO INCLUSION OF CHECKER'S ALTERNATE CALCULATIONS, IF USED.
- PROVIDE ANY NOTES TO ASSIST CHECKING AND APPROVAL.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 2

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelli	3-29-88	G.W.M	3-29-88						

Table of Contents

CALCULATION SHEET

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SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 3

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-29-82	G.W.M	3-29-82						

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 4

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.S.Sethi	3-28-88	G.W.M	3-28-88						

I. PURPOSE

The design basis for cooling the Containment Spray (CS) and Low Pressure Safety Injection (LPSI) pumps equipment rooms, when the pumps are in service, uses Essential Air Cooling Units (ACU) and the Essential Chilled Water System (ECWS) for cooling. In the event that either the ACU or ECWS fails when the pump runs, the room temperature will rise rapidly.

The purpose of this study is to determine the transient air temperature for 24 hours in the CS/LPSI pump rooms (limiting case) for the following two cases. The CS pump was selected as the limiting case. The details for this selection are explained under Assumption 24.

A) Fluid temperature in the pipes of 225°F with no HVAC
B) Fluid temperature in the pipes of 225°F with no HVAC and the room door open.

Standard room heat-up (RMHTUP) computer program, ME204, Rev. A1 is used to study the room ambient air heat-up by the equipment and other heat loads in the CS pump room.

The heat generated in the room is transferred to the room air, stored in the room enclosure concrete (heat sink) and transferred to the air outside the room. The transient temperature for the CS room air is studied for a time period of 24 hours without any HVAC. In addition, the transient temperature is studied when there is no HVAC and the pump room door is open.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 5

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Stelle	3-28-88	G. W.M	3-28-88						

II. DESIGN CRITERIA:

This is a study of the effect of certain equipment failures which are, strictly speaking, beyond the specific design basis for the affected systems. The results will be used as input to a probabalistic risk assessment evaluation done by others.

The systems involved in this study are the Safety Injection (CS subsystem), Auxiliary Building HVAC (Normal and Essential), and Essential Chilled Water. Their design criteria are references 21, 22, and 23.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 6

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0	R.L.Heth	3-28-88	G.W.M	3-28-88						

III. STUDY ASSUMPTIONS:

1. Fluid temperature for the CS system in the CS pump room is 225°F. During post-Loca conditions, the maximum containment sump temperature is 225°F as shown in reference 19, figure 6.2.1-24.

2. The initial temperature inside the CS room is 75°F. This is based on the assumption that normal HVAC is available before the time period of this study. Temperature of 75°F is the typical normal temperature in the auxiliary building and is based on the operating experience.

3. The initial temperature outside the CS room is 75°F. This is based on the assumption that normal HVAC is available before the time period of this study. The initial temperature of 75°F is the typical normal temperature in the auxiliary building and is based on the operating experience.

4. Essential or normal HVAC is not available during time period of this study. This is the principle failure assumed at the onset of this study as discussed in section I.

5. Initially, steady state temperature conditions exist in the CS pump room and outside the pump room.

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0	PSSc/hi	3-28-88	G.W.M	3-28-88						

6. The room is simplified as an enclosed space bounded by the same thickness of walls, ceiling and floor. All of the room walls actually are 2'-9" each. In case of floor, no credit is taken for the thickness being more than the wall thickness of 2'-9". Due to the low heat load generated in 24 hours compared to the capacity of the existing walls to absorb the heat, the additional floor thickness will not make any difference to the room ambient air temperature.

7. The walls, ceiling and floor are used as a heat sink. For details, refer to Section VI.C of this study.

8. The heat generated within the room is considered as being constant. This is due to the fact that more than 85% of the heat load, as shown in figure 1, is from the electric motors. For details refer to Sections VI.D and VII.A.1.e of this study.

9. Temperature at the inner surface of the insulation is equal to the temperature of the fluid in the pipe. This assumes that the temperature of the outside pipe surface is the same as the fluid temperature. It also assumes that the temperature drop across the very small air gap between the pipe and the inside surface of the insulation is zero. This provides a conservative estimate of the piping heat load for this study.

10. For calculation of heat dissipated by the pump, the pump is modeled as a flat surface. This will provide a conservative estimate compared to a cylindrical surface.

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0	PSselki	3-28-88	G.W.M	3-28-88						

11. When a wall is shared by two rooms, which may be heated at the same time, half of the wall surface area will be considered as a heat transmission pathway for each room. This will provide half of the wall as a heat sink for each room. Each CS pump room shares a common wall with a HPSI pump room and with a LPSI pump room. The operating CS pump can be from a different train than the operating HPSI and/or LPSI pump so that the operating pump rooms may not be adjacent to each other. This study uses a worst case scenario and assumes two common walls.

12. The dimensions of the CS pump rooms A and B for all three units are essentially identical. In addition, the electric motors and pumps, equipment, lighting and piping sizes and lengths are virtually the same for all of these room. This study is performed for CS pump room A for Unit 1 and is applicable to CS room A and B for all three units.

13. The shield wall in the pump room is considered a heat sink. The shield wall is converted to an equivalent wall having same thickness as the room walls. In doing this, the equivalent surface area on one side of this wall is modelled as a heat transmission pathway to adjacent spaces. The shield wall surface area and volume are approximately 4% and 2.7% respectively of the pump room surface area and volume. The small percentage surface area and volume of the shield will provide reasonably acceptable results.

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0	PWetli	3-28-88	G.W.M	3-23-88						

As can be seen from the results in Appendixes A and B, very little heat is transmitted through the walls; most is stored in it. This approach reasonably accounts for the shield wall mass, but slightly under estimates the rate at which heat is transferred into the shield wall because only one surface is assumed available for heat transfer. Because the surface area and volume of the shield are a small percentage of the total, this will provide reasonably acceptable results.

14. For the case when the room door is open, half of the room opening is assumed for air flow into the room and the other half is assumed for the air flow out of the room. ASHRAE Ref. 1, Chapter 19, Page 334, indicated that if there is only one opening, or if one opening is extremely large relative to the others, the neutral zone (where there is no pressure difference between inside an outside) will be at or near the center of the opening. This reference supports the above assumption . In addition 50% effectiveness of the opening (normal value 50% to 60%) for air flow is used. For details, refer to section VII.B.1

15. Per assumption 4 above, the essential HVAC is not available during time period of this study. For a conservative approach, ACU fan will be assumed running, without chilled water through the essential coils. The heat load due to this motor is minor as compared to the heat load from the CS pump motor. 81% efficiency of the ACU fan motor is assumed for calculation of room heat load. This is a typical motor efficiency for 3 hp motors as shown in reference 1, chapter 22, table 30, page 417.

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SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 10

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0	P.K.T.	3-28-88	G.W.M	3-28-88						

16. Moving air is assumed in the room due to ACU fan rather than normal still air. A conservative value of the surface resistance of 0.25, based on the assumed value of air velocity of 7 1/2 mph, is used. (See Reference 1, chapter 20, table 1, page 357)

17. The lighting load in the CS pump room is assumed to be 2 Watts/FT^2. This is a typical lighting load for industrial buildings as shown in the national electrical code 1987 handbook, reference 7.

18. This study is performed for a time period of 24 hours. The computer model can provide details for a maximum of 720 steps (Refer Section VI.D). Therefore, each step or time increment is 2 minutes.

NOT AN ASSUMPTION

19. The room walls are required to be divided into a number of layers for computation of temperature distribution in the concrete walls by the computer model. The required input for the thickness of the first layer and the multiplication factor for thickness of other layers are selected as 0.01 ft. (approx. 1/8") and 1.41 respectively. For details, see sections VI.A and B.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 11

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelle	3-28-88	GWM	3-28-88						

20. For calculation of air flow due to temperature difference for the case of an open door, the room average temperature is assumed to be 140° F. For support of this average temperature, see Section VII.C, verification of average room temperature.

BASIS

21. For calculation of air flow due to temperature difference for the case of open room door, the average temperature outside the room is assumed to be 90° F. It assumes that doors in the corridor will be opened for enough air mixing to have the average temperature of 90°F. This approximates an average temperature after the door has been open for a while. Note: The initial temperature was 75°F. (Assumptions 2 and 3)

BASIS

22. Concrete has the following properties:

A. Density 144 lbs/ft^3 (Ref 6)
B. Thermal conductivity 0.54 (Ref 6)
C. Specific heat 0.2 btu/lb-°F (Ref 6)

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0	PSSc.Ltr	3-18-88	G.W.M	3-23-88						

23. The net pump room volume is required as input to the computer model. For calculation of net room volume, the volume of the HVAC equipment in the HPSI pump room is insignificant and is neglected.

24. As shown in section I, this study is to be performed for the limiting case for the CS pump room or LPSI pump room. The pump motors for these two systems have the same nameplate ratings, but the operating BHP is higher for the CS pump than the LPSI pump.

Reviewing references 9, 10, and 20, there are insignificant, minor differences among the pipe layouts of these systems.

The lighting heat loads are practically the same.

CS pump room has a smaller area (20'-6" X 18'-0") than the LPSI pump room area (22'-3" X 18'-0"). The height is the same for these rooms. From the layout of the pump rooms (see page 38), each CS pump room shares two walls, one with the HPSI pump room and the other with the LPSI pump room. In the case of LPSI pump room, there is only one common wall with the CS. Per assumption 11, the CS room has lower heat transmission surface area and lower heat sink volume compared to the LPSI pump room.

From above, it is concluded that CS pump room is the limiting case and this study will be performed for the CS pump room.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 13

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0	R Lethi	3-28-88	G.W.M	3-28-88						

IV. REFERENCES:

1. ASHRAE Handbook of Fundamentals, 1972.
2. Technical specification for thermal insulation materials and the application to piping and equipment, specification number 13-MM-301, Rev. 2.
3. Line designation list, 13-P-ZZG-014, Rev. 29.
4. Auxiliary building essential cooling system heat load calculation, calculation number 13-MC-HA-051, Rev. 1.
5. P & I diagram, safety injection and shutdown cooling system, drawing number 13-M-SIP-001, Rev. 19.
6. Principles of heat transfer, third edition, Frank Kreith, Intext Educational Publishers. table A-2, Physical Properties of Some Nonmetals, page 635.
7. The National Electrical Code 1987 Handbook, fourth edition, General Lighting Loads by Occupancies, table 220-3(b), page 100.
8. NAVCO Piping "Datalog", National Valve and Manufacturing Company, Pittsburg, PA. Edition No. 10.
9. Auxiliary building isometric, drawing number 13-P-SIF-201, Rev. 21.
10. Auxiliary building isometric, drawing number 13-P-SIF-203 Rev 23.
11. Auxiliary building plan at elevation 40'-0", drawing number 13-C-ZAS-110, Rev 16.
12. Auxiliary building plan at elevation 40'-0", drawing number 13-C-ZAS-112 Rev 4.
13. Auxiliary building plan at elevation 51'-6", drawing number 13-C-ZAS-116 Rev 17.
14. General Arrangement, Containment Spray Pump, N001-11.01-36-6

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PAHelke	3-28-88	G.W.M	3-28-88						

15. Ingersoll-Rand Pump Manual, log N001-15.02-11, CS pump data sheet and pump curve.
16. Pump motor data sheets, log N001-11.05-7-2
17. Reliance Electric Co. drawing, log M721A-109-2
18. User's and Theoretical Manuals Verification Report, program RMHTUP-Room Heat Up, program number ME204 Rev. A1, Bechtel Power Corporation, San Francisco Power Division.
19. Final Safety Analysis Report, Palo Verde Nuclear Generating Station, Amendment 17.
20. Auxiliary Building Isometric, Drawing Number 13-P-SIF-207, Rev. 22.
21. Detailed Design Criteria, Part III, System HA, HVAC-Auxiliary building, Rev. 8.
22. Detailed Design Criteria, Part III, System SI, Safety Injection and Shutdown Cooling System, Rev. 5.
23. Detailed Design Criteria, Part III, System EC, Essential Chilled Water System, Rev. 3.
24. Auxiliary Building Base Mat, Sections and Details, Drawing Numbers 13-C-ZAS-124, Rev. 13.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 15

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-19-88	G.W.M	3-19-88						

V. SUMMARY OF RESULTS:

The transient temperature summary for the CS pump room air is shown below. For case A, the temperature values can be used directly. For cases B and C, having the door open results in air flow in and out of the room. As explained in Section VII.D, the average of the results is felt to best estimate the transient temperature profile when the room door is open.

	No HVAC and Closed Door	No HVAC and Open Door		
	Case A	Case B	Case C	Avg B&C
Time Period	Temp. °F	Temp. °F	Temp. °F	Temp. °F
0 min	75	75	75	75
2 min	92.13	84.06	87.98	86.02
4 min	102.05	89.49	95.62	92.56
12 min	114.44	96.83	105.53	101.18
36 min	120.75	100.45	110.49	105.47
1 hr	124.31	102.36	113.21	107.79
2 hr	130.68	105.77	118.07	111.92
4 hr	139.56	110.50	124.83	117.67
6 hr	146.34	114.10	129.98	122.04
8 hr	152.05	117.14	134.32	125.73
12 hr	161.62	122.22	141.60	131.91
24 hr	183.29	133.68	158.02	145.85

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
1	R.L. Hall	3-26-85	G.W.M	3-28-85						

VI. ROOM HEAT-UP COMPUTER MODEL

A. Model Description: (Ref 18)

The room heat-up computer program, RMHTUP, program number ME204, version A1, can be used to study the room ambient air heat-up by the equipment heat or any other heat sources in the room.

The temperature of room ambient air increases with time, due to the heat released from the equipment and other sources. The heat generated within the room is transferred to the ambient room air, stored in the room enclosure (walls, ceiling, and floor) and transferred to the air outside the room.

The room walls are divided into a number of layers with incremental thicknesses for numerical computation by the computer program. In this study, the value of imaginary thickness of first layer of concrete wall is selected as 0.01 ft and the multiplication factor of imaginary thickness of other layers is taken as 1.41. In other words, the first concrete layer thickness is 0.01 ft (approx. 1/8"), the second layer thickness is 0.0141 ft (approx. 3/16"), third layer $0.01 \times (1.41)^2$ ft, etc.

The transient room temperature is determined from the heat balance equation, which balances the heat generated within the room and the heat transferred to the ambient room air, stored in the room enclosure and transferred to the outside air, as shown below:

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SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 17

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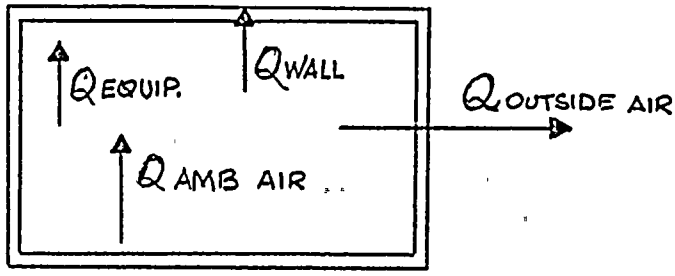
0	R.Hall	3-28-88	G.W.M	3-28-88						



$$Q_{EQUIP} = Q_{AMB\ AIR} + Q_{WALL} + Q_{OUTSIDE\ AIR}$$

WHERE:

Q_{EQUIP} = Heat generated from equipment or any other source in the room, BTU/HR

$Q_{AMB\ AIR}$ = Heat transferred to the room air, BTU/HR

Q_{WALL} = Heat stored in the room walls, ceiling and floor, BTU/HR

$Q_{OUTSIDE\ AIR}$ = Heat transferred to the outside air, BTU/HR

The room ambient temperature and the wall temperature distribution are calculated at fixed time intervals. In addition, total heat stored in the ambient air and in the concrete walls and heat transferred to the outside air are provided for each time interval.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 18

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	[illegible]	3-28-88	G.W.M	3-28-88						

B. Input Required for Computer Model:

The following information is required as input for transient temperature study in the CS pump room:

1. Initial room ambient temperature, degrees F
2. Initial outside ambient temperature, degrees F
3. Equipment and other heat generated in the room, BTU/HR
4. Net room surface area, ft^2
5. Net room volume, ft^3
6. Thickness of room enclosure, ft
7. Density of room enclosure material, lbs/ft^3
8. Thermal conductivity of room enclosure material, BTU/HR-ft-F
9. Specific heat of room enclosure material, BTU/lb-F
10. One period of time increment for calculation, min
11. Imaginary thickness of first layer of room enclosure, ft
12. Multiplication factor of imaginary thickness of other layers

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Weth	3-28-88	G.W.M	3-28-88						

C. Assumptions for the Computer Model

1. The room is simplified as an enclosed space bounded by the same thickness of walls, ceiling, and floors.
2. The gross room volume is corrected for the volume occupied by piping and equipment.
3. The gross room surface area of the room enclosure is corrected for the area occupied by equipment.
4. The enclosure walls, ceiling and floor are taken as a heat sink.

D. Computer Model Limitations

1. The room enclosure walls, ceiling and floor must be considered as having the same thickness and of the homogenous material.
2. The air temperatures outside the room must be considered as being the same and remaining constant.
3. The heat generated within the room must be considered as being constant. No heat generated outside the room can be considered.
4. The program is limited to 720 time period calculations.

E. Computer Model Output

The following information is provided in the computer model output:

TAF = Final room air temperature at each period, ^{o}F
QAT = Heat stored in the ambient air, BTU
QST = Total heat stored in the concrete, BTU
QOT = Heat transferred to the outside air, BTU

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 20

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-28-88	G.W.M	3-28-88						

VII. STUDY:

This study is performed for the following two cases:

A. Fluid temperature in the CS pipes of 225° F with no HVAC and room door closed.

B. Fluid temperature in the CS pipes of 225° F with no HVAC and room door open.

CASE A

FLUID TEMPERATURE IN THE CS PIPES OF 225° F WITH NO HVAC AND ROOM DOOR CLOSED:

1. Heat Loads:

a. Electric Motors Heat Load:

This heat load consists of the heat generated by the CS pump motor and ACU fan motor.

i. CS Pump Electrical Motor Heat Load

CS Pump design flow = 3890 gpm (REF 15)

Pump design flow BHP = 630 hp (REF 15)

Motor efficiency, η = 93.4% (REF 16)

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 21

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Stella	3-28-88	G.W.M	3-28-88						

The pump and the motor are inside the CS pump room. The fluid is pumped to outside of the room.

$$\text{Motor heat load} = BHP \times 2545 \times \frac{(1-\eta)}{\eta}$$

(REF 1, note C, table 30, chap 22, page 417)

$$= 630 \times 2545 \times \frac{(1 - 0.934)}{0.934} \text{ BTU/HR}$$

$$= 113{,}299 \text{ BTU/HR}$$

ii. ACU Fan Motor Heat Load:

The essential ACU fan may be running without essential chilled water thru the essential cooling coils (See Assumption 15)

ACU nameplate fan hp = 3 hp (REF 17)
Motor efficiency = 81% (See Assumption 15)

The motor and the load are both in the CS room and the air and all the motor energy stays inside the room (i.e. all the fan motor energy stays inside the room).

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 22

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RKeltz	3-28-88	G.W.M	3-18-88						

From ref 1, chap 22, table 30, page 417,

Heat gain from fan motor

$$= \frac{\text{hp X 2545}}{\% \text{ eff}}$$

$$= \frac{3 \text{ X } 2545}{0.81}$$

= 9,426 BTU/HR

Total motor heat load = 113,299 + 9,426 = 122,725 BTU/HR

b. Lighting Heat Loads:

The heat load is due to the lighting in the CS pump room.

CS pump room area = (20'-6") x (18'-0") (Ref 11)

= 20.5 x 18 FT^2

= 369 FT^2

Typical lighting load for industrial buildings = 2 watts/FT^2 (REF 7)

Room lighting load = (Room area, ft^2) X (2 watts/ft^2) X 3.41 BTU/HR-watt

= 369 X 2 X 3.41 BTU/HR

= 2517 BTU/HR

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSc/hc	3/28/88	G.W.M	3-28-88						

c. Piping Heat Load:

When the CS pump is operating, design basis cooling is provided by the essential Air Cooling Unit (ACU). Essential chilled water is recirculated through the ACU chilled water cooling coils. In the event that either the essential ACU or the Essential Chilled Water System fails, the pump room temperature will rise rapidly.

The CS pump initially supplies cooling water from the refueling water tank. When that source is used, the CS pump recirculates water from the containment sump to remove decay heat from the core during the time period under study. In addition, the CS will operate continuously during this time period. Essentially all CS piping in this room is in use. Therefore, all the piping is included for calculation of heat loads.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

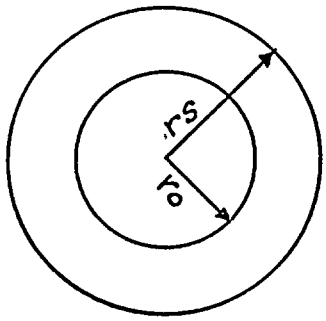
SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 24

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-28-88	G G.M	3-28-88						

This heat load is due to the CS pump suction and discharge piping in the CS pump room. All of the process piping in this room is insulated.

The following equation can be used to calculate the heat flow through insulated piping:

$$qs = \frac{to - ta}{\frac{rs \log_e \frac{rs}{ro}}{K} + Rs}$$



(Ref 1, chap 20, eq 11, page 353)

Where:

qs = Rate of heat transfer per square foot of outer surface of insulation, BTU per (hour) (square foot).

t_o = Temperature: inner surface of insulation, degrees F

t_a = Temperature of ambient air, degrees F

rs = Outer radius of insulation, inches

ro = Inner radius of insulation, inches

k = Thermal conductivity of insulation at mean temperature, BTU per (hour) (square foot) (of per inch thickness)

Rs = Surface resistance, (hour) (square foot) (degrees F) per BTU.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 25

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P Weth	3-28-88	G W. M	3-18-88						

For suction and discharge piping:
Fluid temperature t_o = 225° F (See Assumption 1)

Ambient air temperature t_a = 75° F (See Assumption 2)

Surface resistance, Rs= 0.25 (See Assumption 15)

Jacket emissivity of the calcium silicate insulation = 0.85 @ 100 Degrees F (Ref 2)

Mean insulation temp = $\frac{225 + 75}{2}$ = 150°F

Thermal conductivity of calcium silicate insulation at 150°F mean temperature, K =0.40 BTU per (hour) (square foot) (°F temp difference per inch thickness) (REF 1, table 3B, chapter 20, page 364).

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	K Liethe	3-28-88	G.W.M	3-28-88						

PIPING HEAT LOADS (CONT.)

THE PIPING HEAT LOADS ARE CALCULATED SEPARATELY FOR THE CS PUMP SUCTION PIPING AND THE DISCHARGE PIPING

PUMP SUCTION PIPING

THE PUMP SUCTION PIPING IN THE CS PUMP ROOM CONSISTS OF THE FOLLOWING:

A. LINE NO. 1PSIAL009 AND 1PSIAL067:

LINE SIZE = 14" SCH 20 [REF 3]

INSULATION THICKNESS = 2.5" [REF 2]

TYPE OF INSULATION = CALCIUM SILICATE [REF 3]

PIPE O.D. = 14" [REF 18]

INSULATION O.D. = 14 + (2 × 2.5)

= 19"

B. LINE NO. 1PSIAL009:

LINE NO. 1PSIAL009 IS USED IN TWO SIZES, ONE SHOWN ABOVE & THE OTHER SHOWN BELOW:

LINE SIZE = 18" SCH 20 [REF 3]

INSULATION THICKNESS = 2.5" [REF 2]

TYPE OF INSULATION = CALCIUM SILICATE

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 27

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	R.S.Seth	3-28-88	G.W.M	3-28-88						

PIPE O.D. = 18"

INSULATION O.D. = 18 + (2 × 2.5)

= 23"

FOR 14" PIPE, $Y_s = \frac{19}{2} = 9.5"$

$Y_0 = \frac{14}{2} = 7.0"$

FROM EQUATION SHOWN ON PAGE 24,

$$q_s = \frac{225 - 75}{\frac{9.5 \log_e \frac{9.5}{7}}{0.40} + 0.25}$$

= 19.99 BTU/HR-FT²

OUTER SURFACE AREA OF INSULATION

$= \frac{\pi \times 19}{12} \times 1$ FT²/LINEAR FT

= 4.97 FT²/LINEAR FT

q_s = 19.99 × 4.97 BTU/HR. LINEAR FT

= 99.35 BTU/HR- LINEAR FT

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 28

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.V.Nelle	3-28-88	G.W.M	3-28-88						

FOR 18" PIPE, $r_s = \frac{23}{2} = 11.5"$

$r_o = \frac{18}{2} = 9.0"$

FROM EQUATION SHOWN ON PAGE 24

$$q_s = \frac{225 - 75}{\frac{11.5 \log_e \frac{11.5}{9.0}}{0.40} + 0.25}$$

$= 20.56$ BTU/HR-FT^2

OUTER SURFACE AREA OF INSULATION

$= \frac{\pi \times 23}{12} \times 1$ FT^2/LINEAR FT

$= 6.02$ FT^2/LINEAR FT

$q_s = 20.56 \times 6.02$ BTU/HR-LINEAR FT

$= 123.77$ BTU/HR-LINEAR FT

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-105

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 29

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Lieth	3-28-88	G.W.M	3-28-88						

LINE NO.	PIPE SIZE	* PIPE LENGTH	HEAT LOAD/ LINEAR FT BTU/HR-LIN FT	HEAT LOAD BTU/HR
1PSIAL009	14"	4'	99.35	99.35 x 4 = 397
1PSIAL009	18"	37'	123.77	123.77 x 37 = 4,579
1PSIAL067	14"	25'	99.35	99.35 x 25 = 2,484

HEAT LOAD FOR SUCTION PIPING = 7,460 BTU/HR

* FOR PIPE LENGTHS, SEE REFERENCE 9

NOTE: THE EXISTING INSULATION THICKNESS FOR PIPING AND EQUIPMENT WAS SELECTED PER REF 2, EXHIBIT D, SECTION D.5.4 AND TABLE D-2.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 30

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P Stella	3-28-88	G. W. M	3-28-88						

PUMP DISCHARGE PIPING

THE PUMP DISCHARGE PIPING IN THE CS PUMP ROOM CONSISTS OF THE FOLLOWING.

A. LINE NO. 1PSIAL079 AND 1PSIAL082: [REF 3].

LINE SIZE = 10" SCH 40

INSULATION THICKNESS = 2" [REF 2]

TYPE OF INSULATION = CALCIUM SILICATE

PIPE O.D. = 10.75" [REF 18]

INSULATION O.D. = $10.75 + (2 \times 2)$

$= 14.75"$

FOR 10" PIPE, $r_s = \frac{14.75}{2} = 7.375"$

$r_o = \frac{10.75}{2} = 5.375"$

$$q_s = \frac{225 - 75}{\frac{7.375 \log_e \frac{7.375}{5.375}}{0.40} + 0.25}$$

$= 24.66 \text{ BTU/HR-FT}^2$

OUTSIDE SURFACE AREA OF INSULATION

$= \frac{\pi \times 14.75}{12} \times 1 \text{ FT}^2/\text{LINEAR FT}$

$= 3.86 \text{ FT}^2/\text{LINEAR FT}$

$q_s = 24.66 \times 3.86 \text{ BTU/HR-LIN FT} = 95.19 \text{ BTU/HR-LIN FT}$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 31

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Velethu	3-28-88	G.W.M	3-28-88						

B. LINE NO. 1PSIAL080 :

LINE SIZE = 2" SCH 40

INSULATION THICKNESS = 2" [REF 2]

INSULATION TYPE = CALCIUM SILICATE [REF 3]

PIPE O.D. = 2.375"

INSULATION O.D. = 2.375 + (2×2)

= 6.375"

FOR 2" PIPE, $Y_S = \frac{6.375}{2} = 3.1875"$

$Y_O = \frac{2.375}{2} = 1.1875"$

$$q_s = \frac{225 - 75}{\frac{3.1875 \log_e \frac{3.1875}{1.1875}}{0.40} + 0.25}$$

$= 18.48$ BTU/HR-FT^2

OUTER SURFACE AREA OF INSULATION

$= \frac{\pi \times 6.375}{12}$ FT^2/LINEAR FT

$= 1.67$ FT^2/LINEAR FT

$q_s = 18.48 \times 1.67$ BTU/HR-LINEAR FT

$= 30.86$ BTU/HR-LINEAR FT

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 32

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.S.Vetter	3-28-88	G.W.M	3-28-88						

LINE NO	PIPE SIZE	* PIPE LENGTH	HEAT LOAD/ LINEAR FT BTU/HR-LIN FT	HEAT LOAD BTU/HR
1PSIAL079	10"	77'	95.19	95.19 x 77 = 7330
1PSIAL082	10"	26'	95.19	95.19 x 26 = 2475
1PSIAL080	2"	43'	30.86	30.86 x 43 = 1327

HEAT LOAD FOR DISCHARGE PIPING = 11,132 BTU/HR

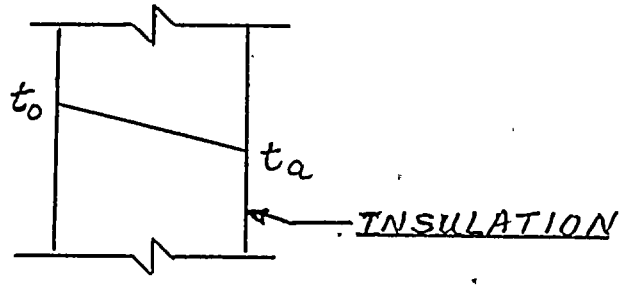
HEAT LOAD FOR SUCTION PIPING = 7,460 BTU/HR

TOTAL PIPING HEAT LOAD = 18,592 BTU/HR

* FOR PIPE LENGTHS, SEE REFERENCES 10. AND 20.

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelke	3-28-88	G.W.M	3-28-88						

d. Heat Dissipated by the CS Pump:



The pump walls are assumed to be flat surfaces (See Assumption 10).

The heat dissipated by the pump can be calculated from the following equation for flat surface:

$$qs = \frac{to - ta}{\frac{L}{K} + Rs}$$ (REF 1, chap 20, page 353, equation 10)

Where L= insulation thickness, inch

Per reference 2, the insulation used on the CS pump is mineral wool and is 2" thick.

Therefore, L = 2"

However, the pump insulation has been replaced with the reflective insulation for Unit 1. CS pumps for Units 2 and 3 still have mineral wool insulation. The thermal conductivity of reflective insulation is almost the same as that of calcium silicate.

At 150°F mean temperature, value of K for the reflective insulation = 0.40 BTU per (hour) (square foot) (°F temp difference per inch thickness)

At 150°F mean temp, value of K for the mineral wool = 0.285 BTU per (hour) (square foot) (°F temp difference per inch thickness) (REF 2, exhibit F, section 2C, para F.2.1E)

R = 0.25 (For details, see Assumption 16).

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-28-88	G.W.M	3-28-88						

The conservative value of the insulation thermal conductivity for mineral wool versus reflective insulation is used. This value is K = 0.40, BTU per (hour) (square foot) (^{o}F temp difference per inch thickness).

$$qs = \frac{225 - 75}{\frac{2}{0.40} + 0.25} = 28.57 \text{ BTU/HR-FT}^2$$

From ref 14,

Surface area of CS pump =

$$2 \times \frac{19.75}{12} \times \frac{7}{12} + \frac{14}{12} \times \frac{13.88-7}{12} + \frac{8.625}{12} \times \frac{25-19}{12}$$

$= 9.26 \text{ft}^2$

Heat dissipated by CS pump

= 28.57 X 9.26 BTU/HR

= 265 BTU/HR

e. Total Heat Loads:

The following is the sum of the heat loads in the CS pump room:

CS pump and ACU fan electric motors heat load	=	122,725 BTU/HR
Lighting heat load	=	2,517 BTU/HR
Piping heat load	=	18,592 BTU/HR
Heat dissipated by pump	=	265 BTU/HR
Total Heat Load	=	144,099 BTU/HR

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 35

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RBleth	3-28-88	G.W.M	3-28-88					-	

CS PUMP ROOM SURFACE AREA & VOLUME

a) CS PUMP ROOM SURFACE AREA:

CS PUMP ROOM DIMENSIONS LxWxH ARE
20'-6" x 18'-0" x 27'-3" [REF 11 & 24]

CS PUMP ROOM 'A' HAS A COMMON WALL (20'-6" x 27'-3") WITH HPSI PUMP ROOM 'A' AND A COMMON WALL (18'-0" x 27'-3") WITH LPSI PUMP ROOM 'A'. [REF 11]

50% OF THE COMMON WALL SURFACE AREA IN THE CS PUMP ROOM 'A' IS CONSIDERED AS A PATHWAY FOR HEAT TRANSMISSION. [REF ASSUMPTION 11]

THEREFORE, THE SURFACE AREA FOR HEAT TRANSFER IS AS FOLLOWS:

$$\text{WALL SURFACE AREA} = 18'\text{-}0" \times 27'\text{-}3" + 20'\text{-}6" \times 27'\text{-}3" + \frac{20'\text{-}6"}{2} \times 27'\text{-}3" + \frac{18'\text{-}0"}{2} \times 27'\text{-}3"$$

$$= 27'\text{-}3" \left(18'\text{-}0" + 20'\text{-}6" + 10'\text{-}3" + 9'\text{-}0" \right)$$

$$= 1574\ FT^2$$

$$\text{CEILING SURFACE AREA} = 20'\text{-}6" \times 18'\text{-}0"$$

$$= 369\ FT^2$$

$$\text{FLOOR SURFACE AREA} = 20'\text{-}6" \times 18'\text{-}0"$$

$$= 369\ FT^2$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 36

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
1	PSeTh	3-28-88	G.W.M	3-28-88						

ROOM SURFACE AREA = 1574 + 369 + 369

= 2312 FT^2

THERE IS A SHIELD WALL IN THE ROOM WITH DIMENSIONS 19'-6" x 5'-3" x 2'-6" [REF 11]

VOLUME OF SHIELD WALL = 19'-6" x 5'-3" x 2'-6"

= 256 FT^2

EQUIVALENT SURFACE AREA FOR 2'-9" THICK SHIELD WALL = $\frac{256}{2.75}$ FT^2

= 93 FT^2

TOTAL SURFACE AREA = 2312 + 93

= 2405 FT^2

FLOOR AREA OCCUPIED BY THE CS PUMP = 9 FT^2 [REF 12]

NET SURFACE AREA FOR HEAT TRANSMISSION

= 2405 - 9

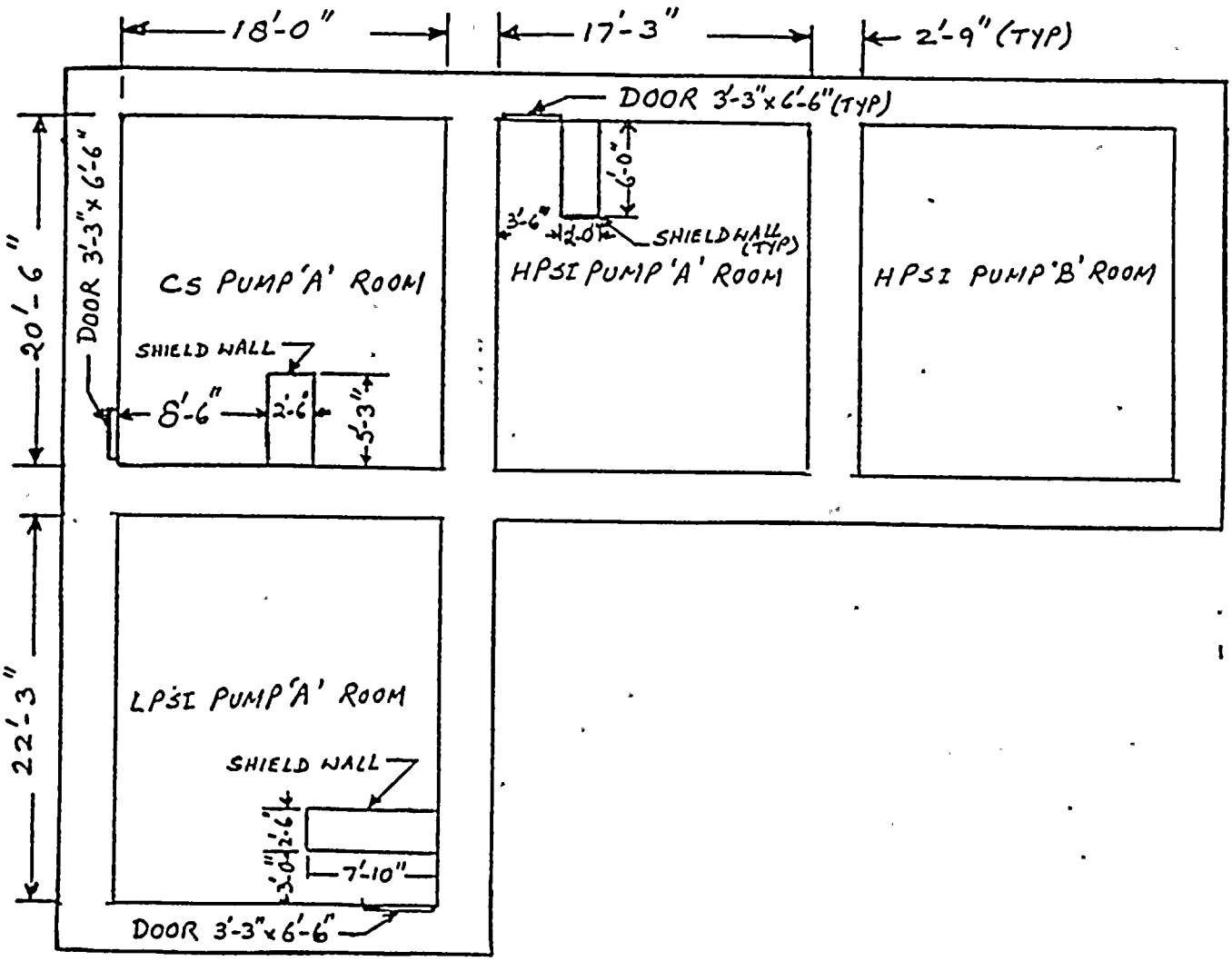
= 2396 FT^2

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 37

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSselli	3-18-88	G.W.M	3-18-88						



LAYOUT OF PUMP ROOMS

(BASED ON REF 11 & 13)

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MCI-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 38

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P Heller	3-28-88	G.W.M	3-28-88						

b. CS PUMP ROOM VOLUME

CS PUMP ROOM VOLUME = 20'-6" × 18'-0" × 27'-3"

[REF 11 & 13]

= 10055 FT^3

TOTAL PUMP VOLUME = VOLUME RELATED TO PUMP + SUCTION END + DISCHARGE END

$$\text{PUMP VOLUME} = \pi\left(\frac{19.75}{12}\right)^2 \times \frac{7}{12} + \frac{\pi}{4} \times \left(\frac{14}{12}\right)^2 \times \left(\frac{13.88-7}{12}\right) + \frac{\pi}{4}\left(\frac{8.625}{12}\right)^2 \times \left(\frac{25-19}{12}\right)$$

[REF 14]

= 5.78 FT^2

COUPLING = 0.5 FT^2 (APPROX)

$$\text{MOTOR VOLUME} = \frac{49}{12} \times \frac{49}{12} \times \frac{75}{12} + \frac{8}{12} \times \frac{8}{12} \times \left(\frac{93.88-35}{12}\right)$$

= 131 FT^2

PUMP & MOTOR SET VOLUME = 5.78 + 0.5 + 131

= 137.28. FT^2,

SAY 137 FT^2

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 39

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
C	[illegible]	3-28-88	G.W.M	3-28-88						

THE FOLLOWING PROVIDES THE PIPING VOLUME IN THE CS PUMP ROOM: (REF PAGES 26, 29, 30, 31 AND 32)

LINE NO	PIPE SIZE	INSULATION O.D.	PIPE LENGTH
1PSIAL009	14"	19"	4'
1PSIAL009	18"	23"	37'
1PSIAL067	14"	19"	25'
1PSIAL079	10"	14.75"	77'
1PSIAL082	10"	14.75"	26'
1PSIAL080	2"	6.375"	43'

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 40

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	R.Wells	3-28-88	G.W.M	3-28-88						

VOLUME OF 1PSIAL009-14" AND 1PSIAL069-14"

$$= \frac{\pi}{4} \times \left(\frac{19}{12}\right)^2 \times (4+25) \text{ FT}^3$$

$$= 57.10 \text{ FT}^3$$

VOLUME OF 1PSIAL009-18"

$$= \frac{\pi}{4} \times \left(\frac{23}{12}\right)^2 \times 37 \text{ FT}^3$$

$$= 106.75 \text{ FT}^3$$

VOLUME OF 1PSIAL079-10" AND 1PSIAL082-10"

$$= \frac{\pi}{4} \times \left(\frac{14.75}{12}\right)^2 \times (77+26) \text{ FT}^3$$

$$= 89.69 \text{ FT}^3$$

VOLUME OF 1PSIAL080-2"

$$= \frac{\pi}{4} \times \left(\frac{6.375}{12}\right)^2 \times 43 \text{ FT}^3$$

$$= 9.53 \text{ FT}^3$$

TOTAL PIPING VOLUME

$$= 57.10 + 106.75 + 89.69 + 9.53$$

$$= 263 \text{ FT}^3$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 41

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RAHetka	3-28-88	G.W.A	3-28-88					-	

CS PUMP ROOM VOLUME = 10055 FT^3 [See page 38]

SHIELD WALL VOLUME = 256 FT^3 [See page 36]

PUMP + MOTOR SET VOLUME = 137 FT^3 [See page 38]

PIPING VOLUME = 263 FT^3 [See page 40]

NET CS PUMP ROOM VOLUME

$= 10055 - (256 + 137 + 263)$

$= 9399$ FT^3

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 42

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSc/h	3-25-88	G.W.M	3-28-88						

3. Input Data: Case A .

The following input data for the computer model is used:

1. Initial room ambient temp. = 75° F [Assumption 2]
2. Initial outside ambient temp. = 75° F [Assumption 3]
3. Equipment and other heat generated in the room = 144,099 BTU/HR [See Section VII.A.1.e]
4. Net room surface area = 2396 FT^2 [See Section VII.A.2]
5. Net room volume = 9399 FT^2 [See Section VII.A.2]
6. Thickness of room enclosure = 2.75 FT [Ref 11]
7. Density of room enclosure material = 144 LBS/FT^3 [Ref 6]
8. Thermal conductivity of room enclosure material = 0.54 BTU/HR-FT-°F [Ref 6]
9. Specific heat of room enclosure material = 0.2 BTU/LB-°F [Ref 6]
10. One period of increment for calculation = 2 min [Assumption 18]
11. Imaginary thickness of first layer of concrete enclosure = 0.01 FT [Assumption 19]
12. Multiplication factor of imaginary thickness of other layers = 1.41 [Assumption 19]

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 43

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PVHeflin	3-28-88	G.W.M	3-28-88						

4. Results: Case A:

The transient temperature for the CS pump room air obtained from the computer output, is shown in Figure 2. The transient temperature output, Appendix A, shows that without any HVAC and the door closed, the calculated temperature in the pump room will be as follows:

Time Period	Temperature ^{o}F
0 min	75
2 min	92.13
4 min	102.05
12 min	114.44
36 min	120.75
1 hr	124.31
2 hr	130.68
4 hr	139.56
6 hr	146.34
8 hr	152.05
12 hr	161.62
24 hr	183.29

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 44

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
1	R.H.Ha	3-28-88	G W.M	3-28-88						

VII.B. CASE B

FLUID TEMPERATURE IN THE CS PIPES OF 225°F WITH NO HVAC AND ROOM DOOR OPEN:

1. Air Flow Due to Temperature Difference:

When the temperature in a building or a room is different from that outside, a pressure difference between inside and outside occurs as a result of difference in air density, i.e. due to the chimney effect.

The air flow due to the temperature difference is calculated as follows:

$$pc = 0.52ph\left(\frac{1}{To} - \frac{1}{Ti}\right)$$ [Ref 1, ASHRAE Chapter 19, Page 334, equation 2)

Where pc = pressure difference across room enclosure due to chimney effect, inches of water

p = absolute pressure, psi

h = distance from neutral zone, feet

To = absolute outside temperature, °F

Ti = absolute room temperature, °F

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 45

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	R.H.Th	3-28-88	G.W.M	3-28-88						

The door opening is 6'-6" X 3'-3" [Ref 13].
Therefore, h = 3'-3" (1/2 height: Assumption 14)
Assuming room temperature of 140 ^{o}F and outside temperature of 90^{o}F, [Assumptions 20 and 21]

BASIS

Pressure difference, pc

$$= 0.52 \times 14.7 \times 3.25 \left[\frac{1}{460+90} - \frac{1}{460+140}\right]$$

$$= 0.52 \times 14.7 \times 3.25 \left[\frac{1}{550} - \frac{1}{600}\right]$$

= 0.0037641 inches of water

The flow velocity can be expressed equivalent to a velocity head as:

$pv = 0.000482V^2$ [Ref 1, chap 19, page 333, eq 1]

Where pv = velocity head, inches water gauge
V = air velocity, miles per hour

Thus setting pc = pv

$0.0037641 = 0.000482V^2$

or V = 2.80 miles/hr.

Quantity of air flow through door opening:

Q = EAV (Ref 1, chap 19, page 344, equation 6)

Where Q = air flow, cfm
A = free area of the opening, ft^2
V = air velocity, feet per minute = miles per hour X 88
E = effectiveness of opening (0.50 to 0.60 for perpendicular flow)

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelle.	3-28-88	G. W M	3-28-88						

Half of the door opening is assumed for flow into the room and the other half for flow out of the room [See Assumption 14]

In addition, E = 0.50 is used

Therefore, $Q = 0.5 \times (3.25 \times 3.25) \times (2.80 \times 88)$

$= 1301$ CFM

2. Heat Loads with Door Open - Case B

Air flow due to open door = 1301 CFM

Heat removed = 1.08 X CFM X (Temp Difference) BTU/HR

[Ref 1, chap 19, page 343, Eq 5]

= 1.08 X 1301 X (140-90)

= 70,254 BTU/HR

Heat generated in the CS pump room = 144,099 BTU/HR

Net heat load in the CS pump room

= (144,099-70,254) BTU/HR

= 73,845 BTU/HR

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSchu	3-28-88	G.W M	3-28-88						

3. Input Data: Case B

All input data for Case B is the same as for Case A except for item #3, Room heat load, which is 73,845 BTU/HR.

4. RESULTS: Case B

The transient temperature for the CS room ambient air, obtained from the computer output, is shown in figure 3. The transient temperature output, Appendix B, shows that, without any HVAC and the pump room door open, temperature in the pump room will be as follows:

Time Period	Temperature ^{o}F
0 min	75
2 min	84.06
4 min	89.49
12 min	96.83
36 min	100.45
1 hr	102.36
2 hr	105.77
4 hr	110.50
6 hr	114.10
8 hr	117.14
12 hr	122.22
24 hr	133.68

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 48

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Wells	3-28-88	G.W.M	3-28-88						

VII.C Case C:

Verification of Average Room Temperature:

Average room temperature was assumed to be 140°F for case B. The computer output for the case B (Appendix B) shows that the room temperature is 122 Degrees F after 12 hours. It is apparent that the average heat removed by the chimney effect is slightly over estimated and that the final temperature may be slightly underestimated. To establish an upper limit, the chimney effect was recalculated for 122 °F.

1. Air flow due to Temperature Difference: Case C

Using the methodology used in case B, the pressure difference, air flow and corresponding heat load are recalculated, due to temperature difference, with room temperature 122°F and outside temp 90°F (same as before):

$$\text{Pressure difference, } p = 0.52 \times 14.7 \times 3.25 \left[\frac{1}{460+90} - \frac{1}{460+122}\right]$$

$$= 0.52 \times 14.7 \times 3.25 \times \left[\frac{1}{550} - \frac{1}{582}\right]$$

$$= 0.0024835$$

$$0.0024835 = 0.000482V^2 \quad \text{[Ref 13, chap 19, page 333, eq 1]}$$

Air velocity, $V = 2.27$ miles/hour

Air flow, $Q = 0.5 \times (3.25 \times 3.25) \times (2.27 \times 88)$

$= 1055$ CFM

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 49

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSc/hu	3-28-88	G.W.M	3-28-88						

2. Heat Load with the Door Open: Case C

Heat removed due to
open door = 1.08 X 1055 (122-90)
= 36,461 BTU/HR

Net Heat load with door open = 144,099 - 36,461 = 107,638 BTU/HR

3. Input Data: Case C

All input data for Case C is the same as for Case A except for item #3, Room heat load, which is 107,638 BTU/HR.

4. RESULTS: Case C:

Using this heat load, computer model is again run. The result of this computer run, Appendix C, is plotted on Figure 3. It indicates that the temperature after 12 hours is 142°F and the 24 hour temperature is 158°F

IF THE ASSUMED INSIDE AIR VOLUME
THE CUBICAL SPACE [illegible] THEN ASSUMPTION
[illegible]

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSathi	3-28-83	G.W.M	3-28-83						

RESULTS: Case C (continued)

The transient temperature for the CS pump room air, obtained from the computer output, is shown in Figure 3. The transient temperature output, Appendix C, shows that, without any HVAC and the pump room door open, the calculated temperature in the pump room will be as follows:

Time Period	Temperature ^{o}F
0 min	75
2 min	87.98
4 min	95.62
12 min	105.53
36 min	110.49
1 hr	113.21
2 hr	118.07
4 hr	124.83
6 hr	129.98
8 hr	134.32
12 hr	141.60
24 hr	158.02

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 51

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-28-88	G.W.M.	3-28-88						

VII.D CONCLUSIONS: No HVAC with Pump Room Door Open:

Reviewing the results for Case B, it is concluded that the temperature at each step beyond eight to twelve hours is slightly underestimated because the chimney effect is slightly overestimated. Similarly for Case C, the temperature in this time interval is slightly overestimated due to the slight underestimation of the chimney effect.

In evaluating these results, it is concluded that the average of the calculated transient room temperatures for Case B and C is a better approximation of the expected results. The average of the results of Cases B and C follows:

No HVAC and Room Door Open

Time Period	Case B: Temp. °F	Case C: Temp. °F	Avg B & C Temp. °F
0 min	75	75	75
2 min	84.06	87.98	86.02
4 min	89.49	95.62	92.56
12 min	96.83	105.53	101.18
36 min	100.45	110.49	105.47
1 hr	102.36	113.21	107.79
2 hr	105.77	118.07	111.92
4 hr	110.50	124.83	117.67
6 hr	114.10	129.98	122.04
8 hr	117.14	134.32	125.73
12 hr	122.22	141.60	131.91
24 hr	133.68	158.02	145.85

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 52

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	R Bell	3-28-85	G.W.M	3-28-85						

CLASSIFICATION OF HEAT LOADS

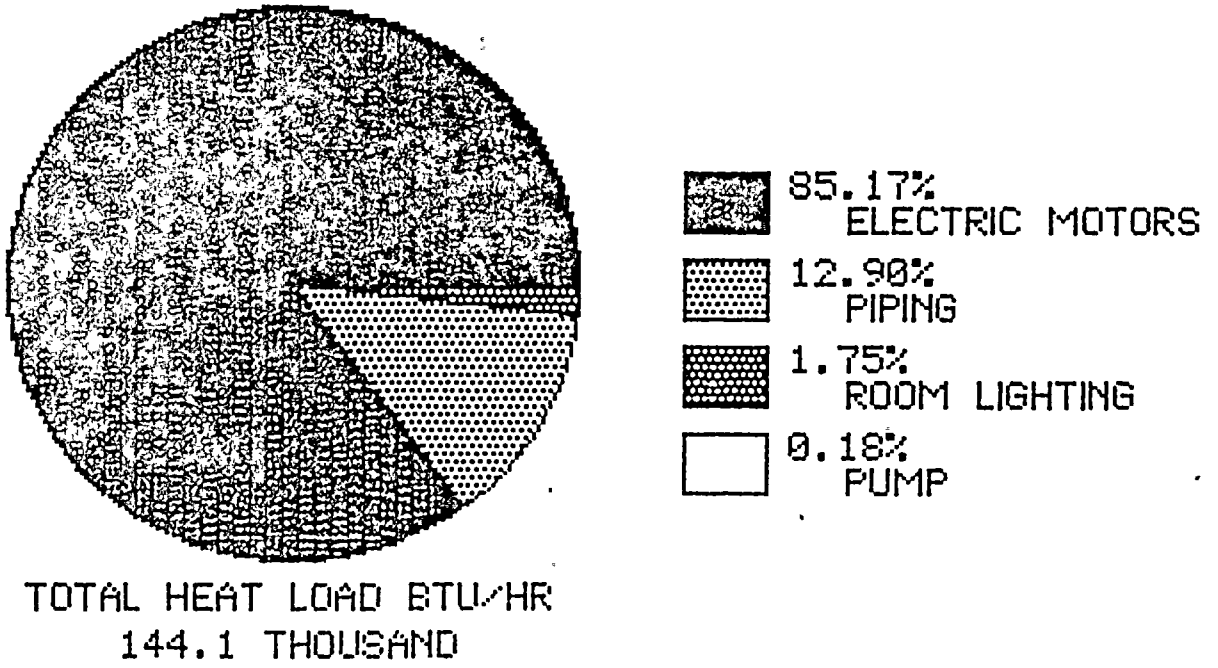


FIGURE 1

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 53

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	[illegible]	3-28-88	G.W.M	3-28-88						

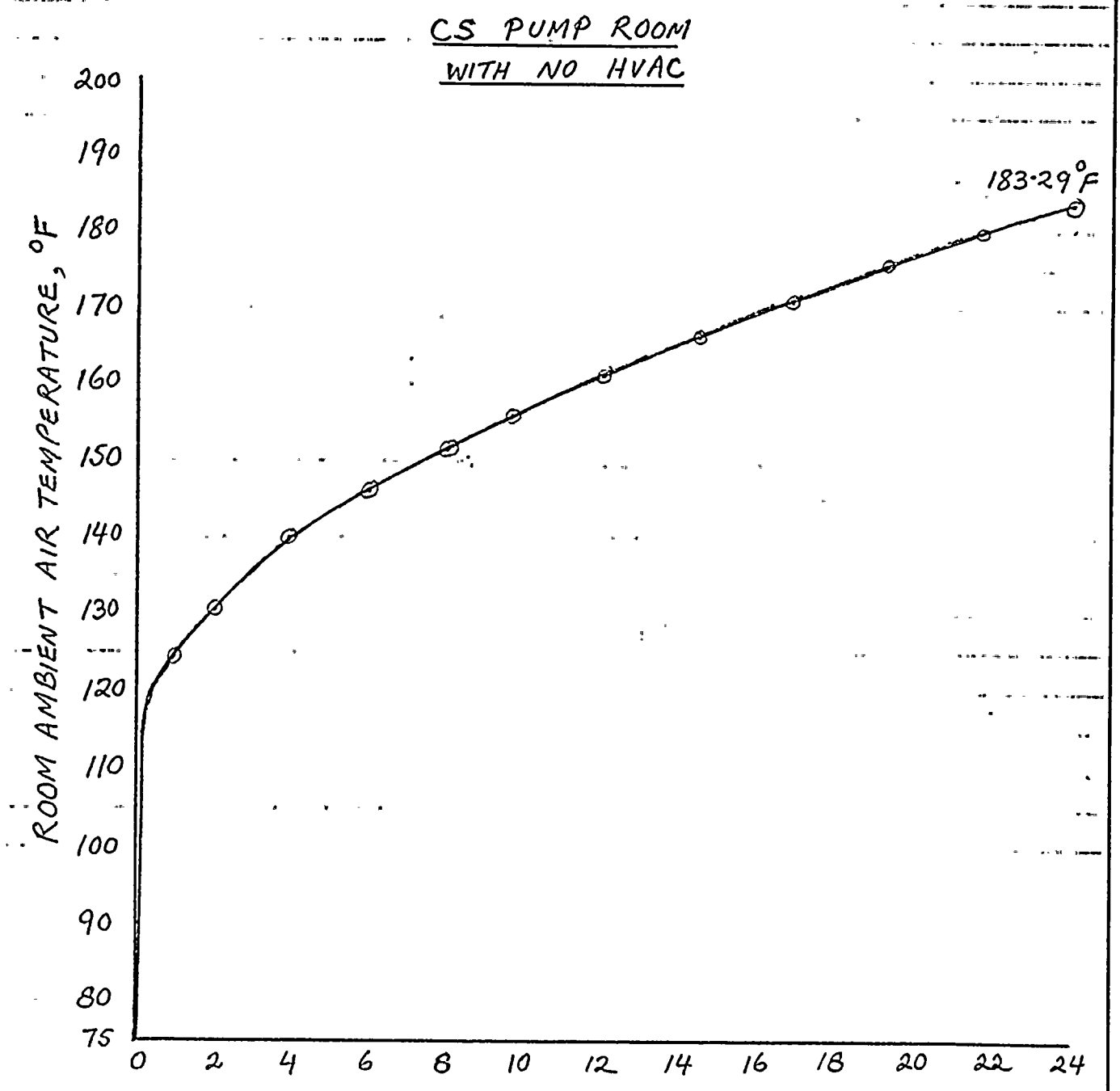


FIGURE 2

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 54

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	[illegible]	3-26-88	G.W.M	3-28-88						

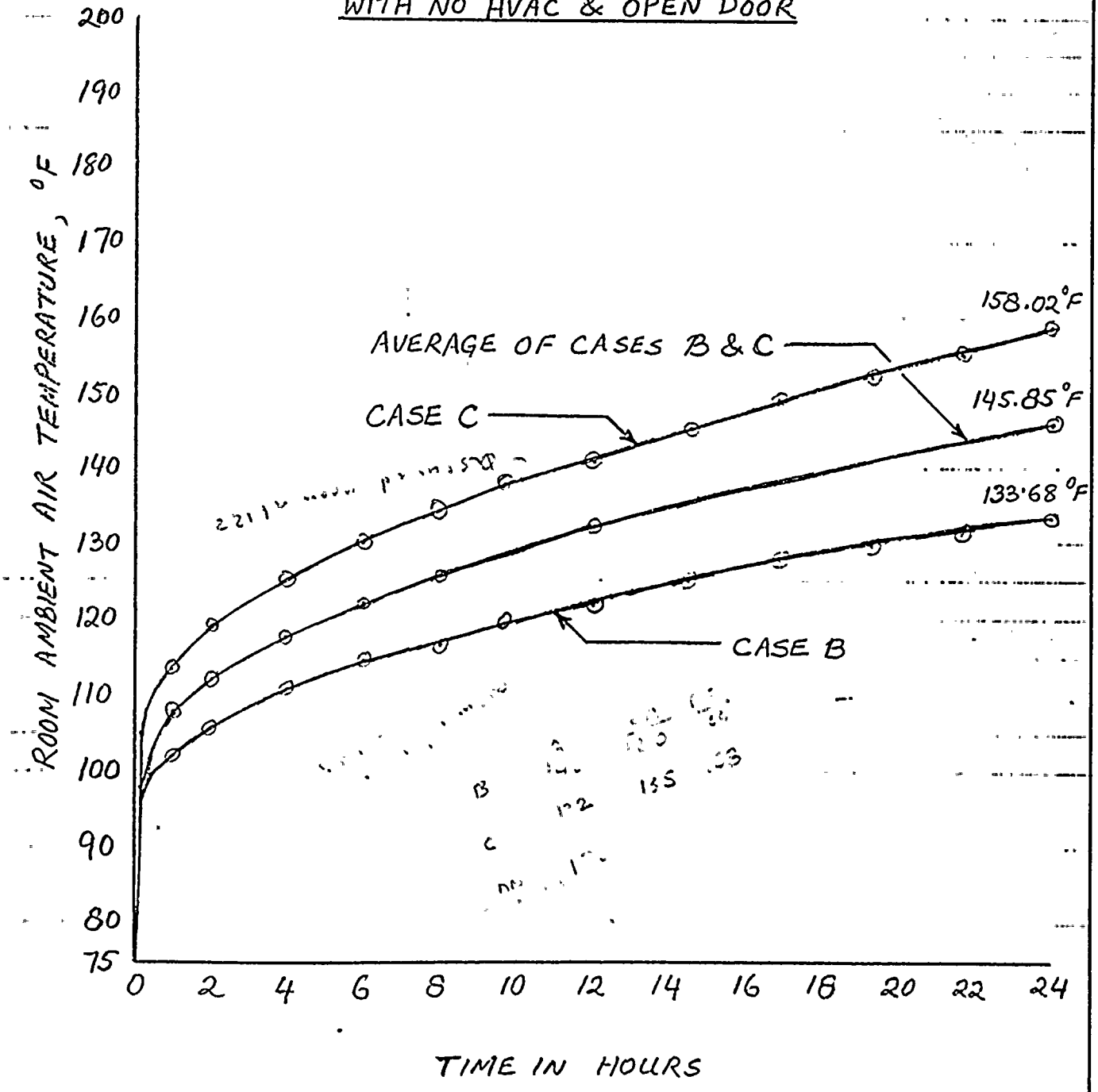


FIGURE 3

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 55

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
10	jWa.Ha.	3-28-88	G.W.M	3-28-88						

APPENDIX A

```
     INITIAL INTERNAL ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     INITIAL ADJACENT ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     EQUIPMENT HEAT GENERATED IN THE INTERNAL ROOM, BTU/HR=?
>144099
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2396
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9399
     THICKNESS OF ROOM ENCLOSURE, FT.=?
>2.75
     DENSITY OF ROOM ENCLOSURE MATERIAL, LBS/CU.FT.=?
>144
     THERMAL CONDUCTIVITY OF ROOM ENCLOSURE MATERIAL, BTU/HR-FT-F=?
>.54
     SPECIFIC HEAT OF ROOM ENCLOSURE MATERIAL, BTU/LB-F=?
>.2
     ONE PERIOD OF TIME INCREMENT FOR CALCULATION, MIN.=?
>2
     IMAGINARY THICKNESS OF FIRST LAYER OF ROOM ENCLOSURE, FT.=?
>.01
     MULTIPLICATION FACTOR OF IMAGINARY THICKNESS OF OTHER LAYERS=?
>1.41

**********************************************************************
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**********************************************************************

   M=NUMBER OF IMAGINARY LAYER= 14

   DX1,DX2,DX3,----------DX(M)
 1.00000-02  1.41000-02  1.98810-02  2.80322-02  3.95254-02  5.57308-02
 7.85805-02  .11080      .15623      .22028      .31059      .43794
  .61749      .65083

2MIN  1 PERIOD QAT=   2873.  QST=   1930.  QOT=      0. HCI=1.4967 HCO= .0000
      TAF= 92.13
      T1,T2,T3,----------T(M+1)
      75.985      75.670      75.395      75.192      75.073      75.020
      75.004      75.000      75.000      75.000      75.000      75.000
      75.000      75.000      75.000

      2 PERIOD QAT=   4484.  QST=   5122.  QOT=      0. HCI=1.6060 HCO= .0000
      TAF= 102.05
      T1,T2,T3,----------T(M+1)
      77.163      76.591      76.032      75.563      75.243      75.077
```

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
10	RHelb	3-28-88	G.W.M	3-28-88						

```
      75.016    75.002    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

   3 PERIOD QAT=   5388. QST=   9021. QOT=      0. HCI=1.6588 HCO= .0000
     TAF= 107.71
     T1,T2,T3,------------T(M+1)
     78.275    77.535    76.758    76.044    75.499    75.178
     75.043    75.006    75.001    75.000    75.000    75.000
     75.000    75.000    75.000

   6 PERIOD QAT=   6449. QST=  22370. QOT=      0. HCI=1.7131 HCO= .0000
     TAF= 114.44
     T1,T2,T3,------------T(M+1)
     80.897    79.953    78.841    77.651    76.543    75.704
     75.229    75.047    75.006    75.000    75.000    75.000
     75.000    75.000    75.000

  12 PERIOD QAT=   7066. QST=  50573. QOT=      0. HCI=1.7380 HCO= .0000
     TAF= 118.40
     T1,T2,T3,------------T(M+1)
     84.320    83.300    82.010    80.469    78.789    77.200
     75.984    75.303    75.056    75.005    75.000    75.000
     75.000    75.000    75.000

  18 PERIOD QAT=   7430. QST=  79027. QOT=      0. HCI=1.7515 HCO= .0000
     TAF= 120.75
     T1,T2,T3,------------T(M+1)
     86.803    85.762    84.412    82.736    80.792    78.767
     76.984    75.765    75.189    75.026    75.002    75.000
     75.000    75.000    75.000

  24 PERIOD QAT=   7725. QST= 107552. QOT=      0. HCI=1.7622 HCO= .0000
     TAF= 122.66
     T1,T2,T3,------------T(M+1)
     88.856    87.804    86.422    84.669    82.567    80.259
     78.055    76.358    75.408    75.071    75.006    75.000
     75.000    75.000    75.000

1HR  30 PERIOD QAT=   7980. QST= 136116. QOT=      0. HCI=1.7715 HCO= .0000
     TAF= 124.31
     T1,T2,T3,------------T(M+1)
     90.648    89.589    88.185    86.381    84.172    81.662
     79.135    77.025    75.698    75.146    75.016    75.001
     75.000    75.000    75.000

  36 PERIOD QAT=   8207. QST= 164708. QOT=      0. HCI=1.7799 HCO= .0000
     TAF= 125.79
     T1,T2,T3,------------T(M+1)
     92.258    91.194    89.776    87.935    85.645    82.983
     80.199    77.735    76.047    75.252    75.033    75.002
     75.000    75.000    75.000

  42 PERIOD QAT=   8414. QST= 193320. QOT=      0. HCI=1.7875 HCO= .0000
     TAF= 127.15
     T1,T2,T3,------------T(M+1)
     93.734    92.666    91.235    89.366    87.015    84.231
     81.237    78.468    76.439    75.389    75.058    75.004
     75.000    75.000    75.000
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 57

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RWeltin	3-28-88	G.W.M	3-28-88						

48 PERIOD QAT= 8606. QST= 221947. QOT= 0. HCI=1.7947 HCO= .0000
TAF= 128.40
T1,T2,T3,----------T(M+1)
95.104 94.033 92.593 90.700 88.299 85.417
82.246 79.210 76.865 75.553 75.093 75.008
75.000 75.000 75.000

2HR 60 PERIOD QAT= 8953. QST= 279237. QOT= 0. HCI=1.8077 HCO= .0000
TAF= 130.68
T1,T2,T3,----------T(M+1)
97.600 96.524 95.070 93.143 90.665 87.629
84.179 80.699 77.787 75.955 75.196 75.020
75.001 75.000 75.000

72 PERIOD QAT= 9265. QST= 336562. QOT= 0. HCI=1.8196 HCO= .9472
TAF= 132.73
T1,T2,T3,----------T(M+1)
99.851 98.771 97.307 95.354 92.821 89.670
86.004 82.168 78.769 76.436 75.342 75.043
75.003 75.000 75.000

84 PERIOD QAT= 9550. QST= 393914. QOT= 0. HCI=1.8306 HCO= .9497
TAF= 134.61
T1,T2,T3,----------T(M+1)
101.92 100.83 99.362 97.390 94.813 91.572
87.735 83.605 79.782 76.979 75.530 75.077
75.005 75.000 75.000

96 PERIOD QAT= 9814. QST= 451287. QOT= 0. HCI=1.8408 HCO= .9524
TAF= 136.36
T1,T2,T3,----------T(M+1)
103.84 102.75 101.27 99.286 96.673 93.360
89.382 85.005 80.812 77.570 75.757 75.126
75.010 75.000 75.000

108 PERIOD QAT= 10061. QST= 508678. QOT= 0. HCI=1.8505 HCO= .9554
TAF= 138.00
T1,T2,T3,----------T(M+1)
105.64 104.55 103.07 101.07 98.426 95.052
90.955 86.367 81.846 78.196 76.020 75.189
75.017 75.001 75.000

4HR 120 PERIOD QAT= 10293. QST= 566082. QOT= 1. HCI=1.8597 HCO= .9584
TAF= 139.56
T1,T2,T3,----------T(M+1)
107.34 106.26 104.77 102.75 100.09 96.661
92.463 87.692 82.879 78.850 76.315 75.267
75.027 75.001 75.001

132 PERIOD QAT= 10514. QST= 623498. QOT= 1. HCI=1.8684 HCO= .9616
TAF= 141.03
T1,T2,T3,----------T(M+1)
108.96 107.87 106.38 104.36 101.67 98.200
93.914 88.981 83.906 79.525 76.637 75.360
75.041 75.002 75.001

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 58

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RHeTh	3-28-88	G.W.M	3-28-88						

144 PERIOD QAT= 10724. QST= 680923. QOT= 2. HCI=1.8769 HCO= .9648
TAF= 142.44
T1,T2,T3,----------T(M+1)
110.51 109.42 107.92 105.89 103.19 99.676
95.312 90.236 84.924 80.215 76.984 75.469
75.058 75.003 75.001

156 PERIOD QAT= 10925. QST= 738357. QOT= 4. HCI=1.8850 HCO= .9682
TAF= 143.79
T1,T2,T3,----------T(M+1)
111.99 110.90 109.40 107.36 104.64 101.10
96.663 91.459 85.931 80.917 77.352 75.593
75.080 75.005 75.002

168 PERIOD QAT= 11118. QST= 795799. QOT= 7. HCI=1.8929 HCO= .9716
TAF= 145.08
T1,T2,T3,----------T(M+1)
113.41 112.32 110.82 108.78 106.04 102.47
97.972 92.652 86.927 81.627 77.740 75.731
75.106 75.007 75.003

6 HR 180 PERIOD QAT= 11304. QST= 853247. QOT= 10. HCI=1.9005 HCO= .9751
TAF= 146.34
T1,T2,T3,----------T(M+1)
114.79 113.70 112.19 110.14 107.39 103.79
99.242 93.817 87.911 82.343 78.144 75.882
75.137 75.010 75.004

192 PERIOD QAT= 11483. QST= 910699. QOT= 15. HCI=1.9079 HCO= .9787
TAF= 147.55
T1,T2,T3,----------T(M+1)
116.12 115.03 113.52 111.47 108.70 105.08
100.48 94.955 88.882 83.062 78.563 76.047
75.173 75.013 75.006

204 PERIOD QAT= 11657. QST= 968156. QOT= 22. HCI=1.9151 HCO= .9823
TAF= 148.72
T1,T2,T3,----------T(M+1)
117.41 116.31 114.81 112.75 109.97 106.32
101.68 96.068 89.840 83.784 78.994 76.225
75.214 75.018 75.008

216 PERIOD QAT= 11825. QST= 1025616. QOT= 31. HCI=1.9221 HCO= .9860
TAF= 149.86
T1,T2,T3,----------T(M+1)
118.66 117.56 116.05 113.99 111.21 107.54
102.85 97.157 90.786 84.507 79.437 76.414
75.260 75.023 75.010

228 PERIOD QAT= 11988. QST= 1083077. QOT= 42. HCI=1.9290 HCO= .9897
TAF= 150.97
T1,T2,T3,----------T(M+1)
119.88 118.78 117.27 115.20 112.41 108.72
103.99 98.225 91.719 85.229 79.889 76.614
75.312 75.029 75.013

2 HR 240 PERIOD QAT= 12147. QST= 1140540. QOT= 56. HCI=1.9357 HCO= .9934
TAF= 152.05

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 59

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.Shelton	3-28-88	G.W.M	3-28-88						

```
   T1,T2,T3,-------------T(M+1)
   121.06      119.96      118.45      116.38      113.58      109.87
   105.11      99.271      92.639      85.950      80.350      76.825
   75.369      75.037      75.017

264 PERIOD  QAT=  12452.  QST= 1255467.  QOT=      97. HCI=1.9487 HCO=1.0009
   TAF= 154.13
   T1,T2,T3,-------------T(M+1)
   123.34      122.25      120.73      118.65      115.84      112.10
   107.27      101.30      94.444      87.386      81.292      77.275
   75.500      75.056      75.025

288 PERIOD  QAT=  12742.  QST= 1370391.  QOT=     156. HCI=1.9612 HCO=1.0084
   TAF= 156.11
   T1,T2,T3,-------------T(M+1)
   125.52      124.43      122.91      120.82      118.00      114.23
   109.34      103.27      96.203      88.811      82.258      77.760
   75.651      75.080      75.036

312 PERIOD  QAT=  13020.  QST= 1485301.  QOT=     239. HCI=1.9733 HCO=1.0159
   TAF= 158.02
   T1,T2,T3,-------------T(M+1)
   127.61      126.52      125.00      122.91      120.07      116.27
   111.34      105.16      97.918      90.222      83.240      78.276
   75.824      75.111      75.050

336 PERIOD  QAT=  13287.  QST= 1600194.  QOT=     353. HCI=1.9851 HCO=1.0233
   TAF= 159.85
   T1,T2,T3,-------------T(M+1)
   129.63      128.53      127.01      124.91      122.06      118.25
   113.26      107.00      99.591      91.617      84.234      78.818
   76.016      75.148      75.066

12HR 360 PERIOD  QAT=  13543.  QST= 1715059.  QOT=     503. HCI=1.9964 HCO=1.0307
   TAF= 161.62
   T1,T2,T3,-------------T(M+1)
   131.57      130.47      128.94      126.85      123.99      120.15
   115.13      108.79      101.23      92.996      85.237      79.384
   76.227      75.193      75.086

432 PERIOD  QAT=  14262.  QST= 2059417.  QOT=    1244. HCI=2.0289 HCO=1.0524
   TAF= 166.61
   T1,T2,T3,-------------T(M+1)
   137.03      135.93      134.40      132.29      129.41      125.52
   120.40      113.86      105.92      97.030      88.270      81.197
   76.968      75.374      75.165

504 PERIOD  QAT=  14918.  QST= 2403235.  QOT=    2579. HCI=2.0594 HCO=1.0730
   TAF= 171.20
   T1,T2,T3,-------------T(M+1)
   142.05      140.95      139.42      137.30      134.40      130.48
   125.27      118.57      110.33      100.91      91.306      83.134
   77.848      75.631      75.275

576 PERIOD  QAT=  15525.  QST= 2746290.  QOT=    4725. HCI=2.0882 HCO=1.0927
   TAF= 175.47
   T1,T2,T3,-------------T(M+1)
   146.72      145.62      144.08      141.96      139.05      135.09
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 60

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	R Stetler	3-28-88	G.W M	3-28-88						

```
      129.83      123.00      114.51      104.64      94.314      85.155
      78.845      75.965      75.417

 648 PERIOD  OAT=  16092.  OST= 3088354.  OOT=     7902. HCI=2.1157 HCO=1.1113
   TAF= 179.49
   T1,T2,T3,-------------T(M+1)
      151.11      150.00      148.47      146.34      143.42      139.44
      134.12      127.18      118.49      108.24      97.281      87.229
      79.940      76.375      75.588

24 HR 720 PERIOD  OAT=  16626.  OST= 3429204.  OOT=    12325. HCI=2.1421 HCO=1.1289
   TAF= 183.29
   T1,T2,T3,-------------T(M+1)
      155.26      154.15      152.62      150.48      147.55      143.55
      138.18      131.15      122.28      111.71      100.20      89.335
      81.118      76.857      75.786
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 61

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	KHetha	3-28-88	G.W.M	3-28-88						

APPENDIX B

```
     INITIAL INTERNAL ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     INITIAL ADJACENT ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     EQUIPMENT HEAT GENERATED IN THE INTERNAL ROOM, BTU/HR=?
>73845
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2396
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9399
     THICKNESS OF ROOM ENCLOSURE, FT.=?
>2.75
     DENSITY OF ROOM ENCLOSURE MATERIAL, LBS/CU.FT.=?
>144
     THERMAL CONDUCTIVITY OF ROOM ENCLOSURE MATERIAL, BTU/HR-FT-F=?
>.54
     SPECIFIC HEAT OF ROOM ENCLOSURE MATERIAL, BTU/LB-F=?
>.2
     ONE PERIOD OF TIME INCREMENT FOR CALCULATION, MIN.=?
>2
     IMAGINARY THICKNESS OF FIRST LAYER OF ROOM ENCLOSURE, FT.=?
>.01
     MULTIPLICATION FACTOR OF IMAGINARY THICKNESS OF OTHER LAYERS=?
>1.41

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 ********************************************************************

   M=NUMBER OF IMAGINARY LAYER= 14

   DX1,DX2,DX3,----------DX(M)
  1.00000-02  1.41000-02  1.98810-02  2.80322-02  3.95254-02  5.57308-02
  7.85805-02  .11080      .15623      .22028      .31059      .43794
  .61749      .65083

2MIN 1 PERIOD QAT=  1518.  QST=   943.  QOT=     0.  HCI=1.3771 HCO= .0000
  TAF= 84.06
  T1,T2,T3,----------T(M+1)
  75.481      75.327      75.193      75.094      75.035      75.010
  75.002      75.000      75.000      75.000      75.000      75.000
  75.000      75.000      75.000

  2 PERIOD QAT=  2415.  QST=  2508.  QOT=     0.  HCI=1.4595 HCO= .0000
  TAF= 89.49
  T1,T2,T3,----------T(M+1)
  76.060      75.779      75.506      75.276      75.119      75.038
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 62

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P Hetu	3-28-88	G.W.M	3-28-88						

```
      75.008    75.001    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

   3 PERIOD QAT=  2945. QST=  4439. QOT=     0. HCI=1.4996 HCO= .0000
     TAF= 92.74
     T1,T2,T3,------------T(H+1)
     76.615    76.249    75.865    75.513    75.245    75.087
     75.021    75.003    75.000    75.000    75.000    75.000
     75.000    75.000    75.000

   6 PERIOD QAT=  3608. QST= 11160. QOT=     0. HCI=1.5420 HCO= .0000
     TAF= 96.83
     T1,T2,T3,------------T(H+1)
     77.958    77.480    76.920    76.322    75.768    75.349
     75.113    75.023    75.003    75.000    75.000    75.000
     75.000    75.000    75.000

  12 PERIOD QAT=  3984. QST= 25553. QOT=     0. HCI=1.5588 HCO= .0000
     TAF= 99.17
     T1,T2,T3,------------T(H+1)
     79.733    79.211    78.553    77.768    76.914    76.108
     75.494    75.152    75.028    75.003    75.000    75.000
     75.000    75.000    75.000

  18 PERIOD QAT=  4190. QST= 40116. QOT=     0. HCI=1.5660 HCO= .0000
     TAF= 100.45
     T1,T2,T3,------------T(H+1)
     81.014    80.481    79.791    78.934    77.941    76.910
     76.003    75.386    75.095    75.013    75.001    75.000
     75.000    75.000    75.000

  24 PERIOD QAT=  4354. QST= 54720. QOT=     0. HCI=1.5716 HCO= .0000
     TAF= 101.48
     T1,T2,T3,------------T(H+1)
     82.070    81.531    80.824    79.928    78.853    77.675
     76.551    75.688    75.206    75.036    75.003    75.000
     75.000    75.000    75.000

1HR 30 PERIOD QAT=  4496. QST= 69346. QOT=     0. HCI=1.5763 HCO= .0000
     TAF= 102.36
     T1,T2,T3,------------T(H+1)
     82.991    82.449    81.730    80.807    79.677    78.394
     77.104    76.029    75.354    75.074    75.008    75.000
     75.000    75.000    75.000

  36 PERIOD QAT=  4622. QST= 83988. QOT=     0. HCI=1.5806 HCO= .0000
     TAF= 103.16
     T1,T2,T3,------------T(H+1)
     83.818    83.273    82.547    81.604    80.433    79.071
     77.649    76.392    75.532    75.128    75.016    75.001
     75.000    75.000    75.000

  42 PERIOD QAT=  4737. QST= 98641. QOT=     0. HCI=1.5845 HCO= .0000
     TAF= 103.88
     T1,T2,T3,------------T(H+1)
     84.576    84.029    83.296    82.339    81.136    79.712
     78.181    76.767    75.732    75.197    75.029    75.002
     75.000    75.000    75.000
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CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 63

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	KSheikh	3-28-88	G.W.M	3-18-88						

48 PERIOD QAT= 4844. QST= 113302. QOT= 0. HCI=1.5880 HCO= .0000
TAF= 104.55
T1,T2,T3,----------T(M+1)
85.279 84.730 83.993 83.024 81.795 80.320
78.698 77.147 75.950 75.281 75.047 75.004
75.000 75.000 75.000

2HR 60 PERIOD QAT= 5037. QST= 142645. QOT= 0. HCI=1.5946 HCO= .0000
TAF= 105.77
T1,T2,T3,----------T(M+1)
86.560 86.009 85.264 84.277 83.009 81.454
79.689 77.909 76.421 75.486 75.099 75.010
75.000 75.000 75.000

72 PERIOD QAT= 5211. QST= 172007. QOT= 0. HCI=1.6005 HCO= .0000
TAF= 106.86
T1,T2,T3,----------T(M+1)
87.714 87.161 86.411 85.411 84.114 82.501
80.625 78.662 76.924 75.732 75.174 75.022
75.001 75.000 75.000

84 PERIOD QAT= 5370. QST= 201384. QOT= 0. HCI=1.6059 HCO= .9476
TAF= 107.87
T1,T2,T3,----------T(M+1)
88.774 88.220 87.465 86.455 85.135 83.476
81.512 79.398 77.443 76.010 75.270 75.039
75.003 75.000 75.000

96 PERIOD QAT= 5517. QST= 230773. QOT= 0. HCI=1.6109 HCO= .9501
TAF= 108.80
T1,T2,T3,----------T(M+1)
89.759 89.203 88.446 87.427 86.089 84.393
82.356 80.116 77.970 76.312 75.386 75.064
75.005 75.000 75.000

108 PERIOD QAT= 5655. QST= 260171. QOT= 0. HCI=1.6156 HCO= .9525
TAF= 109.67
T1,T2,T3,----------T(M+1)
90.683 90.127 89.366 88.341 86.988 85.260
83.162 80.814 78.500 76.633 75.521 75.096
75.009 75.000 75.000

4HR 120 PERIOD QAT= 5785. QST= 289577. QOT= 0. HCI=1.6201 HCO= .9549
TAF= 110.50
T1,T2,T3,----------T(M+1)
91.556 90.999 90.236 89.205 87.840 86.085
83.935 81.493 79.029 76.968 75.671 75.136
75.014 75.001 75.000

132 PERIOD QAT= 5908. QST= 318989. QOT= 1. HCI=1.6244 HCO= .9575
TAF= 111.28
T1,T2,T3,----------T(M+1)
92.386 91.828 91.064 90.028 88.651 86.874
84.679 82.153 79.555 77.313 75.836 75.184
75.021 75.001 75.000

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 64

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P Skelton	3-28-88	G.W.M	3-28-88						

144 PERIOD QAT= 6026. QST= 348406. QOT= 1. HCI=1.6285 HCO= .9602
TAF= 112.03
T1,T2,T3,----------T(H+1)
93.179 92.620 91.854 90.814 89.428 87.630
85.395 82.796 80.077 77.667 76.014 75.239
75.030 75.002 75.001

156 PERIOD QAT= 6138. QST= 377829. QOT= 2. HCI=1.6324 HCO= .9629
TAF= 112.75
T1,T2,T3,----------T(H+1)
93.938 93.380 92.612 91.568 90.174 88.358
86.088 83.423 80.593 78.026 76.202 75.303
75.041 75.002 75.001

168 PERIOD QAT= 6246. QST= 407255. QOT= 3. HCI=1.6362 HCO= .9656
TAF= 113.44
T1,T2,T3,----------T(H+1)
94.669 94.110 93.341 92.294 90.892 89.061
86.759 84.034 81.103 78.390 76.401 75.373
75.054 75.003 75.002

5HR 180 PERIOD QAT= 6351. QST= 436685. QOT= 5. HCI=1.6398 HCO= .9685
TAF= 114.10
T1,T2,T3,----------T(H+1)
95.374 94.815 94.044 92.994 91.585 89.740
87.410 84.631 81.607 78.756 76.608 75.451
75.070 75.005 75.002

192 PERIOD QAT= 6451. QST= 466118. QOT= 8. HCI=1.6434 HCO= .9713
TAF= 114.75
T1,T2,T3,----------T(H+1)
96.056 95.496 94.724 93.671 92.257 90.398
88.042 85.214 82.105 79.125 76.822 75.535
75.088 75.007 75.003

204 PERIOD QAT= 6548. QST= 495553. QOT= 11. HCI=1.6468 HCO= .9742
TAF= 115.37
T1,T2,T3,----------T(H+1)
96.716 96.156 95.383 94.328 92.908 91.038
88.658 85.785 82.596 79.495 77.043 75.626
75.109 75.009 75.004

216 PERIOD QAT= 6643. QST= 524989. QOT= 15. HCI=1.6502 HCO= .9772
TAF= 115.98
T1,T2,T3,----------T(H+1)
97.357 96.797 96.023 94.966 93.540 91.660
89.258 86.343 83.080 79.865 77.270 75.723
75.133 75.012 75.005

228 PERIOD QAT= 6734. QST= 554427. QOT= 21. HCI=1.6534 HCO= .9801
TAF= 116.56
T1,T2,T3,----------T(H+1)
97.981 97.420 96.646 95.586 94.156 92.265
89.843 86.890 83.558 80.235 77.501 75.825
75.159 75.015 75.007

8HR 240 PERIOD QAT= 6824. QST= 583865. QOT= 28. HCI=1.6566 HCO= .9831
TAF= 117.14

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 65

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
10	R Bettis	3-28-88	G.W.M	3-28-88						

T1,T2,T3,----------T(M+1)
98.588 98.027 97.252 96.190 94.756 92.856
90.415 87.426 84.030 80.604 77.737 75.933
75.189 75.019 75.009

264 PERIOD QAT= 6995. QST= 642743. QOT= 49. HCI=1.6628 HCO= .9891
TAF= 118.24
T1,T2,T3,----------T(M+1)
99.758 99.196 98.420 97.355 95.913 93.997
91.523 88.468 84.955 81.340 78.220 76.164
75.255 75.028 75.013

288 PERIOD QAT= 7159. QST= 701620. QOT= 79. HCI=1.6687 HCO= .9952
TAF= 119.30
T1,T2,T3,----------T(M+1)
100.88 100.31 99.536 98.468 97.019 95.089
92.585 89.474 85.856 82.070 78.715 76.412
75.333 75.041 75.019

312 PERIOD QAT= 7316. QST= 760492. QOT= 121. HCI=1.6743 HCO=1.0012
TAF= 120.31
T1,T2,T3,----------T(M+1)
101.95 101.38 100.61 99.536 98.081 96.138
93.608 90.446 86.735 82.793 79.218 76.676
75.421 75.056 75.026

336 PERIOD QAT= 7466. QST= 819354. QOT= 178. HCI=1.6798 HCO=1.0071
TAF= 121.28
T1,T2,T3,----------T(M+1)
102.98 102.42 101.64 100.56 99.103 97.148
94.596 91.388 87.592 83.508 79.727 76.954
75.520 75.075 75.034

12HR 360 PERIOD QAT= 7611. QST= 878204. QOT= 254. HCI=1.6852 HCO=1.0131
TAF= 122.22
T1,T2,T3,----------T(M+1)
103.97 103.41 102.63 101.55 100.09 98.125
95.552 92.303 88.430 84.214 80.241 77.244
75.628 75.098 75.044

432 PERIOD QAT= 8017. QST= 1054634. QOT= 629. HCI=1.7002 HCO=1.0304
TAF= 124.86
T1,T2,T3,----------T(M+1)
106.77 106.21 105.43 104.35 102.87 100.88
98.253 94.901 90.834 86.281 81.795 78.172
76.007 75.191 75.085

504 PERIOD QAT= 8390. QST= 1230794. QOT= 1303. HCI=1.7142 HCO=1.0470
TAF= 127.29
T1,T2,T3,----------T(M+1)
109.34 108.78 108.00 106.91 105.43 103.42
100.75 97.318 93.096 88.269 83.350 79.165
76.458 75.322 75.142

576 PERIOD QAT= 8735. QST= 1406574. QOT= 2386. HCI=1.7273 HCO=1.0628
TAF= 129.55
T1,T2,T3,----------T(M+1)
111.74 111.17 110.39 109.30 107.81 105.78

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 66

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RHelton	3-28-88	G.W.M	3-28-88						

```
      103.08      99.585      95.237      90.182      84.891      80.200
      76.969      75.493      75.216

 648 PERIOD  QAT=   9058.  QST= 1581857.  QOT=     3988. HCI=1.7398 HCO=1.0777
     TAF= 131.67
     T1,T2,T3,-------------T(M+1)
      113.99      113.42      112.64      111.55      110.05      108.01
      105.28      101.73      97.274      92.024      86.411      81.262
      77.530      75.702      75.305

24HR 20 PERIOD  QAT=   9362.  QST= 1756532.  QOT=     6216. HCI=1.7516 HCO=1.0918
     TAF= 133.68
     T1,T2,T3,-------------T(M+1)
      116.11      115.55      114.76      113.67      112.16      110.11
      107.37      103.77      99.221      93.803      87.906      82.342
      78.133      75.948      75.410
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 67

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	K Wells	3-28-88	G.W.M	3-28-88						

APPENDIX C

```
     INITIAL INTERNAL ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     INITIAL ADJACENT ROOM AMBIENT TEMPERATURE, DEG. F=?
>75
     EQUIPMENT HEAT GENERATED IN THE INTERNAL ROOM, BTU/HR=?
>107638
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2396
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9399
     THICKNESS OF ROOM ENCLOSURE, FT.=?
>2.75
     DENSITY OF ROOM ENCLOSURE MATERIAL, LBS/CU.FT.=?
>144
     THERMAL CONDUCTIVITY OF ROOM ENCLOSURE MATERIAL, BTU/HR-FT-F=?
>.54
     SPECIFIC HEAT OF ROOM ENCLOSURE MATERIAL, BTU/LB-F=?
>.2
     ONE PERIOD OF TIME INCREMENT FOR CALCULATION, MIN.=?
>2
     IMAGINARY THICKNESS OF FIRST LAYER OF ROOM ENCLOSURE, FT.=?
>.01
     MULTIPLICATION FACTOR OF IMAGINARY THICKNESS OF OTHER LAYERS=?
>1.41

**********************************************************************
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     M=NUMBER OF IMAGINARY LAYER= 14

     DX1,DX2,DX3,-----------DX(M)
  1.00000-02  1.41000-02  1.98810-02  2.80322-02  3.95254-02  5.57308-02
  7.85805-02  .11080      .15623      .22028      .31059      .43794
  .61749      .65083

2 MIN  1 PERIOD QAT=  2177.  QST=  1411.  QOT=      , Q. HCI=1.4403 HCO= .0000
       TAF= 87.98
       T1,T2,T3,------------T(M+1)
       75.720      75.489      75.288      75.140      75.053      75.014
       75.003      75.000      75.000      75.000      75.000      75.000
       75.000      75.000      75.000

     2 PERIOD QAT=  3428.  QST=  3747.  QOT=      0. HCI=1.5366 HCO= .0000
       TAF= 95.62
       T1,T2,T3,------------T(M+1)
       76.583      76.164      75.755      75.412      75.178      75.056
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 68

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	[illegible]	2-26-88	G.W.M	3-28-88						

```
      75.012    75.002    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

 3 PERIOD QAT=   4148.  QST=   6615.  QOT=      0. HCI=1.5833 HCO= .0000
   TAF= 100.08
   T1,T2,T3,-------------T(M+1)
      77.404    76.860    76.289    75.765    75.366    75.130
      75.032    75.005    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

 6 PERIOD QAT=   5019.  QST=  16508.  QOT=      0. HCI=1.6318 HCO= .0000
   TAF= 105.53
   T1,T2,T3,-------------T(M+1)
      79.362    78.661    77.837    76.956    76.137    75.518
      75.168    75.035    75.004    75.000    75.000    75.000
      75.000    75.000    75.000

12 PERIOD QAT=   5518.  QST=  37537.  QOT=      0. HCI=1.6526 HCO= .0000
   TAF= 108.68
   T1,T2,T3,-------------T(M+1)
      81.933    81.172    80.210    79.062    77.812    76.630
      75.728    75.224    75.041    75.004    75.000    75.000
      75.000    75.000    75.000

18 PERIOD QAT=   5803.  QST=  58778.  QOT=      0. HCI=1.6627 HCO= .0000
   TAF= 110.49
   T1,T2,T3,-------------T(M+1)
      83.793    83.016    82.009    80.758    79.309    77.800
      76.473    75.567    75.140    75.019    75.001    75.000
      75.000    75.000    75.000

24 PERIOD QAT=   6033.  QST=  80075.  QOT=      0. HCI=1.6707 HCO= .0000
   TAF= 111.95
   T1,T2,T3,-------------T(M+1)
      85.330    84.544    83.513    82.204    80.636    78.915
      77.273    76.009    75.302    75.053    75.005    75.000
      75.000    75.000    75.000

1 HR
30 PERIOD QAT=   6231.  QST= 101404.  QOT=      0. HCI=1.6776 HCO= .0000
   TAF= 113.21
   T1,T2,T3,-------------T(M+1)
      86.670    85.879    84.831    83.485    81.835    79.963
      78.079    76.507    75.519    75.108    75.012    75.001
      75.000    75.000    75.000

36 PERIOD QAT=   6407.  QST= 122754.  QOT=      0. HCI=1.6838 HCO= .0000
   TAF= 114.34
   T1,T2,T3,-------------T(M+1)
      87.874    87.080    86.020    84.646    82.937    80.950
      78.873    77.037    75.779    75.187    75.024    75.001
      75.000    75.000    75.000

42 PERIOD QAT=   6568.  QST= 144120.  QOT=      0. HCI=1.6895 HCO= .0000
   TAF= 115.38
   T1,T2,T3,-------------T(M+1)
      88.977    88.180    87.112    85.716    83.960    81.883
      79.649    77.583    76.071    75.289    75.043    75.003
      75.000    75.000    75.000
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 69

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	KWolfe	3-24-88	G.W.M	3-28-88						

48 PERIOD QAT= 6717. QST= 165498. QOT= 0. HCI=1.6948 HCO= .0000
TAF= 116.33
T1,T2,T3,----------T(M+1)
90.001 89.201 88.126 86.713 84.920 82.769
80.403 78.138 76.389 75.412 75.069 75.006
75.000 75.000 75.000

2HR 60 PERIOD QAT= 6988. QST= 208280. QOT= 0. HCI=1.7044 HCO= .0000
TAF= 118.07
T1,T2,T3,----------T(M+1)
91.867 91.063 89.977 88.538 86.689 84.422
81.846 79.249 77.077 75.711 75.146 75.015
75.001 75.000 75.000

72 PERIOD QAT= 7230. QST= 251090. QOT= 0. HCI=1.7131 HCO= .9460
TAF= 119.63
T1,T2,T3,----------T(M+1)
93.549 92.743 91.649 90.191 88.299 85.947
83.210 80.347 77.810 76.070 75.254 75.032
75.002 75.000 75.000

84 PERIOD QAT= 7452. QST= 293922. QOT= 0. HCI=1.7211 HCO= .9489
TAF= 121.07
T1,T2,T3,----------T(M+1)
95.093 94.285 93.185 91.712 89.787 87.368
84.503 81.420 78.567 76.476 75.395 75.058
75.004 75.000 75.000

96 PERIOD QAT= 7658. QST= 336769. QOT= 0. HCI=1.7286 HCO= .9515
TAF= 122.40
T1,T2,T3,----------T(M+1)
96.528 95.718 94.613 93.129 91.178 88.703
85.733 82.466 79.336 76.916 75.565 75.094
75.008 75.000 75.000

108 PERIOD QAT= 7850. QST= 379629. QOT= 0. HCI=1.7356 HCO= .9541
TAF= 123.65
T1,T2,T3,----------T(M+1)
97.874 97.063 95.954 94.460 92.487 89.967
86.909 83.483 80.108 77.384 75.761 75.141
75.013 75.000 75.000

4HR 120 PERIOD QAT= 8032. QST= 422501. QOT= 0. HCI=1.7423 HCO= .9569
TAF= 124.83
T1,T2,T3,----------T(M+1)
99.146 98.334 97.222 95.720 93.729 91.170
88.035 84.473 80.879 77.872 75.980 75.199
75.020 75.001 75.000

132 PERIOD QAT= 8204. QST= 465381. QOT= 1. HCI=1.7487 HCO= .9597
TAF= 125.95
T1,T2,T3,----------T(M+1)
100.36 99.543 98.428 96.918 94.911 92.319
89.119 85.436 81.646 78.376 76.221 75.269
75.030 75.001 75.001

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 70

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	RKelly	3-28-88	G.W.M	3-28-88						

144 PERIOD QAT= 8368. QST= 508270. QOT= 2. HCI=1.7548 HCO= .9627
TAF= 127.02
T1,T2,T3,----------T(M+1)
101.51 100.70 99.580 98.064 96.043 93.422
90.163 86.373 82.407 78.892 76.480 75.350
75.043 75.002 75.001

156 PERIOD QAT= 8524. QST= 551165. QOT= 3. HCI=1.7606 HCO= .9657
TAF= 128.04
T1,T2,T3,----------T(M+1)
102.62 101.80 100.68 99.163 97.129 94.483
91.173 87.287 83.159 79.416 76.755 75.442
75.059 75.004 75.002

168 PERIOD QAT= 8675. QST= 594064. QOT= 5. HCI=1.7663 HCO= .9689
TAF= 129.03
T1,T2,T3,----------T(M+1)
103.68 102.87 101.75 100.22 98.176 95.506
92.150 88.178 83.903 79.946 77.044 75.545
75.079 75.005 75.002

6HR 180 PERIOD QAT= 8820. QST= 636969. QOT= 8. HCI=1.7718 HCO= .9721
TAF= 129.98
T1,T2,T3,----------T(M+1)
104.71 103.90 102.77 101.24 99.187 96.497
93.099 89.048 84.638 80.481 77.346 75.658
75.102 75.007 75.003

192 PERIOD QAT= 8960. QST= 679878. QOT= 11. HCI=1.7772 HCO= .9753
TAF= 130.90
T1,T2,T3,----------T(M+1)
105.70 104.89 103.76 102.23 100.17 97.456
94.021 89.898 85.363 81.018 77.659 75.781
75.129 75.010 75.005

204 PERIOD QAT= 9096. QST= 722790. QOT= 16. HCI=1.7823 HCO= .9786
TAF= 131.79
T1,T2,T3,----------T(M+1)
106.67 105.85 104.72 103.19 101.11 98.388
94.918 90.729 86.079 81.557 77.981 75.914
75.160 75.013 75.006

216 PERIOD QAT= 9227. QST= 765704. QOT= 23. HCI=1.7874 HCO= .9819
TAF= 132.66
T1,T2,T3,----------T(M+1)
107.60 106.78 105.66 104.11 102.04 99.294
95.793 91.543 86.785 82.096 78.311 76.055
75.194 75.017 75.008

228 PERIOD QAT= 9355. QST= 808621. QOT= 31. HCI=1.7923 HCO= .9853
TAF= 133.50
T1,T2,T3,----------T(M+1)
108.51 107.69 106.56 105.02 102.93 100.18
96.646 92.340 87.482 82.636 78.649 76.204
75.233 75.022 75.010

8HR 240 PERIOD QAT= 9479. QST= 851538. QOT= 42. HCI=1.7971 HCO= .9887
TAF= 134.32

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 71

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
1	KKhatri	3-28-88	G.U.M	3-28-88						

```
 T1,T2,T3,------------T(M+1)
 109.39      108.58      107.45      105.90      103.81      101.04
 97.480      93.122      88.170      83.174.     78.993      76.362
 75.275      75.027      75.012

264 PERIOD  QAT=   9717.  QST= 937375.  QOT=      72. HCI=1.8064 HCO= .9955
  TAF= 135.90
 T1,T2,T3,------------T(M+1)
 111.10      110.28      109.15      107.60      105.49      102.70
 99.094      94.641      89.518      84.247      79.697      76.698
 75.373      75.041      75.019

288 PERIOD  QAT=   9944.  QST= 1023209.  QOT=     116. HCI=1.8154 HCO=1.0023
  TAF= 137.41
 T1,T2,T3,------------T(M+1)
 112.73      111.91      110.78      109.22      107.11      104.29
 100.64      96.106      90.831      85.311      80.418      77.060
 75.486      75.060      75.027

312 PERIOD  QAT=  10162.  QST= 1109033.  QOT=     178. HCI=1.8240 HCO=1.0091
  TAF= 138.86
 T1,T2,T3,------------T(M+1)
 114.29      113.47      112.34      110.77      108.65      105.82
 102.13      97.524      92.112      86.365      81.152      77.445
 75.615      75.082      75.037

336 PERIOD  QAT=  10371.  QST= 1194843.  QOT=     262. HCI=1.8324 HCO=1.0158
  TAF= 140.25
 T1,T2,T3,------------T(M+1)
 115.79      114.97      113.84      112.27      110.14      107.29
 103.57      98.897      93.362      87.407      81.894      77.850
 75.758      75.110      75.050

12HR 360 PERIOD  QAT=  10572.  QST= 1280634.  QOT=     374. HCI=1.8405 HCO=1.0225
  TAF= 141.60
 T1,T2,T3,------------T(M+1)
 117.24      116.42.     115.28      113.72      111.58      108.72
 104.97      100.23      94.583      88.437      82.643      78.273
 75.916      75.144      75.064

432 PERIOD  QAT=  11135.  QST= 1537831.  QOT=     924. HCI=1.8635 HCO=1.0422
  TAF= 145.38
 T1,T2,T3,------------T(M+1)
 121.32      120.50      119.36      117.79      115.63      112.73
 108.90      104.02      98.088      91.450      84.909      79.626
 76.469      75.279      75.124

504 PERIOD  QAT=  11650.  QST= 1794636.  QOT=    1914. HCI=1.8850 HCO=1.0610
  TAF= 148.86
 T1,T2,T3,------------T(M+1)
 125.07      124.25      123.11      121.53      119.36      116.43
 112.54      107.54      101.39      94.348      87.176      81.074
 77.126      75.471      75.207

576 PERIOD  QAT=  12128.  QST= 2050878.  QOT=    3506. HCI=1.9053 HCO=1.0788
  TAF= 152.10
 T1,T2,T3,------------T(M+1)
 128.56      127.74      126.59      125.01      122.83      119.88
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A05

SUBJECT TRANSIENT TEMPERATURE STUDY FOR CS PUMP ROOM SHEET NO. 72

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
10	PWells	2-26-88	G.W.M	3-28-88						

```
      115.95      110.85      104.51      97.136      89.423      82.583
      77.871      75.720      75.313

648 PERIOD  QAT=  12574.  QST= 2306380.  QOT=     5862. HCI=1.9245 HCO=1.0957
   TAF= 155.14
   T1,T2,T3,----------T(M+1)
      131.84      131.02      129.87      128.28      126.10      123.12
      119.15      113.97      107.48      99.822      91.639      84.132
      78.689      76.025      75.442

24 HR 720 PERIOD  QAT=  12994.  QST= 2560984.  QOT=     9140. HCI=1.9429 HCO=1.1117
   TAF= 158.02
   T1,T2,T3,----------T(M+1)
      134.94      134.12      132.97      131.37      129.18      126.19
      122.19      116.94      110.31      102.41      93.817      85.705
      79.568      76.385      75.592
```