Arizona Nuclear Power Project

DOCUMENT NUMBER
13-MC-HA-A02

TITLE/DESCRIPTION

Transient temperature study for HPSI pump room

Safety related Quality Class "Q"

REV	REVISION DESCRIPTION	ORIGINATOR DATE	CHECKER DATE	RS DATE	QA DATE	NEM/PEM DATE
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PV214-09C (Rev 2) 5/86

INTERNAL CONTROL NO. 18601-183-CALC-002

CALCULATION COVER SHEET

SHEET 1

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI PUMP ROOM FILE NO.

PROJECT QUALITY CLASS Q DISCIPLINE MECH

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

RECORD OF ISSUES

NO.	DESCRIPTION	TOTAL NO. OF SHEETS	LAST SHEET NO.	ORIG	CKR	GL	GS	CHEF	DATE
0	ORIGINAL ISSUE	72	72	PSSethi	G.W.M	—	TB	—	APPR. 3-28-88 FILM
1									APPR. FILM
2									APPR. FILM
3									APPR. FILM
4									APPR. FILM
5									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

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

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

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I. PURPOSE

The design basis for cooling the HPSI pump equipment rooms, when the pumps are in service, uses unit coolers and the Essential Chilled Water System for cooling. In the event that either the unit coolers or the Essential Chilled Water system fails when the HPSI 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 HPSI pump room for the following two cases:

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.

During post-Loca condition, the limiting containment sump temperature is 225°F as shown in reference 19, figure 6.2.1-24.

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 HPSI pump room.

The heat generated in the room is transferred to the room ambient air, stored in the room enclosure concrete (heat sink) and transferred to the air outside the room. The transient temperature for the HPSI room ambient 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.

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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 (HPSI subsystem), Auxiliary Building HVAC (Normal and Essential), and Essential Chilled Water. Their design criteria are references 21, 22 and 23.

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III. STUDY ASSUMPTIONS:

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

2. The initial temperature inside the HPSI 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 HPSI 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 assumed failure at the onset of this study as discussed in section I.

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

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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 thermal 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 90% 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 provides a conservative estimate compared to a cylindrical surface.

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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 HPSI pump room shares a common wall with the other HPSI pump room and with a CS pump room.

    Operation of only one HPSI pump is required, but two are assumed. The operating HPSI and CS pumps could be from different trains so that these 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 HPSI 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 HPSI pump room A for Unit 1 and is applicable to HPSI 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 the adjacent spaces. The shield wall surface area and volume are approximately 4% and 2.5% respectively of the pump room surface area and volume.

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As can be seen from the results in Appendicies 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 HPSI pump motor. 82% efficiency for the ACU fan motor is assumed for calculation of room heat load. This is a typical motor efficiency for 5 hp motors as shown in reference 1, Chapter 22, table 30, page 417.

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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 HPSI 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.

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.

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20. For calculation of air flow due to temperature difference for the case of 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. 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 pump room door has been open for a while. Note: the initial temperature was 75°F. (Assumptions 2 & 3).

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)

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.

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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. Ingersoll-Rand pump drawing for HPSI pump, log N001-11.01-15-6

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15. Ingersoll-Rand Pump Manual, log N001-11.05-1, HPSI pump data sheet and pump curve.
16. Pump motor data sheets, log N001-11.05-7-2
17. Reliance Electric Co. drawing, log M721A-112-2
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, Ammendment 17.
20. Auxiliary Building Base Mat, Sections and Details, Drawing Number 13-C-ZAS-124, Rev. 13.
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.

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V. SUMMARY OF RESULTS:

The transient temperature summary for the HPSI pump room air for the cases 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 on page 51 the average of the results is felt to best estimate the transient temperature profile when the room door is open.

	No HVAC and Door Closed	No HVAC and Room Door Open		
Time Period	CASE A: Temp., °F	CASE B: Temp., °F	CASE C: Temp., °F	Avg B & C Temp., °F
0 min	75.	75	75	75
2 min	93.34	84.93	87.77	86.35
4 min	104.10	90.97	95.42	93.20
12 min	117.79	99.26	105.64	102.45
36 min	124.76	103.37	110.74	107.06
1 hr	128.66	105.53	113.50	109.52
2 hr	135.64	109.36	118.40	113.88
4 hr	145.37	114.69	125.22	119.96
6 hr	152.80	118.75	130.43	124.59
8 hr	159.07	122.16	134.80	128.48
12 hr	169.57	127.88	142.14	135.01
24 hr	193.35	140.79	158.72	149.76

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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 X $(1.41)^2$ 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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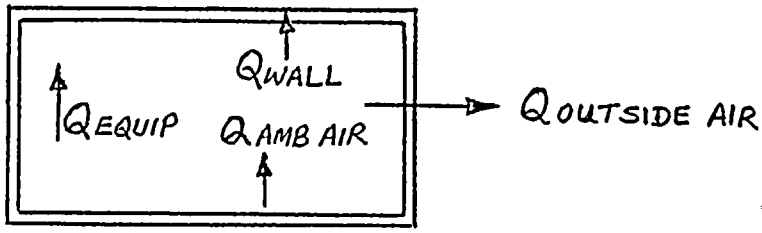

$$Q_{EQUIP} = Q_{AMB\ AIR} + Q_{WALL} + Q_{OUTSIDE\ AIR}$$

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

$Q_{AMB\ AIR}$ = Heat transferred to the ambient 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.

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B. Input Required for Computer Model:

The following information is required as input for transient temperature study in the HPSI 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

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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

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VII. STUDY:

This study is performed for the following two cases:

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

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

CASE A

FLUID TEMPERATURE IN THE HPSI 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 HPSI pump motor and ACU fan motor.

1. HPSI Pump Electrical Motor Heat Load:

HPSI Pump design flow = 850 gpm (REF 15)

Pump design flow BHP = 885 hp (REF 15)

Motor efficiency, η = 94.8% (REF 16)

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

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

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

= 885 X 2545 X $\frac{(1 - 0.948)}{0.948}$ BTU/HR

= 123,545 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 fan nameplate hp = 5 (REF 17)
Motor efficiency = 82% (See Assumption 15)

The motor and the driver are both in the HPSI room and the air stays inside the room (i.e. all the fan motor energy remains in the room).

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

Heat gain from fan motor = $\frac{\text{hp} \times 2545}{\text{eff}}$

$= \frac{5 \times 2545}{0.82}$

= 15,518 BTU/HR

Total motor heat load = 123,545 + 15,518

= 139,063 BTU/HR

b. Lighting Heat Loads:

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

HPSI pump room area = (20'-6") X (17'-3") (Ref 11)

= 20.5 X 17.25 FT^2

= 353.63 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

= 353.63 X 2 X 3.41 BTU/HR

= 2412 BTU/HR

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c. Piping Heat Load:

When the HPSI pump is operating; design basis cooling is provided by an 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 HPSI pump initially supplies cooling water from the refueling water tank. When that source is used, the HPSI pump recirculates water from the containment sump to remove decay heat in the core during the time period under study. It is assumed that the HPSI system is operating in both safety injection and long term recirculation modes during this time period. The HPSI piping in this room is used for one of these two operating modes. Therefore, all the HPSI piping in the room is used to calculate heat loads.

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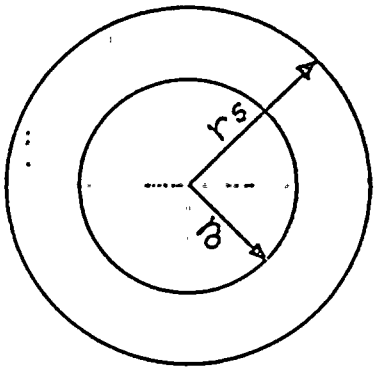
This heat load is due to the HPSI pump suction and discharge piping in the HPSI pump room. All of the process piping in this room is insulated.

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



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

(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 of inner surface of insulation, degrees F



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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.

For suction and discharge piping:
Fluid temperature or $t_o = 225^\circ$ F (See Assumption 1)

Ambient air temperature or $t_a = 75^\circ$ 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 = $\frac{225 + 75}{2} = 150^\circ F$

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

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

PIPING HEAT LOADS (CONT.)

1. PUMP SUCTION PIPING

THE PUMP SUCTION PIPING IN THE HPSI PUMP ROOM CONSISTS OF THE FOLLOWING 10" LINE:

LINE NO. 1PSIAL008: [REF 3]

LINE SIZE = 10" SCH 20

INSULATION THICKNESS = 2.0"

TYPE OF INSULATION = CALCIUM SILICATE

PIPE O.D. = 10.75" [REF 8]

INSULATION O.D. = 10.75 + (2 x 2)

= 14.75"

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 AWPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI PUMP ROOM SHEET NO. 26

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REVISION
0	PSSella	3-28-88	G.W.M	3-28-88						

PUMP SUCTION PIPING

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

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

FROM EQUATION SHOWN ON PAGE 23,

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

$= 24.66$ BTU/HR-FT^2

OUTSIDE SURFACE AREA OF INSULATION

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

$= 3.86$ FT^2/LINEAR FT

$q_s = 24.66 \times 3.86$ FT^2/LINEAR FT

$= 95.19$ BTU/HR. LINEAR FT

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REVISION
PSSelk	3-28-88	G.W.M	3-28-88						

PUMP SUCTION SIDE

LINE NO.	PIPE SIZE IN	*PIPE LENGTH FT	**HEAT LOAD/ LINEAR FT BTU/HR.LIN FT	HEAT LOAD BTU/HR
1PSIAL008	10"	12'-0"	95.19	95.19×12 = 1142

* THE PIPE LENGTH INFORMATION IS FROM REF 9

** HEAT LOAD/LINEAR FT IS SHOWN ON PAGE 26.

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

2. PUMP DISCHARGE PIPING

THE PUMP DISCHARGE PIPING IN THE HPSI PUMP ROOM CONSISTS OF THE FOLLOWING LINES:

A. LINE NO. 1PSIAL099 AND 1PSIAL100: [REF 3]

LINE SIZE = 4" SCH 120

INSULATION THICKNESS = 1.5"

TYPE OF INSULATION = CALCIUM SILICATE

PIPE O.D. = 4.5" [REF 8]

INSULATION O.D. = 4.5 + (2x1.5)
= 7.5"

B. LINE NO. 1PSIAL105: [REF 3]

LINE SIZE = 2" SCH 160

INSULATION THICKNESS = 1.5"

TYPE OF INSULATION = CALCIUM SILICATE

PIPE O.D. = 2.375" [REF 8]

INSULATION O.D. = 2.375 + (2 x 1.5)
= 5.375"

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

C. LINE NO 1PSIAL106

LINE SIZE = 3" SCH 160

INSULATION THICKNESS = 3.5"

TYPE OF INSULATION = CALCIUM SILICATE

PIPE O.D. = 3.5"

INSULATION O.D. = 3.5 + (2 x 3.5)

= 10.5"

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

PUMP DISCHARGE PIPING

FOR 4" PIPE,

$$r_s = \frac{7.5}{2} = 3.75"$$

$$r_o = \frac{4.5}{2} = 2.25"$$

FROM EQUATION SHOWN ON PAGE 23,

$$q_s = \frac{225 - 75}{\frac{3.75 \log_e \frac{3.75}{2.25}}{0.40} + 0.25}$$

$$= 29.77 \text{ BTU/HR FT}^2$$

OUTSIDE SURFACE AREA OF INSULATION.

$$= \pi \times \frac{7.5}{12} \times 1 \text{ FT}^2/\text{LINEAR FT}$$

$$= 1.96 \text{ FT}^2/\text{LINEAR FT}$$

$$q_s = 29.77 \times 1.96 \text{ BTU/HR. LINEAR FT}$$

$$= 58.35 \text{ BTU/HR. LINEAR FT}$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelle	3-2-88	G.W.M	3-28-88						

FOR 2" PIPE,

$$r_s = \frac{5.375}{2}$$

$$= 2.6875"$$

$$r_o = \frac{2.375}{2}$$

$$= 1.1875"$$

$$q_s = \frac{225-75}{\frac{2.6875 \log_e \frac{2.6875}{1.1875}}{0.40} + 0.25}$$

$$= 26.14 \text{ BTU/HR FT}^2$$

OUTSIDE SURFACE AREA OF INSULATION

$$= \pi \times \frac{5.375}{12} \times 1 \text{ FT}^2/\text{LINEAR FT}$$

$$= 1.41 \text{ FT}^2/\text{LINEAR FT}$$

$$q_s = 26.14 \times 1.41 \text{ BTU/HR. LINEAR FT}$$

$$= 36.86 \text{ BTU/HR. LINEAR FT.}$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-28-88	G.W.M	3.28.88						

FOR 3" PIPE,

$$r_s = \frac{10.5}{2}\text{"}$$

$$= 5.25\text{"}$$

$$r_o = \frac{3.5}{2}\text{"}$$

$$= 1.75\text{"}$$

$$q_s = \frac{225-75}{\frac{5.25 \log_e \frac{5.25}{1.75}}{0.40} + 0.25}$$

$$= 10.23 \text{ BTU/HR-FT}^2$$

OUTSIDE SURFACE AREA OF INSULATION

$$= \pi \times \frac{10.5}{12} \times 1 \text{ FT}^2/\text{LINEAR FT}$$

$$= 2.75 \text{ FT}^2/\text{LINEAR FT}$$

$$q_s = 10.23 \times 2.75 \text{ BTU/HR. LINEAR FT}$$

$$= 28.13 \text{ BTU/HR. LINEAR FT.}$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI PUMP ROOM SHEET NO. 33

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

PUMP DISCHARGE SIDE

LINE NO	PIPE SIZE IN	PIPE LENGTH FT *	HEAT LOAD/ LINEAR FT BTU/HR. LIN FT	HEAT LOAD BTU/HR
1PSIAL099	4"	9'-0"	58.35	58.35 x 9 = 525
1PSIAL100	4"	36'-0"	58.35	58.35 x 36 = 2,101
1PSIAL105	2"	51'-0"	36.86	36.86 x 51 = 1,880
1PSIAL106	3"	12'-0"	28.13	28.13 x 12 = 338

HEAT LOAD FOR DISCHARGE PIPING = 4,844 BTU/HR

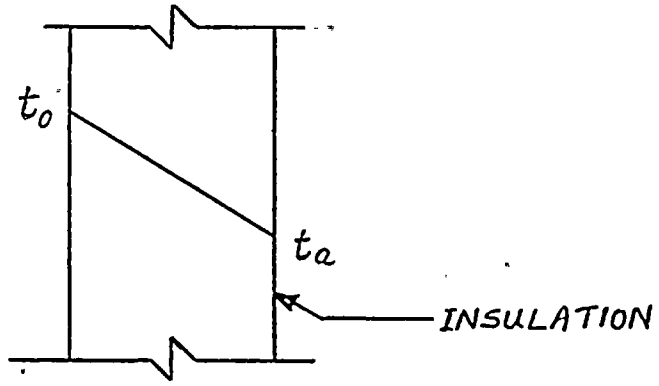
HEAT LOAD FOR SUCTION PIPING = 1,142 BTU/HR
(SEE PAGE 27)

TOTAL PIPING HEAT LOAD = 5,986 BTU/HR

* FOR PIPE LENGTHS, SEE REFERENCE 10

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-26-85	G W M	3-28-85						

d. Heat Dissipated by the HPSI 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 HPSI pump is mineral wool and is 2" thick.
Therefore, L = 2"

At mean 150°F, the mean temp K = 0.285 (REF 2, exhibit F, section 2C, para F.2.1E)

Rs = 0.25 (For details, see Assumption 16)

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P3Sa/kc	3-28-88	G.W.H	3-28-88						

$$qs = \frac{225 - 75}{\frac{2}{0.285} + 0.25} = 20.64 \text{ BTU/HR-FT}^2$$

From ref 14,

Surface area of HPSI pump =

$$\pi \times \frac{34}{12} \times \frac{42.5}{12} = 31.53 \text{ Ft}^2$$

Heat dissipated by HPSI pump

= 20.64 X 31.53 BTU/HR

= 651 BTU/HR

e. Total Heat Loads:

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

HPSI pump and ACU fan

Electric motors heat load	=	139,063 BTU/HR
Lighting heat load	=	2,412 BTU/HR
Piping heat load	=	5,986 BTU/HR
Heat dissipated by pump	=	651 BTU/HR
Total Heat Load	=	148,112 BTU/HR

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

2. HPSI PUMP ROOM SURFACE AREA & VOLUME

a. HPSI PUMP ROOM SURFACE AREA:

HPSI PUMP ROOM DIMENSIONS ARE,

$L \times W \times H = 20'-6" \times 17'-3" \times 27'-3"$ (REF 11 & 20)

HPSI PUMP ROOM A HAS A COMMON WALL ($20'-6" \times 27'-3"$) WITH HPSI PUMP ROOM B AND A COMMON WALL ($20'-6" \times 27'-3"$) WITH CS PUMP ROOM A (REF 11)

THE SURFACE AREA OF THE SHARED WALL IS CONSIDERED 50% FOR HPSI PUMP ROOM A [SEE ASSUMPTION 11]

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

$$\text{WALL SURFACE AREA} = 2 \times (17'-3" \times 27'-3") + \frac{20'-6"}{2} \times 27'-3" + \frac{20'-6"}{2} \times 27'-3"$$

$$= 1499 \text{ FT}^2$$

$$\text{CEILING SURFACE AREA} = 17'-3" \times 20'-6" = 354 \text{ FT}^2$$

$$\text{FLOOR SURFACE AREA} = 17'-3" \times 20'-6" = 354 \text{ FT}^2$$

$$\text{TOTAL SURFACE AREA} = 1499 + 354 + 354$$

$$= 2207 \text{ FT}^2$$

THERE IS A SHIELD WALL IN THE ROOM WITH DIMENSIONS, $L \times W \times H = 19'-6" \times 6'-0" \times 2'-0"$ (REF 11)

$$\text{VOLUME OF SHIELD WALL} = 19'-6" \times 6" \times 2'-0"$$

$$= 234 \text{ FT}^3$$

EQUIVALENT SURFACE AREA FOR 2'-9" THICK SHIELD WALL $= \frac{234}{2.75} = 85 \text{ FT}^2$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

TOTAL SURFACE AREA = 2207 + 85

= 2292 FT^2

FLOOR AREA OCCUPIED BY THE HPSI PUMP AND MOTOR SET = [FOR DIMENSIONS, SEE REF 14]

$$\frac{50.50}{12} \times \frac{104}{12} + \frac{(160-104)}{12} \times \frac{60.5}{12}$$

= 60 FT^2

NET SURFACE AREA FOR HEAT TRANSMISSION

= 2292 - 60

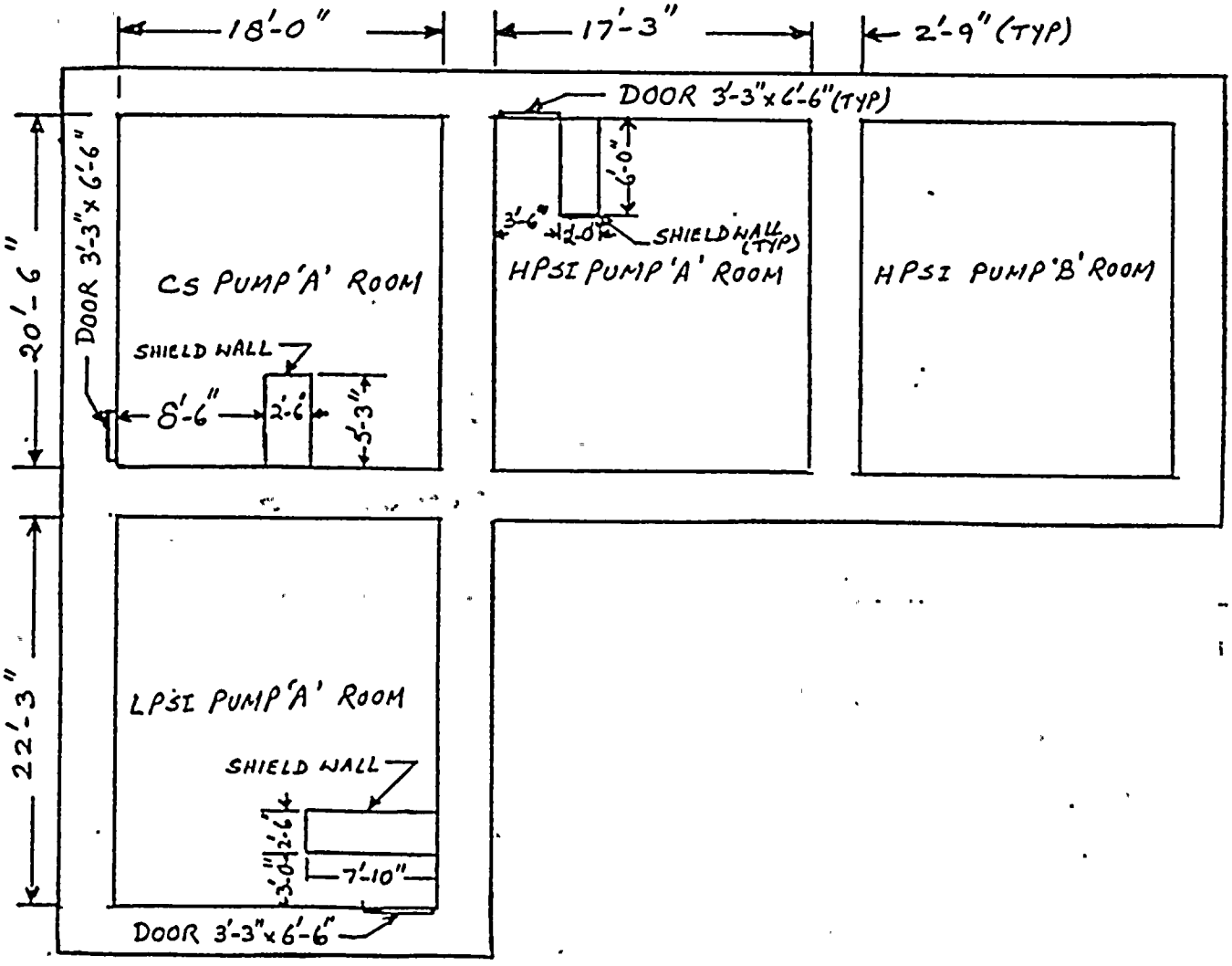
= 2232 FT^2

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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



LAYOUT OF PUMP ROOMS

(BASED ON REF 11 & 13)

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

b. HPSI PUMP ROOM VOLUME

FROM REF 14,

$$\text{PUMP VOLUME} = \frac{\pi}{4} \times \left(\frac{34}{12}\right)^2 \times \frac{42.5}{12} + \frac{\pi \times 1^2}{4} \times \frac{15}{12}$$

$$= 23.31 \text{ FT}^3$$

$$\text{COUPLING VOLUME} = \frac{\pi \times 1^2}{4} \times \frac{15}{12} = 0.98 \text{ FT}^3$$

$$\text{BASE PLATE VOLUME} = \frac{160}{12} \times \frac{8}{12} \times \frac{50.50}{12}$$

$$= 37.41 \text{ FT3}$$

$$\text{MOTOR VOLUME} = \frac{160-104}{12} \times \frac{60.5}{12} \times \frac{(82-8)}{12}$$

$$= \frac{56}{12} \times \frac{60.5}{12} \times \frac{74}{12}$$

$$= 145.09 \text{ FT3}$$

ESTIMATED PUMP & MOTOR SET VOLUME

$$= 23.31 + 0.98 + 37.41 + 145.09$$

$$= 206.79 \text{ FT}^3, \text{ SAY } 207 \text{ FT3}$$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

THE FOLLOWING PROVIDES THE PIPING VOLUME IN THE HPSI ROOM: (REF PAGES 25, 27, 28, 29 AND 33)

LINE NO	PIPE SIZE	INSULATION O.D.	PIPE LENGTH
1PSIAL008	10"	14.75"	12'-0"
1PSIAL099	4"	7.5"	9'-0"
1PSIAL100	4"	7.5"	36'-0"
1PSIAL105	2"	5.375"	51'-0"
1PSIAL106	3"	10.5"	12'-0"

VOLUME OF 1PSIAL008 $= \frac{\pi}{4} \times \left(\frac{14.75}{12}\right)^2 \times 12'\text{-}0''$

$= 14.24\ FT^3$

VOLUME OF 1PSIAL099 $= \frac{\pi}{4} \times \left(\frac{7.5}{12}\right)^2 \times 9'\text{-}0''$

$= 2.76\ FT^3$

VOLUME OF 1PSIAL100 $= \frac{\pi}{4} \times \left(\frac{7.5}{12}\right)^2 \times 36'\text{-}0''$

$= 11.04\ FT^3$

VOLUME OF 1PSIAL105 $= \frac{\pi}{4} \times \left(\frac{5.375}{12}\right)^2 \times 51'\text{-}0''$

$= 8.04\ FT^3$

VOLUME OF 1PSIAL106 $= \frac{\pi}{4} \times \left(\frac{10.5}{12}\right)^2 \times 12'\text{-}0'' = 7.22\ FT^3$

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

TOTAL PIPING VOLUME = 14.24 + 2.76 + 11.04 + 8.04 + 7.22
= 43.30 FT^3

HPSI PUMP ROOM VOLUME = 20'-6" x 17'-3" x 27'-3"
= 9636 FT^3

SHIELD WALL VOLUME = 234 FT^3 (SEE PAGE 36)

PUMP + MOTOR SET VOLUME = 207 FT^3

PIPING VOLUME = 43.30 FT^3

NET HPSI PUMP ROOM VOLUME = 9636 - (234 + 207 + 43.30)
= 9152 FT^3

VOLUME OF THE HVAC EQUIPMENT IS INSIGNIFICANT AND IS NEGLECTED. [SEE ASSUMPTION 23]

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	P.S.Seth	3-28-88	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 = 148,112 BTU/HR [See Section VII.A.1.e]
4. Net room surface area = 2232 FT^2 [See Section VII.A.2]
5. Net room volume = 9152 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]

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

4. Results: Case A

The transient temperature for the HPSI pump room ambient 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 HPSI pump room will be as follows:

Time Period	Temperature
0 min	75
2 min	93.34
4 min	104.10
12 min	117.79
36 min	124.76
1 hr	128.66
2 hr	135.64
4 hr	145.37
6 hr	152.80
8 hr	159.07
12 hr	169.57
24 hr	193.35

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

VII.B CASE B FLUID TEMPERATURE IN THE HPSI 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 the inside and the outside occurs as a result of the 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-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelhi	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 the height, assumption 14)

Assuming room temperature of 140 ^{o}F and outside temperature of 90^{o}F, [Assumptions 20 and 21], the pressure difference, pc

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

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

= 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,

$0.0037641 = 0.000482V^2$

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 (1/2 height x width, assumption 14)
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	PSSethi	3-28-88	G.W.M	3-18-88						

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 x (3.25 x 3.25) x (2.80 x 88)
= 1301 CFM

2. Heat Loads with Door Open -- Case B

The heat load generated within the room is the same as in Case A. With the door open there is energy transport from the room as a result of the air flow. This energy transport from the room is modelled as a constant over the 24 hour period of interest and is calculated as follows:

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 HPSI pump room = 148,112 BTU/HR (page 35)

Net heat load in the HPSI pump room = (148,112-70,254) BTU/HR
= 77,858 BTU/HR

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSEelw	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 on page 42 except for item # 3, Room heat load, which is 77,858 BTU/HR.

4. RESULTS: Case B

The transient temperature for the HPSI pump 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, the calculated temperature in the pump room will be as follows:

Time Period	Temperature ^{o}F
0 min	75
2 min	84.93
4 min	90.97
12 min	99.26
36 min	103.37
1 hr	105.53
2 hr	109.36
4 hr	114.69
6 hr	118.75
8 hr	122.16
12 hr	127.88
24 hr	140.79

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

VII.C CASE C: Verification of Average HPSI Room Temperature:

The average room ambient 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 128°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 128°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 128°F and outside temp 90°F (same as before):

$$pc = 0.52 \times 14.7 \times 3.25 \times \left[\frac{1}{460+90} - \frac{1}{460+128}\right]$$

$$= 0.52 \times 14.7 \times 3.25 \times \left[\frac{1}{550} - \frac{1}{588}\right]$$

$$= 0.0029191$$

Calculating an equivalent air velocity and flow as before:

$0.0029191 = 0.000482V^2$ [Ref 13, chap 19, page 333, eq 1]

Air velocity, V = 2.46 miles/hour

Air flow, Q = 0.5 x(3.25 x 3.25) x (2.46 x 80) CFM

= 1143 CFM

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	BSSchu	3-28-88	G.W.M	3.28.88						

2. Heat Load with the Door Open: CASE C

Heat removed through the open door = 1.08 x 1143 (128-90)
= 1.08 X 1143 X 38
= 46,909 BTU/HR

Net heat load with door open = 148,112-46,909
= 101,203 BTU/HR

3. Input Data: Case C

All input data for Case is the same as for Case A on page 42 except for item # 3, Room heat load, which is 101,203 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 158.72°F.

The transient temperature for the HPSI pump room ambient 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:

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI PUMP ROOM SHEET NO. 50

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

4. RESULTS CASE C (Continued)

Time Period	Temperature ^{o}F
0 min	75
2 min	87.77
4 min	95.42
12 min	105.64
36 min	110.74
1 hr	113.50
2 hr	118.40
4 hr	125.22
6 hr	130.43
8 hr	134.80
12 hr	142.14
24 hr	158.72

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

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

VI.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 of the chimney effect.

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

No HVAC and Room Door Open

Time Period	CASE B: Temp. ^{o}F	CASE C: Temp. ^{o}F	Avg B & C Temp. ^{o}F
0 min	75	75	75
2 min	84.93	87.77	86.35
4 min	90.97	95.42	93.20
12 min	99.26	105.64	102.45
36 min	103.37	110.74	107.06
1 hr	105.53	113.50	109.52
2 hr	109.36	118.40	113.88
4 hr	114.69	125.22	119.96
6 hr	118.75	130.43	124.59
8 hr	122.16	134.80	128.48
12 hr	127.88	142.14	135.01
24 hr	140.79	158.72	149.76

CALCULATION SHEET

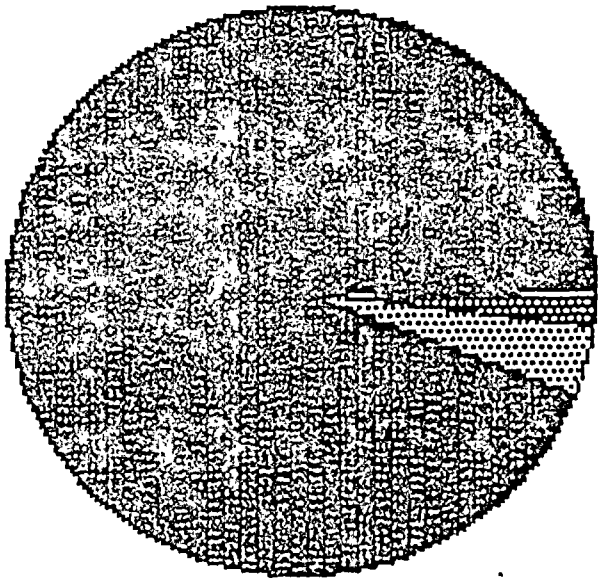
PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-21-88	G.W.M	3-25-88						

CLASSIFICATION OF HEAT LOADS

HPSI PUMP RM HEATUP



TOTAL HEAT LOAD BTU/HR
148.1 THOUSAND

FIGURE 1

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI ROOM SHEET NO. 53

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE
0	PSSethi	3-21-88	G.W.M	3-21-88					

REV. INDICATOR

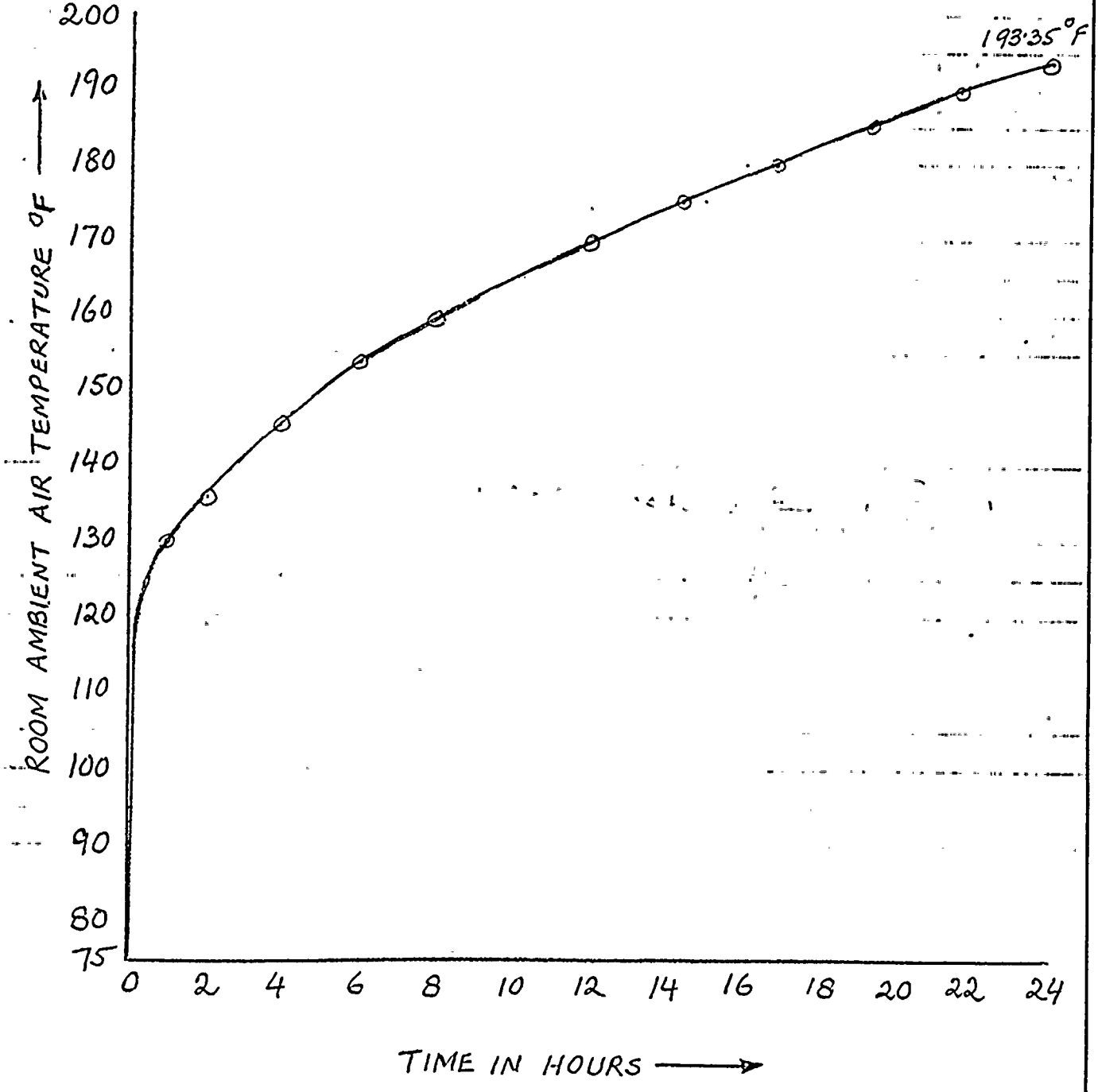


FIGURE 2

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI ROOM SHEET NO. 54

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-21-88	G. W. M	3-21-88						

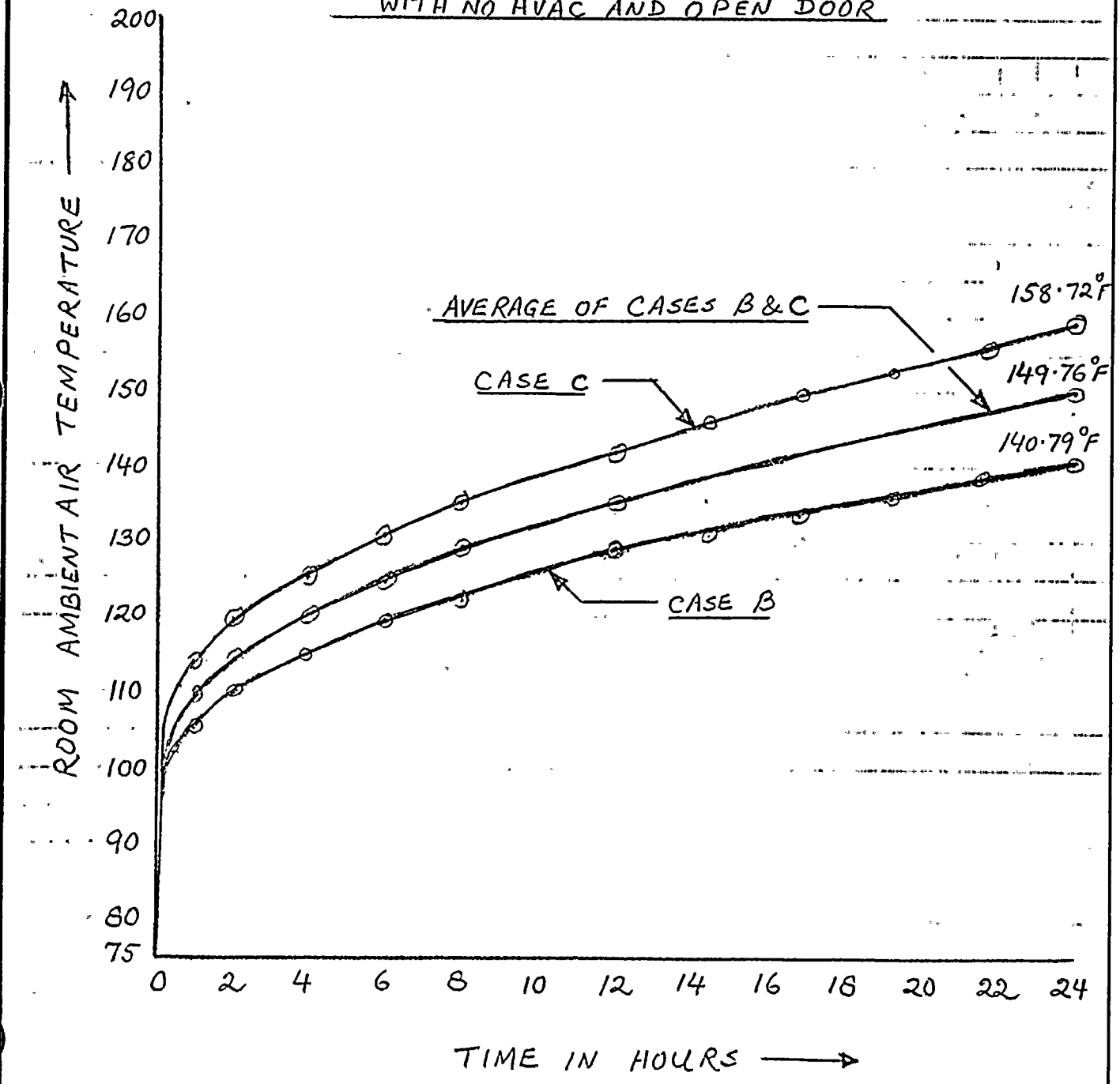


FIGURE 3

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-26-88	G.W.M	3-16-88						

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=?
>148112
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2232
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9152
     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=   2994.  QST=   1943.  QOT=      0. HCI=1.5118 HCO= .0000
    TAF= 93.34
    T1,T2,T3,------------T(M+1)
    76.064      75.724      75.426      75.207      75.078      75.021
    75.004      75.000      75.000      75.000      75.000      75.000
    75.000      75.000      75.000

   2 PERIOD QAT=   4694.  QST=   5180.  QOT=      0. HCI=1.6266 HCO= .0000
    TAF= 104.10
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

SUBJECT TRANSIENT TEMPERATURE STUDY FOR HPSI PUMP ROOM SHEET NO. 56

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelke	3-26-88	G.W.M	3-16-88						

```
 T1,T2,T3,----------T(M+1)
 77.351      76.728      76.121      75.611      75.264      75.084
 75.018      75.002      75.000      75.000      75.000      75.000
 75.000      75.000      75.000

 3 PERIOD  QAT=   5656.  QST=   9154.  QOT=      0. HCI=1.6829 HCO= .0000
  TAF= 110.31
 T1,T2,T3,----------T(M+1)
 78.573      77.765      76.916      76.136      75.543      75.194
 75.047      75.007      75.001      75.000      75.000      75.000
 75.000      75.000      75.000

 6 PERIOD  QAT=   6797.  QST=  22824.  QOT=      0. HCI=1.7419 HCO= .0000
  TAF= 117.79
 T1,T2,T3,----------T(M+1)
 81.471      80.432      79.211      77.903      76.688      75.769
 75.250      75.051      75.006      75.000      75.000      75.000
 75.000      75.000      75.000

 12 PERIOD  QAT=   7458.  QST=  51784.  QOT=      0. HCI=1.7694 HCO= .0000
  TAF= 122.17
 T1,T2,T3,----------T(M+1)
 85.259      84.134      82.712      81.014      79.165      77.416
 76.080      75.332      75.061      75.006      75.000      75.000
 75.000      75.000      75.000

 18 PERIOD  QAT=   7847.  QST=  81017.  QOT=      0. HCI=1.7842 HCO= .0000
  TAF= 124.76
 T1,T2,T3,----------T(M+1)
 88.002      86.854      85.366      83.518      81.375      79.144
 77.181      75.841      75.208      75.028      75.002      75.000
 75.000      75.000      75.000

 24 PERIOD  QAT=   8159.  QST= 110326.  QOT=      0. HCI=1.7963 HCO= .0000
  TAF= 126.85
 T1,T2,T3,----------T(M+1)
 90.270      89.110      87.585      85.652      83.334      80.791
 78.363      76.493      75.448      75.078      75.007      75.000
 75.000      75.000      75.000

1HR
 30 PERIOD  QAT=   8429.  QST= 139678.  QOT=      0. HCI=1.8066 HCO= .0000
  TAF= 128.66
 T1,T2,T3,----------T(M+1)
 92.248      91.080      89.532      87.543      85.106      82.339
 79.554      77.229      75.768      75.160      75.017      75.001
 75.000      75.000      75.000

 36 PERIOD  QAT=   8669.  QST= 169058.  QOT=      0. HCI=1.8159 HCO= .0000
  TAF= 130.28
 T1,T2,T3,----------T(M+1)
 94.026      92.853      91.288      89.257      86.732      83.796
 80.727      78.012      76.152      75.277      75.036      75.002
 75.000      75.000      75.000

 42 PERIOD  QAT=   8889.  QST= 198459.  QOT=      0. HCI=1.8244 HCO= .0000
  TAF= 131.77
 T1,T2,T3,----------T(M+1)
 95.655      94.477      92.899      90.837      88.244      85.174
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-26-88	G.W.M	3-26-88						

81.872 78.820 76.584 75.428 75.064 75.005
75.000 75.000 75.000

48 PERIOD QAT= 9092. QST= 227877. QOT= 0. HCI=1.8323 HCO= .0000
TAF= 133.14
T1,T2,T3,----------T(H+1)
97.167 95.986 94.397 92.310 89.661 86.482
82.986 79.639 77.054 75.609 75.103 75.009
75.000 75.000 75.000

2HR 60 PERIOD QAT= 9460. QST= 286751. QOT= 0. HCI=1.8469 HCO= .0000
TAF= 135.64
T1,T2,T3,----------T(H+1)
99.922 98.735 97.131 95.005 92.273 88.924
85.119 81.281 78.071 76.052 75.215 75.022
75.001 75.000 75.000

72 PERIOD QAT= 9790. QST= 345663. QOT= 0. HCI=1.8601 HCO= .0000
TAF= 137.89
T1,T2,T3,----------T(H+1)
102.41 101.22 99.600 97.446 94.651 91.176
87.133 82.902 79.154 76.582 75.376 75.047
75.003 75.000 75.000

84 PERIOD QAT= 10091. QST= 404603. QOT= 0. HCI=1.8723 HCO= .9477
TAF= 139.95
T1,T2,T3,----------T(H+1)
104.69 103.49 101.87 99.692 96.849 93.275
89.042 84.488 80.272 77.181 75.584 75.085
75.006 75.000 75.000

96 PERIOD QAT= 10371. QST= 463566. QOT= 0. HCI=1.8837 HCO= .9519
TAF= 141.87
T1,T2,T3,----------T(H+1)
106.81 105.61 103.98 101.78 98.903 95.247
90.859 86.032 81.407 77.833 75.835 75.138
75.011 75.000 75.000

108 PERIOD QAT= 10632. QST= 522546. QOT= 0. HCI=1.8945 HCO= .9552
TAF= 143.67
T1,T2,T3,----------T(H+1)
108.79 107.60 105.96 103.75 100.84 97.114
92.596 87.535 82.549 78.524 76.124 75.208
75.019 75.001 75.000

4HR 120 PERIOD QAT= 10878. QST= 581542. QOT= 1. HCI=1.9048 HCO= .9586
TAF= 145.37
T1,T2,T3,----------T(H+1)
110.67 109.47 107.83 105.61 102.67 98.891
94.260 88.997 83.688 79.245 76.449 75.294
75.030 75.001 75.001

132 PERIOD QAT= 11111. QST= 640550. QOT= 1. HCI=1.9146 HCO= .9619
TAF= 146.99
T1,T2,T3,----------T(H+1)
112.46 111.26 109.61 107.38 104.42 100.59
95.860 90.419 84.821 79.989 76.804 75.397
75.045 75.002 75.001

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSalk	3-26-88	G. W. M	3-26-88						

144 PERIOD QAT= 11333. QST= 699568. QOT= 2. HCI=1.9240 HCO= .9654
TAF= 148.53
T1,T2,T3,----------T(M+1)
116.17 112.96 111.31 109.07 106.09 102.22
97.403 91.804 85.944 80.751 77.187 75.517
75.064 75.003 75.002

156 PERIOD QAT= 11546. QST= 758596. QOT= 4. HCI=1.9331 HCO= .9689
TAF= 150.01
T1,T2,T3,----------T(M+1)
115.80 114.60 112.94 110.70 107.69 103.78
98.894 93.153 87.056 81.525 77.594 75.653
75.088 75.005 75.002

168 PERIOD QAT= 11750. QST= 817631. QOT= 7. HCI=1.9419 HCO= .9725
TAF= 151.43
T1,T2,T3,----------T(M+1)
117.38 116.17 114.51 112.26 109.24 105.30
100.34 94.470 88.154 82.308 78.021 75.806
75.117 75.008 75.003

6HR 180 PERIOD QAT= 11946. QST= 876672. QOT= 10. HCI=1.9504 HCO= .9761
TAF= 152.80
T1,T2,T3,----------T(M+1)
118.89 117.69 116.03 113.77 110.73 106.76
101.74 95.755 89.240 83.098 78.467 75.973
75.151 75.011 75.005

192 PERIOD QAT= 12136. QST= 935720. QOT= 15. HCI=1.9587 HCO= .9798
TAF= 154.13
T1,T2,T3,----------T(M+1)
120.36 119.15 117.49 115.23 112.18 108.18
103.10 97.010 90.311 83.892 78.929 76.155
75.191 75.015 75.007

204 PERIOD QAT= 12319. QST= 994771. QOT= 22. HCI=1.9668 HCO= .9836
TAF= 155.42
T1,T2,T3,----------T(M+1)
121.78 120.58 118.91 116.64 113.58 109.55
104.43 98.238 91.368 84.688 79.404 76.350
75.236 75.019 75.009

216 PERIOD QAT= 12496. QST= 1053826. QOT= 31. HCI=1.9747 HCO= .9874
TAF= 156.67
T1,T2,T3,----------T(M+1)
123.16 121.95 120.29 118.01 114.94 110.89
105.72 99.440 92.412 85.485 79.893 76.559
75.287 75.025 75.012

228 PERIOD QAT= 12669. QST= 1112884. QOT= 43. HCI=1.9824 HCO= .9912
TAF= 157.88
T1,T2,T3,----------T(M+1)
124.50 123.30 121.63 119.35 116.27 112.20
106.98 100.62 93.441 86.282 80.392 76.780
75.344 75.032 75.015

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSselli	3-26-88	G.W.H	3-26-88						

8HR 240 PERIOD QAT= 12836. QST= 1171942. QOT= 58. HCI=1.9899 HCO= .9951
TAF= 159.07
T1,T2,T3,----------T(M+1)
125.81 124.60 122.93 120.65 117.56 113.47
108.21 101.77 94.457 87.077 80.900 77.012
75.407 75.040 75.018

264 PERIOD QAT= 13158. QST= 1290061. QOT= 99. HCI=2.0045 HCO=1.0028
TAF= 161.35
T1,T2,T3,----------T(M+1)
128.33 127.12 125.45 123.15 120.05 115.92
110.59 104.02 96.448 88.661 81.940 77.509
75.551 75.061 75.028

288 PERIOD QAT= 13465. QST= 1408175. QOT= 159. HCI=2.0186 HCO=1.0106
TAF= 163.53
T1,T2,T3,----------T(M+1)
130.74 129.53 127.85 125.55 122.43 118.27
112.88 106.18 98.388 90.234 83.005 78.044
75.718 75.088 75.040

312 PERIOD QAT= 13758. QST= 1526278. QOT= 245. HCI=2.0322 HCO=1.0183
TAF= 165.62
T1,T2,T3,----------T(M+1)
133.04 131.83 130.15 127.85 124.72 120.53
115.08 108.27 100.28 91.790 84.088 78.613
75.908 75.122 75.055

336 PERIOD QAT= 14040. QST= 1644362. QOT= 362. HCI=2.0454 HCO=1.0260
TAF= 167.63
T1,T2,T3,----------T(M+1)
135.26 134.05 132.37 130.06 126.92 122.71
117.21 110.30 102.13 93.330 85.185 79.211
76.120 75.163 75.073

12HR 360 PERIOD QAT= 14310. QST= 1762419. QOT= 516. HCI=2.0582 HCO=1.0336
TAF= 169.57
T1,T2,T3,----------T(M+1)
137.40 136.19 134.51 132.20 129.04 124.81
119.27 112.27 103.93 94.852 86.292 79.836
76.354 75.213 75.095

432 PERIOD QAT= 15068. QST= 2116344. QOT= 1279. HCI=2.0948 HCO=1.0560
TAF= 175.04
T1,T2,T3,----------T(M+1)
143.43 142.22 140.53 138.20 135.02 130.74
125.09 117.87 109.11 99.302 89.639 81.835
77.170 75.413 75.182

504 PERIOD QAT= 15760. QST= 2469714. QOT= 2653. HCI=2.1292 HCO=1.0773
TAF= 180.08
T1,T2,T3,----------T(M+1)
148.97 147.76 146.07 143.73 140.53 136.20
130.46 123.07 113.98 103.58 92.987 83.973
78.141 75.696 75.303

576 PERIOD QAT= 16400. QST= 2822301. QOT= 4863. HCI=2.1618 HCO=1.0976
TAF= 184.77

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelle	3-26-88	G.W.M	3-26-88						

```
      T1,T2,T3,----------T(M+1)
      154.13     152.91     151.22     148.88     145.66     141.30
      135.49     127.95     118.59     107.70     96.307     86.202
      79.241     76.065     75.458


 648 PERIOD  QAT=  16998.  QST= 3173869.  QOT=     8135. HCI=2.1929 HCO=1.1169
      TAF= 189.18
      T1,T2,T3,----------T(M+1)
      158.97     157.75     156.06     153.71     150.48     146.09
      140.22     132.57     122.97     111.67     99.580     88.490
      80.449     76.517     75.647

24 HR 720 PERIOD  QAT=  17560.  QST= 3524188.  QOT=    12691. HCI=2.2229 HCO=1.1351
      TAF= 193.35
      T1,T2,T3,----------T(M+1)
      163.54     162.33     160.63     158.28     155.04     150.63
      144.71     136.95     127.17     115.50     102.80     90.814
      81.749     77.048     75.865
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
C	PSSelki	3-26-88	G.W.M	3.16.88						

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=?
>77858
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2232
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9152
     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=   1622.  QST=    973.  QOT=       0. HCI=1.3923 HCO= .0000
  TAF=  84.93
  T1,T2,T3,-------------T(M+1)
  75.533       75.363       75.214       75.104       75.039       75.011
  75.002       75.000       75.000       75.000       75.000       75.000
  75.000       75.000       75.000

 2 PERIOD QAT=   2589.  QST=   2601.  QOT=       0. HCI=1.4794 HCO= .0000
  TAF=  90.97
  T1,T2,T3,-------------T(M+1)
  76.181       75.868       75.563       75.307       75.132       75.042
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethu	3-26-88	G.W.M	3.16.88						

```
      75.009    75.001    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

 3 PERIOD QAT= 3168.  QST=  4618.  QOT=      0. HCI=1.5223 HCO= .0000
   TAF= 94.61
   T1,T2,T3,----------T(M+1)
      76.806    76.396    75.967    75.573    75.274    75.097
      75.024    75.003    75.000    75.000    75.000    75.000
      75.000    75.000    75.000

 6 PERIOD QAT= 3898.  QST= 11672.  QOT=      0. HCI=1.5686 HCO= .0000
   TAF= 99.26
   T1,T2,T3,----------T(M+1)
      78.327    77.789    77.158    76.484    75.861    75.391
      75.127    75.026    75.003    75.000    75.000    75.000
      75.000    75.000    75.000

12 PERIOD QAT= 4313.  QST= 26828.  QOT=      0. HCI=1.5875 HCO= .0000
   TAF= 101.92
   T1,T2,T3,----------T(M+1)
      80.342    79.752    79.008    78.121    77.157    76.248
      75.556    75.170    75.031    75.003    75.000    75.000
      75.000    75.000    75.000

18 PERIOD QAT= 4539.  QST= 42173.  QOT=      0. HCI=1.5956 HCO= .0000
   TAF= 103.37
   T1,T2,T3,----------T(M+1)
      81.794    81.191    80.411    79.442    78.320    77.154
      76.131    75.435    75.107    75.015    75.001    75.000
      75.000    75.000    75.000

24 PERIOD QAT= 4718.  QST= 57564.  QOT=      0. HCI=1.6019 HCO= .0000
   TAF= 104.53
   T1,T2,T3,----------T(M+1)
      82.991    82.382    81.582    80.567    79.352    78.020
      76.751    75.776    75.232    75.040    75.004    75.000
      75.000    75.000    75.000

1 HR 30 PERIOD QAT= 4873.  QST= 72980.  QOT=      0. HCI=1.6073 HCO= .0000
   TAF= 105.53
   T1,T2,T3,----------T(M+1)
      84.034    83.420    82.608    81.563    80.285    78.835
      77.376    76.161    75.399    75.083    75.009    75.000
      75.000    75.000    75.000

36 PERIOD QAT= 5011.  QST= 88412.  QOT=      0. HCI=1.6121 HCO= .0000
   TAF= 106.42
   T1,T2,T3,----------T(M+1)
      84.971    84.354    83.532    82.466    81.141    79.601
      77.993    76.572    75.600    75.144    75.019    75.001
      75.000    75.000    75.000

42 PERIOD QAT= 5136.  QST= 103857.  QOT=      0. HCI=1.6165 HCO= .0000
   TAF= 107.24
   T1,T2,T3,----------T(M+1)
      85.829    85.210    84.381    83.298    81.937    80.326
      78.595    76.996    75.827    75.223    75.033    75.002
      75.000    75.000    75.000
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSEckle	3-26-88	G.W.M	3.26.88						

48 PERIOD QAT= 5252. QST= 119311. QOT= 0. HCI=1.6206 HCO= .0000
TAF= 107.99
T1,T2,T3,----------T(M+1)
86.625 86.004 85.170 84.073 82.683 81.014
79.180 77.426 76.073 75.317 75.053 75.004
75.000 75.000 75.000

2HR 60 PERIOD QAT= 5463. QST= 150241. QOT= 0. HCI=1.6280 HCO= .0000
TAF= 109.36
T1,T2,T3,----------T(M+1)
88.075 87.451 86.609 85.492 84.057 82.299
80.301 78.289 76.606 75.549 75.112 75.012
75.001 75.000 75.000

72 PERIOD QAT= 5652. QST= 181192. QOT= 0. HCI=1.6347 HCO= .0000
TAF= 110.60
T1,T2,T3,----------T(M+1)
89.382 88.757 87.908 86.776 85.308 83.483
81.361 79.140 77.175 75.828 75.197 75.025
75.001 75.000 75.000

84 PERIOD QAT= 5825. QST= 212160. QOT= 0. HCI=1.6408 HCO= .0000
TAF= 111.73
T1,T2,T3,----------T(M+1)
90.582 89.955 89.101 87.958 86.464 84.587
82.365 79.974 77.762 76.142 75.305 75.044
75.003 75.000 75.000

96 PERIOD QAT= 5985. QST= 243140. QOT= 0. HCI=1.6466 HCO= .9482
TAF= 112.78
T1,T2,T3,----------T(M+1)
91.697 91.068 90.211 89.059 87.545 85.624
83.320 80.786 78.358 76.484 75.437 75.072
75.006 75.000 75.000

108 PERIOD QAT= 6135. QST= 274130. QOT= 0. HCI=1.6520 HCO= .9518
TAF= 113.76
T1,T2,T3,----------T(M+1)
92.743 92.113 91.253 90.093 88.562 86.606
84.233 81.576 78.958 76.846 75.589 75.109
75.010 75.000 75.000

4HR 120 PERIOD QAT= 6277. QST= 305129. QOT= 0. HCI=1.6571 HCO= .9548
TAF= 114.69
T1,T2,T3,----------T(M+1)
93.731 93.101 92.238 91.071 89.526 87.540
85.108 82.344 79.557 77.225 75.759 75.154
75.016 75.001 75.000

132 PERIOD QAT= 6411. QST= 336135. QOT= 1. HCI=1.6619 HCO= .9577
TAF= 115.57
T1,T2,T3,----------T(M+1)
94.671 94.040 93.174 92.002 90.445 88.433
85.949 83.092 80.152 77.616 75.946 75.208
75.023 75.001 75.000

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSkh	3-26-88	G.W.M	3-26-88						

144 PERIOD QAT= 6539. QST= 367147. QOT= 1. HCI=1.6666 HCO= .9605
TAF= 116.41
T1,T2,T3,----------T(M+1)
95.568 94.936 94.069 92.892 91.324 89.289
86.760 83.819 80.742 78.016 76.146 75.271
75.034 75.002 75.001

156 PERIOD QAT= 6661. QST= 398164. QOT= 2. HCI=1.6711 HCO= .9635
TAF= 117.22
T1,T2,T3,----------T(M+1)
96.428 95.796 94.927 93.746 92.168 90.113
87.544 84.529 81.326 78.423 76.360 75.342
75.046 75.003 75.001

168 PERIOD QAT= 6779. QST= 429186. QOT= 3. HCI=1.6754 HCO= .9664
TAF= 118.00
T1,T2,T3,----------T(M+1)
97.255 96.623 95.752 94.567 92.980 90.908
88.304 85.221 81.904 78.834 76.584 75.422
75.061 75.004 75.002

6 HR 180 PERIOD QAT= 6892. QST= 460211. QOT= 5. HCI=1.6796 HCO= .9694
TAF= 118.75
T1,T2,T3,----------T(M+1)
98.053 97.420 96.548 95.360 93.766 91.677
89.040 85.896 82.474 79.249 76.818 75.510
75.079 75.005 75.003

192 PERIOD QAT= 7002. QST= 491240. QOT= 8. HCI=1.6836 HCO= .9724
TAF= 119.47
T1,T2,T3,----------T(M+1)
98.825 98.191 97.318 96.127 94.525 92.423
89.756 86.556 83.037 79.666 77.061 75.605
75.100 75.007 75.003

204 PERIOD QAT= 7107. QST= 522271. QOT= 11. HCI=1.6875 HCO= .9755
TAF= 120.17
T1,T2,T3,----------T(M+1)
99.572 98.938 98.064 96.870 95.262 93.146
90.453 87.202 83.593 80.085 77.311 75.708
75.123 75.010 75.005

216 PERIOD QAT= 7210. QST= 553304. QOT= 16. HCI=1.6914 HCO= .9785
TAF= 120.85
T1,T2,T3,----------T(M+1)
100.30 99.664 98.788 97.592 95.978 93.850
91.132 87.834 84.141 80.503 77.567 75.817
75.150 75.013 75.006

228 PERIOD QAT= 7310. QST= 584338. QOT= 22. HCI=1.6951 HCO= .9817
TAF= 121.52
T1,T2,T3,----------T(M+1)
101.00 100.37 99.493 98.294 96.675 94.536
91.795 88.453 84.682 80.922 77.829 75.933
75.180 75.017 75.008

8 HR 240 PERIOD QAT= 7407. QST= 615373. QOT= 29. HCI=1.6988 HCO= .9848
TAF= 122.16

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSC/hc	3-26-88	G.W.M	3-26-88						

```
   T1,T2,T3,-------------T(M+1)
   101.69      101.06      100.18      98.977      97.354      95.204
   92.442      89.060      85.216      81.340      78.096      76.055
   75.213      75.021      75.010

264 PERIOD  QAT=   7593.  QST=  677446.  QOT=      51. HCI=1.7058 HCO= .9911
   TAF= 123.40
   T1,T2,T3,-------------T(M+1)
   103.02      102.38      101.50      100.30      98.664      96.495
   93.696      90.239      86.263      82.173      78.643      76.316
   75.289      75.032      75.015

288 PERIOD  QAT=   7771.  QST=  739517.  QOT=      82. HCI=1.7126 HCO= .9973
   TAF= 124.59
   T1,T2,T3,-------------T(M+1)
   104.28      103.64      102.76      101.56      99.916      97.731
   94.898      91.377      87.283      82.999      79.202      76.597
   75.377      75.046      75.021

312 PERIOD  QAT=   7941.  QST=  801583.  QOT=     127. HCI=1.7191 HCO=1.0036
   TAF= 125.73
   T1,T2,T3,-------------T(M+1)
   105.49      104.86      103.98      102.76      101.12      98.919
   96.056      92.478      88.278      83.817      79.772      76.896
   75.476      75.064      75.029

336 PERIOD  QAT=   8104.  QST=  863639.  QOT=     187. HCI=1.7254 HCO=1.0098
   TAF= 126.83
   T1,T2,T3,-------------T(M+1)
   106.66      106.02      105.14      103.93      102.27      100.06
   97.174      93.544      89.248      84.626      80.348      77.211
   75.588      75.085      75.038

12HR 360 PERIOD  QAT=   8262.  QST=  925682.  QOT=     267. HCI=1.7315 HCO=1.0160
   TAF= 127.88
   T1,T2,T3,-------------T(M+1)
   107.79      107.15      106.27      105.05      103.39      101.17
   98.256      94.579      90.196      85.426      80.929      77.539
   75.710      75.111      75.050

432 PERIOD  QAT=   8703.  QST= 1111685.  QOT=     663. HCI=1.7487 HCO=1.0341
   TAF= 130.86
   T1,T2,T3,-------------T(M+1)
   110.95      110.32      109.43      108.21      106.54      104.28
   101.31      97.520      92.918      87.765      82.688      78.589
   76.139      75.216      75.096

504 PERIOD  QAT=   9107.  QST= 1297405.  QOT=    1375. HCI=1.7648 HCO=1.0514
   TAF= 133.59
   T1,T2,T3,-------------T(M+1)
   113.87      113.23      112.34      111.11      109.43      107.16
   104.14      100.26      95.478      90.015      84.448      79.712
   76.649      75.365      75.161

576 PERIOD  QAT=   9481.  QST= 1482724.  QOT=    2519. HCI=1.7799 HCO=1.0678
   TAF= 136.14
   T1,T2,T3,-------------T(M+1)
   116.58      115.94      115.05      113.82      112.13      109.84
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelhi	3-26-88	G.W.M	5-16-88						

106.78 102.82 97.901 92.180 86.193 80.884
77.227 75.558 75.244

648 PERIOD QAT= 9832. QST= 1667518. QOT= 4211. HCI=1.7942 HCO=1.0833
TAF= 138.53
T1,T2,T3,----------T(M+1)
119.12 118.48 117.59 116.36 114.66 112.35
109.27 105.25 100.21 94.265 87.913 82.086
77.862 75.795 75.345

24HR 720 PERIOD QAT= 10162. QST= 1851670. QOT= 6566. HCI=1.8079 HCO=1.0980
TAF= 140.79
T1,T2,T3,----------T(M+1)
121.53 120.89 120.00 118.76 117.06 114.74
111.63 107.55 102.41 96.278 89.604 83.307
78.545 76.073 75.462

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethu	3-26-88	G.W.M	4-6-88						

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=?
>101203
     NET INTERNAL ROOM SURFACE AREA, SQ. FT.=?
>2232
     NET INTERNAL ROOM VOLUME, CU.FT.=?
>9152
     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=  2084.  QST=,  1289.  QOT=       0. HCI=1.4371 HCO= .0000
       TAF= 87.77
       T1,T2,T3,-------------T(M+1)
       75.706      75.480      75.283      75.138      75.052      75.014
       75.003      75.000      75.000      75.000      75.000      75.000
       75.000      75.000      75.000

       2 PERIOD QAT=  3305.  QST=  3441.  QOT=       0. HCI=1.5342 HCO= .0000
       TAF= 95.42
       T1,T2,T3,-------------T(M+1)
       76.562      76.148      75.745      75.406      75.175      75.055
```

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-26-88	G.W.M	3-26-88						

75.012 75.002 75.000 75.000 75.000 75.000
75.000 75.000 75.000

3 PERIOD QAT= 4020. QST= 6099. QOT= 0. HCI=1.5821 HCO= .0000
TAF= 99.97
T1,T2,T3,----------T(M+1)
77.384 76.843 76.277 75.757 75.362 75.129
75.031 75.005 75.000 75.000 75.000 75.000
75.000 75.000 75.000

6 PERIOD QAT= 4903. QST= 15337. QOT= 0. HCI=1.6329 HCO= .0000
TAF= 105.64
T1,T2,T3,----------T(M+1)
79.363 78.659 77.833 76.951 76.132 75.515
75.167 75.034 75.004 75.000 75.000 75.000
75.000 75.000 75.000

12 PERIOD QAT= 5406. QST= 35073. QOT= 0. HCI=1.6547 HCO= .0000
TAF= 108.90
T1,T2,T3,----------T(M+1)
81.970 81.202 80.233 79.077 77.820 76.633
75.728 75.224 75.041 75.004 75.000 75.000
75.000 75.000 75.000

18 PERIOD QAT= 5689. QST= 55030. QOT= 0. HCI=1.6650 HCO= .0000
TAF= 110.74
T1,T2,T3,----------T(M+1)
83.852 83.068 82.052 80.792 79.331 77.813
76.478 75.569 75.140 75.019 75.001 75.000
75.000 75.000 75.000

24 PERIOD QAT= 5915. QST= 75043. QOT= 0. HCI=1.6732 HCO= .0000
TAF= 112.22
T1,T2,T3,----------T(M+1)
85.405 84.613 83.572 82.253 80.672 78.938
77.284 76.013 75.303 75.053 75.005 75.000
75.000 75.000 75.000

1 HR 30 PERIOD QAT= 6110. QST= 95087. QOT= 0. HCI=1.6802 HCO= .0000
TAF= 113.50
T1,T2,T3,----------T(M+1)
86.759 85.962 84.905 83.547 81.883 79.996
78.098 76.515 75.521 75.109 75.012 75.001
75.000 75.000 75.000

36 PERIOD QAT= 6284. QST= 115153. QOT= 0. HCI=1.6865 HCO= .0000
TAF= 114.64
T1,T2,T3,----------T(M+1)
87.976 87.174 86.106 84.719 82.996 80.992
78.899 77.049 75.783 75.188 75.024 75.001
75.000 75.000 75.000

42 PERIOD QAT= 6442. QST= 135234. QOT= 0. HCI=1.6922 HCO= .0000
TAF= 115.68
T1,T2,T3,----------T(M+1)
89.090 88.286 87.208 85.800 84.029 81.934
79.682 77.600 76.078 75.290 75.043 75.003
75.000 75.000 75.000

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSchu	3-26-88	G.W.M	3-26-88						

48 PERIOD QAT= 6588. QST= 155327. QOT= 0. HCI=1.6975 HCO= .0000
TAF= 116.65
T1,T2,T3,----------T(M+1)
90.124 89.317 88.232 86.807 84.999 82.828
80.443 78.160 76.398 75.414 75.070 75.006
75.000 75.000 75.000

2 HR 60 PERIOD QAT= 6854. QST= 195539. QOT= 0. HCI=1.7072 HCO= .0000
TAF= 118.40
T1,T2,T3,----------T(M+1)
92.008 91.198 90.102 88.650 86.784 84.498
81.900 79.281 77.092 75.716 75.146 75.015
75.001 75.000 75.000

72 PERIOD QAT= 7092. QST= 235779. QOT= 0. HCI=1.7160 HCO= .0000
TAF= 119.98
T1,T2,T3,----------T(M+1)
93.707 92.893 91.790 90.319 88.410 86.037
83.276 80.389 77.831 76.078 75.256 75.032
75.002 75.000 75.000

84 PERIOD QAT= 7310. QST= 276040. QOT= 0. HCI=1.7241 HCO= .0000
TAF= 121.43
T1,T2,T3,----------T(M+1)
95.265 94.450 93.340 91.856 89.913 87.471
84.581 81.472 78.595 76.487 75.398 75.058
75.004 75.000 75.000

96 PERIOD QAT= 7512. QST= 316316. QOT= 0. HCI=1.7317 HCO= .9498
TAF= 122.77
T1,T2,T3,----------T(M+1)
96.714 95.897 94.783 93.285 91.316 88.820
85.823 82.527 79.370 76.931 75.569 75.094
75.008 75.000 75.000

108 PERIOD QAT= 7701. QST= 356605. QOT= 0. HCI=1.7388 HCO= .9532
TAF= 124.03
T1,T2,T3,----------T(M+1)
98.074 97.255 96.137 94.629 92.638 90.096
87.009 83.554 80.150 77.403 75.766 75.142
75.013 75.000 75.000

4 HR 120 PERIOD QAT= 7879. QST= 396905. QOT= 0. HCI=1.7455 HCO= .9563
TAF= 125.22
T1,T2,T3,----------T(M+1)
99.358 98.539 97.417 95.900 93.891 91.310
88.147 84.553 80.928 77.895 75.988 75.200
75.020 75.001 75.000

132 PERIOD QAT= 8048. QST= 437215. QOT= 1. HCI=1.7520 HCO= .9593
TAF= 126.35
T1,T2,T3,----------T(M+1)
100.58 99.759 98.634 97.110 95.085 92.470
89.240 85.525 81.702 78.404 76.231 75.271
75.031 75.001 75.001

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSethi	3-24-88	G.W.M	3-26-88						

144 PERIOD QAT= 8209. QST= 477532. QOT= 1. HCI=1.7582 HCO= .9624
TAF= 127.43
T1,T2,T3,----------T(M+1)
101.75 100.92 99.796 98.267 96.227 93.583
90.295 86.471 82.469 78.924 76.492 75.352
75.044 75.002 75.001

156 PERIOD QAT= 8363. QST= 517855. QOT= 3. HCI=1.7641 HCO= .9655
TAF= 128.47
T1,T2,T3,----------T(M+1)
102.86 102.04 100.91 99.376 97.324 94.654
91.314 87.393 83.229 79.453 76.769 75.445
75.060 75.003 75.002

168 PERIOD QAT= 8511. QST= 558183. QOT= 4. HCI=1.7698 HCO= .9687
TAF= 129.47
T1,T2,T3,----------T(M+1)
103.94 103.12 101.98 100.44 98.381 95.687
92.300 88.292 83.980 79.988 77.061 75.549
75.080 75.005 75.002

6 HR 180 PERIOD QAT= 8654. QST= 598517. QOT= 7. HCI=1.7754 HCO= .9720
TAF= 130.43
T1,T2,T3,----------T(M+1)
104.98 104.15 103.02 101.47 99.401 96.686
93.258 89.170 84.721 80.527 77.366 75.664
75.103 75.007 75.003

192 PERIOD QAT= 8791. QST= 638854. QOT= 10. HCI=1.7808 HCO= .9753
TAF= 131.35
T1,T2,T3,----------T(M+1)
105.98 105.15 104.02 102.47 100.39 97.655
94.188 90.028 85.453 81.069 77.681 75.788
75.130 75.010 75.005

204 PERIOD QAT= 8924. QST= 679194. QOT= 15. HCI=1.7860 HCO= .9786
TAF= 132.25
T1,T2,T3,----------T(M+1)
106.95 106.13 104.99 103.44 101.35 98.596
95.094 90.867 86.175 81.613 78.006 75.921
75.161 75.013 75.006

216 PERIOD QAT= 9053. QST= 719537. QOT= 21. HCI=1.7911 HCO= .9819
TAF= 133.13
T1,T2,T3,----------T(M+1)
107.89 107.07 105.93 104.37 102.28 99.511
95.977 91.689 86.888 82.158 78.339 76.064
75.196 75.017 75.008

228 PERIOD QAT= 9178. QST= 759882. QOT= 29. HCI=1.7961 HCO= .9853
TAF= 133.98
T1,T2,T3,----------T(M+1)
108.81 107.99 106.85 105.29 103.18 100.40
96.838 92.493 87.591 82.702 78.680 76.214
75.235 75.022 75.010

8 HR 240 PERIOD QAT= 9300. QST= 800229. QOT= 39. HCI=1.8010 HCO= .9887
TAF= 134.80

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelk	3-26-88	G.W.M	3-26-88						

T1,T2,T3,----------T(H+1)
109.70 108.88 107.74 106.18 104.07 101.27
97.680 93.282 88.285 83.245 79.027 76.373
75.278 75.027 75.013

264 PERIOD QAT= 9534. QST= 880923. QOT= 67. HCI=1.8104 HCO= .9955
TAF= 136.40
T1,T2,T3,----------T(H+1)
111.42 110.60 109.46 107.89 105.77 102.95
99.309 94.815 89.646 84.328 79.738 76.712
75.376 75.042 75.019

288 PERIOD QAT= 9757. QST= 961615. QOT= 108. HCI=1.8195 HCO=1.0024
TAF= 137.92
T1,T2,T3,----------T(H+1)
113.07 112.24 111.10 109.53 107.40 104.56
100.87 96.295 90.972 85.402 80.465 77.078
75.490 75.060 75.027

312 PERIOD QAT= 9971. QST= 1042300. QOT= 166. HCI=1.8282 HCO=1.0092
TAF= 139.38
T1,T2,T3,----------T(H+1)
114.65 113.82 112.67 111.10 108.96 106.10
102.38 97.725 92.264 86.465 81.205 77.466
75.620 75.083 75.037

336 PERIOD QAT= 10176. QST= 1122970. QOT= 245. HCI=1.8366 HCO=1.0160
TAF= 140.79
T1,T2,T3,----------T(H+1)
116.16 115.33 114.19 112.61 110.46 107.59
103.83 99.111 93.526 87.517 81.955 77.875
75.765 75.111 75.050

12 HR 360 PERIOD QAT= 10373. QST= 1203623. QOT= 350. HCI=1.8448 HCO=1.0227
TAF= 142.14
T1,T2,T3,----------T(H+1)
117.63 116.80 115.65 114.07 111.91 109.02
105.24 100.46 94.758 88.557 82.710 78.302
75.924 75.145 75.065

432 PERIOD QAT= 10926. QST= 1445418. QOT= 866. HCI=1.8681 HCO=1.0425
TAF= 145.96
T1,T2,T3,----------T(H+1)
121.74 120.91 119.76 118.17 116.00 113.07
109.21 104.28 98.296 91.598 84.997 79.667
76.482 75.281 75.125

504 PERIOD QAT= 11432. QST= 1686847. QOT= 1797. HCI=1.8898 HCO=1.0613
TAF= 149.47
T1,T2,T3,----------T(H+1)
125.53 124.70 123.54 121.95 119.76 116.81
112.89 107.83 101.62 94.522 87.285 81.128
77.145 75.475 75.208

576 PERIOD QAT= 11900. QST= 1927747. QOT= 3293. HCI=1.9103 HCO=1.0792
TAF= 152.74
T1,T2,T3,----------T(H+1)
129.05 128.22 127.06 125.46 123.27 120.29

CALCULATION SHEET

PROJECT ANPP JOB NO. 18601-183 CALC. NO. 13-MC-HA-A02

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

REV	ORIGINATOR	DATE	CHECKER	DATE	REV	ORIGINATOR	DATE	CHECKER	DATE	REV. INDICATOR
0	PSSelk	3-26-88	G.W.M	3-16-88						

116.32 111.17 104.77 97.336 89.552 82.650
77.896 75.726 75.316

648 PERIOD OAT= 12338. OST= 2167957. OOT= 5507. HCI=1.9298 HCO=1.0962
TAF= 155.81
T1,T2,T3,----------T(H+1)
132.36 131.53 130.37 128.77 126.56 123.56
119.55 114.32 107.77 100.05 91.789 84.213
78.721 76.034 75.446

24 HR
720 PERIOD OAT= 12750. OST= 2407320. OOT= 8588. HCI=1.9484 HCO=1.1122
TAF= 158.72
T1,T2,T3,----------T(H+1)
135.49 134.66 133.50 131.89 129.68 126.66
122.62 117.32 110.63 102.66 93.988 85.801
79.609 76.397 75.597