Form 01077 (R7-89)

FORM 101.1 | REVISION 13

CERTIFICATION OF ENGINEERING CALCULATION

STATION AND UNIT NUMBER Oconee Units 1, 2, + 3

TITLE OF CALCULATION Room Heat-up Calculation for Station Blackout

CALCULATION NUMBER OSC-4747

ORIGINALLY CONSISTING OF:

PAGES 1 THROUGH 43

TOTAL ATTACHMENTS 5 TOTAL MICROFICHE ATTACHMENTS

TOTAL VOLUMES 1 TYPE I CALCULATION/ANALYSIS YES ☐ NO ☒

TYPE I REVIEW FREQUENCY

THESE ENGINEERING CALCULATIONS COVER QA CONDITION 1 ITEMS. IN ACCORDANCE WITH ESTABLISHED PROCEDURES, THE QUALITY HAS BEEN ASSURED AND I CERTIFY THAT THE ABOVE CALCULATION HAS BEEN ORIGINATED, CHECKED OR APPROVED AS NOTED BELOW:

ORIGINATED BY Jeffrey O. Henninger / D K Hanelson DATE 6-16-92 / 6/16/92

CHECKED BY R. S. Lytton DATE 6/24/92

APPROVED BY S L Nader DATE 6-25-92

ISSUED TO TECHNICAL SERVICES DIVISION DATE

RECEIVED BY TECHNICAL SERVICES DIVISION DATE

MICROFICHE ATTACHMENT LIST: ☐ Yes ☒ No SEE FORM 101.4

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1.0 PURPOSE

The purpose of this calculation is to determine the temperature rise in the Control, Electrical Equipment, Cable and Control Battery Rooms at the Oconee Nuclear Station during a station blackout. The reliability of equipment and controls in these areas could become a problem if the temperature rises are excessive.

2.0 QA CONDITION

This calculation is QA Condition 1. The operation of certain equipment and controls within these areas is necessary to bring the units to a safe shutdown during a station blackout.

3.0 DESIGN METHOD

The temperature rise within a room is due to more energy being generated within a room than is being conducted into and through the boundaries of the room. This excess energy is absorbed by the air (this neglects energy absorbed by equipment within the room) raising the temperature of the room. Energy being generated within a room is determined from the total kilowatts of energy being used by equipment which continues to operate within the room during a station blackout. (In the case of the Control Rooms, this value is higher during the first 30 minutes than during the next 3.5 hours due to load shedding.) Areas surrounding the room are assumed to be at a constant temperature and standard heat transfer equations are used to determine the amount of heat energy conducted through the walls. Energy is also absorbed by the walls and ceiling of the room.

To be consistent with NUMARC 87-00 (Reference 8.3), the floor is assumed to absorb no energy.

The following method is used to determine the temperature rise within a room during a station blackout.

Step 1: Determine the amount of energy available for heating up air mass in room.

The general heat transfer equation is:

$$Q_{air}=Q_{gen}-Q_{out}-Q_{conc}$$

where:

Q_{air} = energy absorbed by the air in the room (Btu)
Q_{gen} = energy generated within the room (Btu)
Q_{out} = energy transferred out of the room by conduction (Btu)
Q_{conc} = energy absorbed by the walls and ceiling (Btu)

The amount of energy being generated within the room is:

$$\dot{Q}_{gen} = 3.41\,(Btu/hr{\cdot}W) \cdot (ElectricalEquipmentHeatLoad(Watts))$$

Step 2: Determine the amount of energy conducted through the room boundaries.

The equation representing the energy being transferred through the walls is:

$$\dot{Q}_{out} = \sum UA\Delta T = T_{air}\Sigma UA - \Sigma UAT_{surr}\ ,\ Btu/hr$$

where:

U = the overall heat transfer coefficient for the boundary ($Btu/hr \cdot ft^2 \cdot {}^{\circ}F$)
A = the surface area of the boundary (ft^2)
ΔT = difference between the room temperature (T_{air}) and the assumed temperatures of the surrounding areas (T_{surr}).

Step 3: Determine the final steady state room temperature ($T_{air,ss}$).

The final steady state room temperature can be determined by setting

$$\dot{Q}_{gen} = \dot{Q}_{out}$$

or:

$$T_{air,ss} = \frac{\dot{Q}_{gen} + \Sigma UAT_{surr}}{\Sigma UA}$$

If this final steady state room temperature is less than the allowable maximum room temperature then the calculation can be ended. If not, continue on to the next step.

Step 4: Assume an average room air temperature for the desired time interval ($T_{air,avg(assumed)}$).

Step 5: Determine the amount of energy absorbed by the room boundaries (ie. walls and ceiling) (Q_{conc}).

The amount of energy absorbed by the boundaries is a function of the following:

a) Boundary (concrete) volume (ft^3)

b) Concrete conductivity (1.0 Btu/hr·ft·°F) Reference 8.1.

c) Thermal diffusivity (0.036 ft^2/hr) Reference 8.1.

d) Air film convection coefficient (1.47 Btu/hr·ft^2·°F for walls and 1.64 Btu/hr·ft^2·°F for ceiling)

e) Temperature difference between the boundary and the average room air temperature. (The initial boundary temperature will be assumed to be the average of the initial room temperatures on each side of the boundary.)

f) Length of time at which the energy transfer takes place. (hr)

Knowing these values, the amount of energy absorbed by the boundaries can be determined graphically (Reference 8.2). This graph uses a value for L which is equal to 1/2 the wall/ceiling thickness. For the case where a wall is constructed of hollow concrete blocks, L is set to one inch which is approximately the shell thickness of the block.

The <u>maximum</u> amount of energy which the concrete boundary can absorb (Q_o) can be determined from:

$$Q_o=\rho_{conc}V_{conc}c_{p,conc}\Delta T$$

where:

ρ_{conc} = density of concrete (140 lb/ft^3)

V_{conc} = volume of concrete (ft^3)
$c_{p,conc}$ = heat capacity of concrete (0.20 Btu/lb·°F)
ΔT = assumed average room temperature - initial boundary temperature (°F)

The graph in Reference 8.2 will yield a value of Q/Q_o which is the amount of energy absorbed by a wall as a percent of the maximum possible absorption. This graph assumes that an equal amount of energy is being transferred from each side. To take into account heat transfer from one room into the wall it is assumed that

$$Q_{conc}=\frac{Q/Q_o}{2}(Q_o)$$

Step 6: Determine the room air temperature at the end of the time interval.

With Q_{gen}, Q_{out}, and Q_{conc} known, Q_{air} can be determined from the equation in step 1. The room temperature at the end of the specified period of time can be found from the following equation.

$$T_{air}=\frac{Q_{air}}{\rho_{air}V_{air}c_{p,air}}+T_{air,i}$$

where:

Q_{air} = energy absorbed by the air in the room (Btu)
ρ_{air} = density of air (lb/ft^3)
V_{air} = volume of room (ft^3)
$c_{p,air}$ = heat capacity of air (Btu/lb·°F)
T_{air} = room air temperature (°F)
$T_{air,i}$ = initial room air temperature (°F)

To account for part of the room volume taken up by equipment, a factor of 80% of the internal room volume will be used to determine the amount of air in the room.

Step 7: Determine the function which describes the room air temperature between the start of the blackout event and the final steady state air temperature.

For the time between the start of the blackout event and before the room reaches a steady state condition, the temperature of the room can be determined by the following method.

From the equation in step 2 it can be seen that

$$\frac{dQ_{air}}{dt} = f(T_{air,ss} - T_{air})$$

because when $T_{air} = T_{air,ss}$; $dQ_{air}/dt = 0$.

On the other hand, the equation in step 6 shows that

$$\frac{dQ_{air}}{dt} = f\left(\frac{dT_{air}}{dt}\right)$$

Setting these last two equations equal to each other gives

$$c_a(T_{air,ss} - T_{air}) = c_b\left(\frac{dT_{air}}{dt}\right)$$

or

$$\frac{dT_{air}}{T_{air,ss} - T_{air}} = dt \cdot \frac{c_a}{c_b}$$

Setting $c_1 = c_b/c_a$ where c_1 is a constant which controls the rate of temperature change, and integrating both sides gives:

$$\int \frac{dT_{air}}{T_{air,ss} - T_{air}} = \int \frac{dt}{c_1}$$

Integrating the above equation yields:

$$-\ln(T_{air,ss}-T_{air})=\frac{t}{C_1}+C_2$$

where:

c_2 = constant of integration

At t = 0, $c_2 = -\ln(T_{air,ss}-T_{air,i})$

This yields an equation of the form:

$$\ln\frac{(T_{air,ss}-T_{air,i})}{(T_{air,ss}-T_{air})}=\frac{t}{C_1}$$

Inserting the value of T_{air} from step 6 allows one to solve for c_1.

$$C_1=\frac{t}{\ln\frac{(T_{air,ss}-T_{air,i})}{(T_{air,ss}-T_{air})}}$$

Step 8: Determine the calculated average room temperature for the time period.

At this point the average air temperature over the time period can be calculated by the equation:

$$T_{air,avg}=\frac{\int_0^t T_{air}dt}{\int_0^t dt}$$

After integrating the above equation it becomes the following:

$$T_{air,avg}=\frac{T_{air,ss}(t)+(T_{air,ss}-T_{air,i})\,(C_1)\,(e^{\frac{-t}{C_1}}-1)}{t}$$

The calculated average room temperature is then compared to the assumed room temperature selected in step 4. If they are more than 0.5°F apart a new average room temperature is assumed and the process is repeated beginning with step 5.

This iterative process is done using the software EXCEL. Output from this program is included in section 9.0 of this calculation. The terms used in the EXCEL spreadsheet are as follows:

Tair,avg(assumed) = assumed average room air temperature
Time = Length of heat-up period
Tair,ss = Steady state room air temperature at time = ∞
Tair,i = Initial room air temperature at time = 0
Qgen = Internal heat generation

Qout = Heat conducted through the walls
Qair = Heat absorbed by the air
Qconc(total) = Heat absorbed by the concrete walls and ceiling.
Tair(t) = Final room air temperature at end of the time period calculated from step 6 of Design Method
C1 = Constant calculated from step 7 of Design Method
Tair,avg(calc) = calculated average room air temperature from step 8 of Design Method (Used to check against assumed average room air temperature)

4.0 CODES AND STANDARDS

4.1 NUMARC 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors"

5.0 DESIGN INPUTS

ANSI N45.2.11 has been reviewed, and all applicable design inputs are documented in the appropriate sections.

6.0 FSAR CRITERIA

Section 9.4.1 of the FSAR covers the Control Room Ventilation System, however its contents do not apply to this calculation.

7.0 ASSUMPTIONS

7.1 See attachment 2 for assumed temperatures of room boundaries and surrounding areas.

7.2 Floors do not absorb any energy.

7.3 Equipment within the room does not absorb any energy.

7.4 No energy passes though doorways.

7.5 Volume of air within a room is 80% of internal room volume to account for space taken up by equipment.

7.6 Sheetrock within the Control Rooms does not absorb energy.

7.7 Load shedding within the Control Rooms takes place 30 minutes after the start of a station blackout.

8.0 REFERENCES

8.1 ASHRAE Handbook, Fundamentals, 1989, Chapter 22, Table 4.

8.2 Holman, J. P., Heat Transfer, 1976, Fig. 4-16.

8.3 NUMARC 87-00, Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors.

8.4 Letter from J H Bryan to B J Dolan dated June 11, 1992 specifying electrical equipment heat loads (Attachment 1).

8.5 Drawing O-1024-03, Unit 1 Electrical Equipment Room

8.6 Drawing O-1024-09, Unit 3 Electrical Equipment Room

8.7 Drawing O-1025-02, Unit 1 Cable Room

8.8 Drawing O-1025-07, Unit 3 Cable Room

8.9 Drawings O-1026-02,03 Unit 1 & 2 Control Room

8.10 Drawing O-1026-05 Unit 3 Control Room

8.11 OSSD-0210.16-09 Control Room and Administration Building Air Conditioning System Description

8.12 OSC-592, Oconee 1, 2, & 3 Mechanical Calculations

8.13 OSC-615, Containment Temperature Rise During Hot Shutdown and Loss of A. C. Power

8.14 Note from L. S. Underwood on hydrogen generation of batteries (Attachment 3)

9.0 CALCULATION

9.1 Control Rooms

The calculations which follow are based on full station blackout loads for the first 30 minutes into the event. At this time, all nonessential loads are manually stripped thus greatly reducing the internal heat generation and the corresponding peak temperature. Satisfactory temperatures cannot be maintained in the Control Rooms without load stripping.

9.2 Cable and Electrical Equipment Rooms

The calculations which follow for the Cable and Electrical Equipment Rooms are based on full station blackout loads. Even though reference 1 indicates that load stripping can be accomplished in these rooms, it is not necessary for obtaining satisfactory temperatures.

9.3 Control Battery Rooms

There is no internal heat generation for these rooms during a station blackout.

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UNITS 1 & 2 CONTROL ROOM ($T_{AIR,i} = 74°F$) TIME INTERVAL = 0-30 MINUTES

$\dot{Q}_{gen} = 256,575$ BTU/hr (for first 30 minutes into event)

$\therefore Q_{gen} = (256575 \text{ BTU/hr})(0.5 \text{ hours}) = 128,287$ BTU

& $Q_{OUT} = \sum UA\Delta T = T_{AIR}\sum UA - \sum UAT_{surr.}$

SECTION*	THICKNESS	RESISTANCE: AIR	WALL	AIR	GYPSUM	CARPET	ACOUST. TILE	AIR	U (BTU/hr-ft²-°F)	A (ft²)	T_{surr} (°F)
1a	42"	.68	3.36	.68	.56	—	—	.68	0.168	373	95
1b	42"	.68	3.36	.68	—	—	—	—	0.212	341.8	95
2a	12"	.68	.96	.68	.56	—	—	.68	0.281	373	110
2b	12"	.68	.96	.68	—	—	—	—	0.431	341.8	110
3a	42"	.68	3.36	.68	.56	—	—	.68	0.168	164	95
3b	42"	.68	3.36	.68	—	—	—	—	0.212	150.3	95
4a	42"	.68	3.36	.68	.56	—	—	.68	0.168	80	95
4b	42"	.68	3.36	.68	—	—	—	—	0.212	73.3	95
5a	42"	.68	3.36	.68	.56	—	—	.68	0.168	373	120
5b	42"	.68	3.36	.68	—	—	—	—	0.212	341.8	120
6a	42"	.68	3.36	.68	.56	—	—	.68	0.68	373	120
6b	42"	.68	3.36	.68	—	—	—	—	0.212	341.8	120
7a	42"	.68	3.36	.68	.56	—	—	.68	0.168	80	95
7b	42"	.68	3.36	.68	—	—	—	—	0.212	73.3	95
8a	42"	.68	3.36	.68	.56	—	—	.68	0.168	164	95
8b	42"	.68	3.36	.68	—	—	—	—	0.212	150.3	95
9a	12"	.68	.96	.68	.56	—	—	.68	0.281	373	110
9b	12"	.68	.96	.68	—	—	—	—	0.431	341.8	110
10a	42"	.68	3.36	.68	.56	—	—	.68	0.168	373	95
10b	42"	.68	3.36	.68	—	—	—	—	0.212	341.8	95
FLOOR	12"	.92	.96	—	—	1.23	—	.92	0.248	8113	100
CEILING	8"	.61	.64	.61	—	—	2.50	.61	0.201	8113	95

* "a" refers to wall section from floor to drop-in ceiling } Reference attachment 4 for
"b" refers to wall section from drop-in ceiling to roof } diagram of wall section

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$$\dot{Q}_{OUT} = (.168)(373)(T_{AIR}-95) + (.212)(341.8)(T_{AIR}-95) + (.281)(373)(T_{AIR}-110)$$
$$+ (.431)(341.8)(T_{AIR}-110) + (.168)(164)(T_{AIR}-95) + (.212)(150.3)(T_{AIR}-95)$$
$$+ (.168)(80)(T_{AIR}-95) + (.212)(73.3)(T_{AIR}-95) + (.168)(373)(T_{AIR}-120)$$
$$+ (.212)(341.8)(T_{AIR}-120) + (.68)(373)(T_{AIR}-120) + (.212)(341.8)(T_{AIR}-120)$$
$$+ (.168)(80)(T_{AIR}-95) + (.212)(73.3)(T_{AIR}-95) + (.168)(164)(T_{AIR}-95)$$
$$+ (.212)(150.3)(T_{AIR}-95) + (.281)(373)(T_{AIR}-110) + (.431)(341.8)(T_{AIR}-110)$$
$$+ (.168)(373)(T_{AIR}-95) + (.212)(341.8)(T_{AIR}-95) + (.248)(8113)(T_{AIR}-100)$$
$$+ (.201)(8113)(T_{AIR}-95)$$

$$\dot{Q}_{OUT} = 4847\,T_{AIR} - 484656 \text{ BTU/hr}$$

$$T_{AIR,ss} = \frac{\dot{Q}_{gen} + \Sigma UA\,T_{surr}}{\Sigma UA}$$

$$T_{AIR,ss} = \frac{236{,}575 + 484656}{4847}$$

$$T_{AIR,ss} = \underline{\underline{153\,^{\circ}F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.

- Control Room Volume = total room volume X .80 ; reference 8.12
  = 105000 ft^3

Unit 1&2 Control Room(30 min)

Tair,avg(assumed) = 95.3F

Time = 0.5hr
Tair,ss = 164F
Tair,ss-Tair,i = 90F

Section	L	h	$\frac{h^2 \alpha \tau}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.039	2.57	2503	85	10.3	721865	0.01	0.005	3609
2	0.5	1.47	0.039	0.74	715	92	3.3	66066	0.05	0.025	1652
3	1.75	1.47	0.039	2.57	1099	92	3.3	101548	0.01	0.005	508
4	1.75	1.47	0.039	2.57	536	85	10.3	154582	0.01	0.005	773
5	1.75	1.47	0.039	2.57	2503	97	-1.7	-119143	0.01	0.005	-596
6	1.75	1.47	0.039	2.57	2503	97	-1.7	-119143	0.01	0.005	-596
7	1.75	1.47	0.039	2.57	536	85	10.3	154582	0.01	0.005	773
8	1.75	1.47	0.039	2.57	1099	92	3.3	101548	0.01	0.005	508
9	0.5	1.47	0.039	0.74	715	92	3.3	66066	0.05	0.025	1652
10	1.75	1.47	0.039	2.57	2503	85	10.3	721865	0.01	0.005	3609
floor	0.5	0.465	0.004	0.23	8113	87	8.3	1885461	0	0	0
ceiling	0.33	1.64	0.048	0.54	5355	85	10.3	1544382	0.07	0.035	54053

Qconc(total) = 65945

Qgen = 128287 Qout = -11368 Qair = 73710

$\boxed{\text{Tair(t) = 113F}}$

C1 = 0.8803

Tair,avg(calc) = 95.3F

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UNITS 1 & 2 CONTROL ROOM ($T_{AIR_2} = 74\,°F$) TIME INTERVAL = 0-45 MINUTES

$\dot{Q}_{gen} = 256{,}575$ BTU/hr (for first 30 minutes into event)
$\dot{Q}_{gen} = 96{,}619$ BTU/hr (for 30 minutes - 4 hours)

$\therefore$ $Q_{gen} = (256{,}575\ \text{BTU/hr})(0.5\ \text{hours}) + (96{,}619\ \text{BTU/hr})(0.25\ \text{hours})$
$Q_{gen} = 152{,}442$ BTU

$\dot{Q}_{OUT} = 4847\,T_{AIR} - 484656$ BTU/hr (as before)

$\therefore$

$$T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA T_{surr}}{\Sigma UA}$$

$$T_{AIR,SS} = \frac{\left[256{,}575\left(\tfrac{2}{3}\right) + 96{,}619\left(\tfrac{1}{3}\right)\right] + 484656}{4847}$$

$$T_{AIR\,SS} = \underline{\underline{142\,°F}}$$

Energy absorbed by concrete:

- Refer to the spreadsheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.
- Control Room Volume = total room volume X .80 ; reference 8.12
  = 105,000 ft^3

Unit 1&2 Control Room (45 minutes)

Tair,avg(assumed) = 97.3F

Time = 0.75hr
Tair,ss = 151F
Tair,ss-Tair,i = 77F

Section	L	h	$\frac{h^2 \alpha \tau}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.058	2.57	2503	85	12.3	862033	0.01	0.005	4310
2	0.5	1.47	0.058	0.74	715	92	5.3	106106	0.07	0.035	3714
3	1.75	1.47	0.058	2.57	1099	92	5.3	163092	0.01	0.005	815
4	1.75	1.47	0.058	2.57	536	85	12.3	184598	0.01	0.005	923
5	1.75	1.47	0.058	2.57	2503	97	0.3	21025	0.01	0.005	105
6	1.75	1.47	0.058	2.57	2503	97	0.3	21025	0.01	0.005	105
7	1.75	1.47	0.058	2.57	536	85	12.3	184598	0.01	0.005	923
8	1.75	1.47	0.058	2.57	1099	92	5.3	163092	0.01	0.005	815
9	0.5	1.47	0.058	0.74	715	92	5.3	106106	0.07	0.035	3714
10	1.75	1.47	0.058	2.57	2503	85	12.3	862033	0.01	0.005	4310
floor	0.5	0.465	0.006	0.23	8113	87	10.3	2339789	0	0	0
ceiling	0.33	1.64	0.073	0.54	5355	85	12.3	1844262	0.07	0.035	64549

Qconc(total) = 84284

Qgen = 152442 Qout = -9782 Qair = 77940

$\boxed{\text{Tair(t)} = 115\text{F}}$

C1 = 0.97412

Tair,avg(calc) = 97.2F

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UNITS 1&2 CONTROL ROOM ($T_{AIR,i} = 74\,°F$) TIME INTERVAL = 0-60 MINUTES

$\dot{Q}_{gen} = 256{,}575$ BTU/hr (for first 30 minutes into event)

$\dot{Q}_{gen} = 96{,}619$ BTU/hr (for 30 minutes - 4 hours)

$\therefore Q_{gen} = (256{,}575\ \text{BTU/hr})(0.5\ \text{hours}) + (96{,}619\ \text{BTU/hr})(0.5\ \text{hours})$

$Q_{gen} = 176{,}597$ BTU

& $Q_{OUT} = 4847\, T_{AIR} - 484656$ BTU/hr (as before)

$$\therefore T_{AIR,ss.} = \frac{\dot{Q}_{gen} + \Sigma UA\, T_{surr}}{\Sigma UA}$$

$$T_{AIR,ss.} = \frac{\left[256{,}575\ \tfrac{BTU}{hr}\left(\tfrac{1}{2}\right) + 96{,}619\ \tfrac{BTU}{hr}\left(\tfrac{1}{2}\right)\right] + 484656}{4847}$$

$$T_{AIR,ss.} = \underline{\underline{136\ °F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.

- Control Room Volume = total room volume x .80 ; reference 8.12
  = 105000 ft^3

Unit 1&2 Control Room(1 hr)

Tair,avg(assumed) = 94.53F

Time =	1hr
Tair,ss =	144F
Tair,ss-Tair,i =	70F

Section	L	h	$\frac{h^2 \alpha T}{k^2}$	$\frac{hl}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.078	2.57	2503	85	9.53	667900.52	0.02	0.01	6679
2	0.5	1.47	0.078	0.74	715	92	2.53	50650.6	0.1	0.05	2533
3	1.75	1.47	0.078	2.57	1099	92	2.53	77853.16	0.02	0.01	779
4	1.75	1.47	0.078	2.57	536	85	9.53	143026.24	0.02	0.01	1430
5	1.75	1.47	0.078	2.57	2503	97	-2.47	-173107.48	0.02	0.01	-1731
6	1.75	1.47	0.078	2.57	2503	97	-2.47	-173107.48	0.02	0.01	-1731
7	1.75	1.47	0.078	2.57	536	85	9.53	143026.24	0.02	0.01	1430
8	1.75	1.47	0.078	2.57	1099	92	2.53	77853.16	0.02	0.01	779
9	0.5	1.47	0.078	0.74	715	92	2.53	50650.6	0.1	0.05	2533
10	1.75	1.47	0.078	2.57	2503	85	9.53	667900.52	0.02	0.01	6679
floor	0.5	0.465	0.008	0.23	8113	87	7.53	1710544.92	0	0	0
ceiling	0.33	1.64	0.097	0.54	5355	85	9.53	1428928.2	0.16	0.08	114314

Qconc(total) = 133693

Qgen = 176597 Qout = -26469 Qair = 69373

$\boxed{\text{Tair(t)} = 111\text{F}}$

C1 = 1.3514

Tair,avg(calc) = 94.6F

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UNITS 1 & 2 CONTROL ROOM ($T_{AIR,i} = 74°F$) TIME INTERVAL = 0-240 MINUTES

$\dot{Q}_{gen} = 256,575$ BTU/hr (for first 30 minutes into event)

$\dot{Q}_{gen} = 96,619$ BTU/hr (for 30 minutes - 4 hours)

$\therefore$ $Q_{gen} = (256,575 \frac{BTU}{hr})(0.5 \text{ hours}) + (96,619 \frac{BTU}{hr})(3.5 \text{ hours})$

$Q_{gen} = 466,454$ BTU

&

$Q_{OUT} = 4847\, T_{AIR} - 484656$ BTU/hr (as before)

$\therefore$ $$T_{AIR,SS.} = \frac{\dot{Q}_{gen} + \Sigma UA \Delta T_{surr.}}{\Sigma UA}$$

$$T_{AIR,SS.} = \frac{\left[256,575 \frac{BTU}{hr}(.125) + 96,619 \frac{BTU}{hr}(.875)\right] + 484656}{4847}$$

$$T_{AIR,SS.} = \underline{\underline{124\ °F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.

- Control Room Volume = total room volume x .80 ; reference 8.12
  = 105,000 ft^3

Unit 1&2 Control Room(4 hours)

Tair,avg(assumed) = 96.32F

Time = 4hr
Tair,ss = 129F
Tair,ss-Tair,i = 55F

Section	L	h	$\frac{h^2 \alpha T}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.311	2.57	2503	85	11.32	793351	0.08	0.04	31734
2	0.5	1.47	0.311	0.74	715	92	4.32	86486	0.3	0.15	12973
3	1.75	1.47	0.311	2.57	1099	92	4.32	132935	0.08	0.04	5317
4	1.75	1.47	0.311	2.57	536	85	11.32	169891	0.08	0.04	6796
5	1.75	1.47	0.311	2.57	2503	97	-0.68	-47657	0.08	0.04	-1906
6	1.75	1.47	0.311	2.57	2503	97	-0.68	-47657	0.08	0.04	-1906
7	1.75	1.47	0.311	2.57	536	85	11.32	169891	0.08	0.04	6796
8	1.75	1.47	0.311	2.57	1099	92	4.32	132935	0.08	0.04	5317
9	0.5	1.47	0.311	0.74	715	92	4.32	86486	0.3	0.15	12973
10	1.75	1.47	0.311	2.57	2503	85	11.32	793351	0.08	0.04	31734
floor	0.5	0.465	0.031	0.23	8113	87	9.32	2117168	0	0	0
ceiling	0.33	1.64	0.387	0.54	5355	85	11.32	1697321	0.42	0.21	356437

Qconc(total) = 466265

Qgen = 466454   Qout = -71172   Qair = 71361

$\boxed{\text{Tair(t)} = 112\text{F}}$

C1 = 3.49579

Tair,avg(calc) = 96.4F

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Unit 1 Cable Room ($T_{AIR,c}$ = 74°F)

$\dot{Q}_{gen}$ = 140,205 Btu/hr Q_{gen} = 140,205 (4 hrs) = 560,820 Btu

$\dot{Q}_{OUT} = \sum UA\Delta T = T_{AIR}\sum UA - \sum UAT_{surr}$

Section	Thickness	Resistance Air	Resistance Wall	Resistance Air	U (Btu/hr ft² °F)	A (ft²)	T_{surr} (°F)
① Aux Wall	42"	.68	3.36	.68	.21	311	95
② Turb Wall (block)	8"	.68	1.72	.68	.32	781	120
③ Aux Wall (block)	8"	.68	1.72	.68	.32	105	95
④ Pen Wall (block)	8"	.68	1.72	.68	.32	140	110
⑤ Pen Wall	12"	.68	.96	.68	.43	940	110
Floor	8"	.92	.64	.92	.40	2765	100
Ceiling	12"	.61	.96	.61	.46	2765	110

- Assume no heat transfer between Units 1 + 2 cable rooms.

$\dot{Q}_{OUT} = (.40 * 2765)(T_{AIR} - 100) + (.21 * 311 + .32 * 105)(T_{AIR} - 95)$

$+ (.46 * 2765 + .32 * 140 + .43 * 940)(T_{AIR} - 110)$

$+ (.32 * 781)(T_{AIR} - 120)$

$\dot{Q}_{OUT} = 1106 (T_{AIR} - 100) + 40 (T_{AIR} - 95) + 1720 (T_{AIR} - 110)$

$+ 250 (T_{AIR} - 120)$

$\dot{Q}_{OUT} = 3116\ T_{AIR} - 333600$, Btu/hr

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Unit 1 Cable Room cont.

$$T_{AIR,ss} = \frac{\dot{Q}_{gen} + \Sigma UA\,T_{surr}}{\Sigma UA}$$

$$= \frac{118,330 + 333600}{3116}$$

$$\underline{\underline{T_{AIR,ss} = 145\,°F}}$$

Volume of Unit 1 Cable Room

$$V = 2765\ ft^2\,(11.75\ ft)\,(0.80) = 25991\ ft^3$$

Unit 1 Cable Room

Tair,avg(assumed) = 108.09F

Time = 4hr
Tair,ss = 145F
Tair,ss-Tair,i = 71F

Section	L	h	$\frac{h^2 \alpha \tau}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.311	2.57	1088	85	23.09	703413.76	0.1	0.05	35171
2	0.08	1.47	0.311	0.12	130	97	11.09	40367.6	0.9	0.45	18165
3	0.08	1.47	0.311	0.12	17	85	23.09	10990.84	0.9	0.45	4946
4	0.08	1.47	0.311	0.12	23	92	16.09	10361.96	0.9	0.45	4663
5	0.5	1.47	0.311	0.73	940	92	16.09	423488.8	0.3	0.15	63523
Floor	0.33	1.09	0.171	0.36	1825	80	28.09	1435399	0	0	0
Ceiling	0.5	1.64	0.387	0.82	2765	74	34.09	2639247.8	0.3	0.15	395887

Qconc(total) = 522355

Qgen = 560820 Qout = 12833.8 Qair = 25631

AssumedT
105.5F

$\boxed{\text{Tair(t) = 129F}}$

C1 = 2.70857 Tair,avg(calc) = 107.9F

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Unit 1 Electrical Equipment Room ($T_{AIR,i} = 86\,°F$)

$\dot{Q}_{gen} = 65{,}353$ Btu/hr $Q_{gen} = 65353(4hr) = 261410$ Btu

$\dot{Q}_{out} = \Sigma UA\Delta T = T_{AIR}\Sigma UA - \Sigma UAT_{surr}$

Section	Thickness	Resistance Air	Wall	Air	$U\left(\frac{Btu}{hr\,Ft^2\,°F}\right)$	$A(ft^2)$	$T_{surr}(°F)$
① Aux Wall (Block)	8"	.68	1.72	.68	.32	1740	95
② Aux Wall	12"	.68	.96	.68	.43	552	95
③ Turbine Wall (Block)	4" *	.68	.71	.68	.48	540	120
Floor	8"	.92	2.88	.92	.21	2782	95
Ceiling	12"	.61	.64	.61	.54	2782	105

* Neglect 8" wall behind 4" wall separating equipment room from the Turbine Building. This is conservative since the 120°F assumed in the Turbine Building is higher than the average temperature in the equipment room

- Assume no heat transfer between Units 1 + 2 equipment rooms.

$$Q_{out} = (.21 * 2782 + .32 * 1740 + .43 * 552)(T_{AIR} - 95)$$

$$+ (.54 * 2782)(T_{AIR} - 105) + (.48 * 540)(T_{AIR} - 120)$$

$$Q_{out} = 1378(T_{AIR} - 95) + 1502(T_{AIR} - 105) + 259(T_{AIR} - 120)$$

$$Q_{out} = 3139\,T_{AIR} - 317700, \text{ Btu/hr}$$

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Unit 1 Elect. Equip. Room, cont

$$T_{AIR,ss} = \frac{\dot{Q}_{gen} + \Sigma UAT_{surr}}{\Sigma UA}$$

$$= \frac{90420 + 319900}{3139}$$

$$T_{AIR,ss} = 131°F$$

Volume of Unit 1 Elect. Equip. Room

$$V = 2782\ ft^2\ (12\ ft)\ (0.80) = 26707\ ft^3$$

Unit 1 Equipment Room

Tair,avg(assumed) = 100.02F

Time =	4hr
Tair,ss =	131F
Tair,ss-Tair,i =	45F

Section	L	h	$\frac{h^2 \alpha t}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	0.08	1.47	0.311	0.12	290	91	9.02	73242	0.9	0.45	32959
2	0.5	1.47	0.311	0.74	552	91	9.02	139413	0.3	0.15	20912
3	0.08	1.47	0.311	0.12	90	103	-2.98	-7510	0.9	0.45	-3379
Floor	1.5	1.09	0.171	1.64	8346	91	9.02	2107866	0	0	0
Ceiling	0.33	1.64	0.387	0.54	1836	80	20.02	1029188	0.42	0.21	216130

Qconc(total) = 266621

Qgen = 261412 Qout = -22949 Qair = 17740

$\boxed{\text{Tair(t) = 111F}}$

C1 = 4.9626 Tair,avg(calc) = 100.1F

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UNIT 3 CONTROL ROOM ($T_{AIR,i}$ = 74°F) TIME INTERVAL = 0-30 MINUTES

$\dot{Q}_{gen}$ = 170,411 BTU/hr (for first 30 minutes into event)

$\therefore Q_{gen}$ = (170,411 BTU/hr)(0.5 hrs)

Q_{gen} = 85,206 BTU

$Q_{OUT} = \Sigma UA\Delta T = T_{AIR}\Sigma UA - \Sigma UAT_{surr}$

SECTION*	THICKNESS	RESISTANCE: AIR	WALL	AIR	GYPSUM	CARPET	ACOUST. TILE	AIR	U (BTU/hr-ft²-°F)	A (ft²)	T_{surr} (°F)
1a	42"	.68	3.36	.68	.56	–	–	.68	0.168	536	95
1b	42"	.68	3.36	.68	–	–	–	–	0.212	491.1	95
2a**	8"	.68	1.72	.68	.56	–	–	.68	0.231	608	95
2b**	8"	.68	1.72	.68	–	–	–	–	0.325	557.1	95
3a	42"	.68	3.36	.68	.56	–	–	.68	0.168	80	95
3b	42"	.68	3.36	.68	–	–	–	–	0.212	73.3	95
4a	42"	.68	3.36	.68	.56	–	–	.68	0.168	536	120
4b	42"	.68	3.36	.68	–	–	–	–	0.212	491.1	120
5a	42"	.68	3.36	.68	.56	–	–	.68	0.168	80	95
5b	42"	.68	3.36	.68	–	–	–	–	0.212	73.3	95
6a	42"	.68	3.36	.68	.56	–	–	.68	0.168	164	95
6b	42"	.68	3.36	.68	–	–	–	–	0.212	150.3	95
7a	12"	.68	.96	.68	.56	–	–	.68	0.281	373	110
7b	12"	.68	.96	.68	–	–	–	–	0.431	341.8	110
FLOOR	12"	.92	.96	–	–	1.23	–	.92	0.248	5896	105
CEILING	8"	.61	.64	.61	–	–	2.50	.61	0.201	5896	95

* "a" refers to wall section from floor to drop-in ceiling } Reference Attachment 5 for
"b" refers to wall section from drop-in ceiling to roof. } diagram of wall sections

** 8" fire rated concrete block (hollow)

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$$\dot{Q}_{OUT} = (0.168)(536)(T_{AIR}-95) + (0.212)(491.1)(T_{AIR}-95) + (0.231)(608)(T_{AIR}-95)$$
$$+ (0.325)(557.1)(T_{AIR}-95) + (0.168)(80)(T_{AIR}-95) + (0.212)(73.3)(T_{AIR}-95)$$
$$+ (0.168)(536)(T_{AIR}-120) + (0.212)(491.1)(T_{AIR}-120) + (0.168)(80)(T_{AIR}-95)$$
$$+ (0.212)(73.3)(T_{AIR}-95) + (0.168)(164)(T_{AIR}-95) + (0.212)(150.3)(T_{AIR}-95)$$
$$+ (0.281)(373)(T_{AIR}-110) + (0.431)(341.8)(T_{AIR}-110) + (0.248)(5896)(T_{AIR}-105)$$
$$+ (0.201)(5896)(T_{AIR}-95)$$

$$\dot{Q}_{OUT} = 3726\, T_{AIR} - 377220 \text{ BTU/hr}$$

$$T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA \Delta T_{surr}}{\Sigma UA}$$

$$T_{AIR,SS} = \frac{170{,}411 + 377{,}220}{3726}$$

$$T_{AIR,SS} = \underline{\underline{147\,°F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.
- Control Room Volume = total room volume x .80 ; reference 8.12
  = 51605 ft^3

Unit 3 Control Room (30 minutes)

Tair,avg(assumed) = 94.62F

Time =	0.50hr
Tair,ss =	154F
Tair,ss-Tair,i =	80F

Section	L	h	$\frac{h^2 \Delta T}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.039	2.57	3595	85	9.62	968349	0.01	0.005	4842
2	0.083	1.47	0.039	0.12	193	85	9.62	51986	0.28	0.14	7278
3	1.75	1.47	0.039	2.57	536	85	9.62	144377	0.01	0.005	722
4	1.75	1.47	0.039	2.57	3595	97	-2.38	-239571	0.01	0.005	-1198
5	1.75	1.47	0.039	2.57	536	85	9.62	144377	0.01	0.005	722
6	1.75	1.47	0.039	2.57	1099	85	9.62	296027	0.01	0.005	1480
7	0.5	1.47	0.039	0.74	715	92	2.62	52452	0.05	0.025	1311
floor	0.5	0.465	0.004	0.23	5896	90	4.62	762707	0	0	0
ceiling	0.33	1.64	0.048	0.54	3927	85	9.62	1057777	0.09	0.045	47600

Qconc(total) = 62757

Qgen = 85206 Qout = -12333 Qair = 34782

$\boxed{\text{Tair(t) = 111F}}$

C1 = 0.79212

Tair,avg(calc) = 94.7F

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UNIT 3 CONTROL ROOM ($T_{AIR_i} = 74°F$) TIME INTERVAL = 0-45 MINUTES

$\dot{Q}_{gen} = 170{,}411$ BTU/hr (for first 30 minutes into event)
$\dot{Q}_{gen} = 62{,}655$ BTU/hr (for 30 minutes – 4 hours)

$\therefore Q_{gen} = (170{,}411 \text{ BTU/hr})(0.5 \text{ hours}) + (62{,}655 \text{ BTU/hr})(0.25 \text{ hours})$
$Q_{gen} = 100{,}870$ BTU

& $\dot{Q}_{OUT} = 3726\, T_{AIR} - 377220$ BTU/hr (as before)

$$\therefore T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA\Delta T_{surr}}{\Sigma UA}$$

$$T_{AIR,SS} = \frac{\{170{,}411\left(\frac{2}{3}\right) + 62{,}655\left(\frac{1}{3}\right)\} + 377220}{3726}$$

$$T_{AIR,SS} = \underline{\underline{137\ °F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.
- Control Room Volume = total room volume x .80 ; reference 8.12
  = 51,605 ft^3

Unit 3 Control Room (45 minutes)

Tair,avg(assumed) = 94.72F

Time = 0.75hr
Tair,ss = 146F
Tair,ss-Tair,i = 72F

Section	L	h	$\frac{h^2 \alpha t}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.058	2.57	3595	85	9.72	978415	0.01	0.005	4892
2	0.083	1.47	0.058	0.12	193	85	9.72	52527	0.45	0.225	11819
3	1.75	1.47	0.058	2.57	536	85	9.72	145878	0.01	0.005	729
4	1.75	1.47	0.058	2.57	3595	97	-2.28	-229505	0.01	0.005	-1148
5	1.75	1.47	0.058	2.57	536	85	9.72	145878	0.01	0.005	729
6	1.75	1.47	0.058	2.57	1099	85	9.72	299104	0.01	0.005	1496
7	0.5	1.47	0.058	0.74	715	92	2.72	54454	0.08	0.04	2178
floor	0.5	0.465	0.006	0.23	5896	90	4.72	779215	0	0	0
ceiling	0.33	1.64	0.073	0.54	3927	85	9.72	1068772	0.12	0.06	64126

Qconc(total) = 84822

Qgen = 100870 Qout = -18220 Qair = 34268

$\boxed{\text{Tair(t) = 111F}}$

C1 = 1.05678 Tair,avg(calc) = 94.7F

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UNIT 3 CONTROL ROOM ($T_{AIR,i} = 74°F$) TIME INTERVAL = 0-60 MINUTES

$\dot{Q}_{gen} = 170,411$ BTU/hr (for first 30 minutes into event)
$\dot{Q}_{gen} = 62,655$ BTU/hr (for 30 minutes - 4 hours)

$\therefore$ $Q_{gen} = (170,411 \text{ BTU/hr})(0.5 \text{ hours}) + (62,655 \text{ BTU/hr})(0.5 \text{ hours})$
$Q_{gen} = 116,533$ BTU

& $\dot{Q}_{OUT} = 3726\, T_{AIR} - 377220$ BTU/hr (as before)

$\therefore$

$$T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA \Delta T_{surr}}{\Sigma UA}$$

$$T_{AIR,SS} = \frac{\{170,411(\tfrac{1}{2}) + 62,655(\tfrac{1}{2})\} + 377220}{3726}$$

$$T_{AIR,SS} = \underline{\underline{133\ °F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.
- Control Room Volume = total room volume X .80 ; reference 8.12
  = 51,605 ft³

Unit 3 Control Room (1 hour)

Tair,avg(assumed) = 94.35F

Time = 1hr
Tair,ss = 142F
Tair,ss-Tair,i = 68F

Section	L	h	$\frac{h^2 \alpha T}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.078	2.57	3595	85	9.35	941171	0.01	0.005	4706
2	0.083	1.47	0.078	0.12	193	85	9.35	50527	0.5	0.25	12632
3	1.75	1.47	0.078	2.57	536	85	9.35	140325	0.01	0.005	702
4	1.75	1.47	0.078	2.57	3595	97	-2.65	-266749	0.01	0.005	-1334
5	1.75	1.47	0.078	2.57	536	85	9.35	140325	0.01	0.005	702
6	1.75	1.47	0.078	2.57	1099	85	9.35	287718	0.01	0.005	1439
7	0.5	1.47	0.078	0.74	715	92	2.35	47047	0.1	0.05	2352
floor	0.5	0.465	0.008	0.23	5896	90	4.35	718133	0	0	0
ceiling	0.33	1.64	0.097	0.54	3927	85	9.35	1028089	0.17	0.085	87388

Qconc(total) = 108586

Qgen = 116534 Qout = -25672 Qair = 33620

$\boxed{\text{Tair(t) = 110F}}$

C1 = 1.3277

Tair,avg(calc) = 94.3F

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UNIT 3 CONTROL ROOM ($T_{AIR,i} = 74°F$) TIME INTERVAL = 0-240 MINUTES

$\dot{Q}_{gen} = 170,411$ BTU/hr (for first 30 minutes into event)
$\dot{Q}_{gen} = 62,655$ BTU/hr (for 30 minutes - 4 hours)

$\therefore$

$Q_{gen} = (170,411 \text{ BTU/hr})(0.5 \text{ hours}) + (62,655 \text{ BTU/hr})(3.5 \text{ hours})$
$Q_{gen} = 304,499$ BTU

&

$\dot{Q}_{OUT} = 3726\, T_{AIR} - 377220$ BTU/hr (as before)

$\therefore$

$$T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA \Delta T_{surr}}{\Sigma UA}$$

$$T_{AIR,SS} = \frac{\{170,411(.125) + 62,655(.875)\} + 377220}{3726}$$

$$T_{AIR,SS} = \underline{\underline{122\ °F}}$$

Energy absorbed by concrete:

- Refer to the spread sheet that follows for calculation of $T_{AIR}(t)$ factoring in the heat absorption ability of concrete.

- Control Room Volume = total room volume × .80 ; reference 8.12
 = 51,605 ft^3

Unit 3 Control Room (4 hours)

Tair,avg(assumed) = 95.46F

Time = 4hr
Tair,ss = 134F
Tair,ss-Tair,i = 60F

Section	L	h	$\frac{h^2\alpha\tau}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.311	2.57	3595	85	10.46	1052904	0.08	0.04	42116
2	0.083	1.47	0.311	0.12	193	85	10.46	56526	0.9	0.45	25437
3	1.75	1.47	0.311	2.57	536	85	10.46	156984	0.08	0.04	6279
4	1.75	1.47	0.311	2.57	3595	97	-1.54	-155016	0.08	0.04	-6201
5	1.75	1.47	0.311	2.57	536	85	10.46	156984	0.08	0.04	6279
6	1.75	1.47	0.311	2.57	1099	85	10.46	321875	0.08	0.04	12875
7	0.5	1.47	0.311	0.74	715	92	3.46	69269	0.3	0.15	10390
floor	0.5	0.465	0.031	0.23	5896	90	5.46	901380	0	0	0
ceiling	0.33	1.64	0.387	0.54	3927	85	10.46	1150140	0.45	0.225	258781

Qconc(total) = 355958

Qgen = 304499 Qout = -86144 Qair = 34685

$\boxed{\text{Tair(t) = 111F}}$

C1 = 4.08462 Tair,avg(calc) = 95.7F

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DUKE POWER COMPANY

Form 00184 (R4-88)

Station ______ Unit ______ Rev. ______ File No. ______ Sheet 34 Of 43

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By JDH Date 6-16-92

Prob No. OSC-4747 Checked By ______ Date ______

Unit 3 Cable Room ($T_{AIR,i} = 74\ °F$)

$\dot{Q}_{gen} = 107,541$ Btu/hr $\quad Q_{gen} = 107,541 (4\,hr) = 430164$ Btu

$\dot{Q}_{out} = T_{AIR} \sum UA - \sum UA T_{surr}$

Section	Thickness	Resistance Air	Resistance Wall	Resistance Air	U (Btu/hr ft² °F)	A (ft²)	T_{surr} (°F)
① Aux Wall	42"	.68	3.36	.68	.21	552	95
② Aux Wall	12"	.68	.96	.68	.43	928	95
③ Aux Wall (Block)	8"	.68	1.72	.68	.32	1128	95
④ Turb Wall (Block)	8"	.68	1.72	.68	.32	940	120
⑤ Pen Wall	12"	.68	.96	.68	.43	587	110
Floor	8"	.92	.64	.92	.40	4958	100
Ceiling	12"	.61	.96	.61	.46	4958	110

$$\dot{Q}_{out} = (.40 * 4958)(T_{AIR} - 100) + (.46 * 4958 + .43 * 587)(T_{AIR} - 110)$$

$$+ (.21 * 552 + .43 * 928 + .32 * 1128)(T_{AIR} - 95)$$

$$+ (.32 * 940)(T_{AIR} - 120)$$

$$\dot{Q}_{out} = 1983 (T_{AIR} - 100) + 2533 (T_{AIR} - 110) + 876 (T_{AIR} - 95)$$

$$+ 301 (T_{AIR} - 120)$$

$$\dot{Q}_{out} = 5693\, T_{AIR} - 596270, \quad \text{Btu/hr}$$

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Station ______ Unit ______ Rev. ______ File No. ______ Sheet 35 Of 43

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Unit 3 Cable Room cont.

$$T_{AIR,ss} = \frac{\dot{Q}_{gen} + \Sigma UAT_{surr}}{\Sigma UA}$$

$$= \frac{192614 + 576270}{5693}$$

$$\underline{\underline{T_{AIR,ss} = 139°F}}$$

Volume of Unit 3 Cable Room

$$V = 4958\ ft^3 (11.75\ ft)(0.80) = 46605\ ft^3$$

Unit 3 Cable Room

Tair,avg(assumed) = 96.2F

Time = 4hr
Tair,ss = 139F
Tair,ss-Tair,i = 65F

Section	L	h	$\frac{h^2 \alpha \tau}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	1.75	1.47	0.311	2.57	1932	85	11.2	605875	0.1	0.05	30294
2	0.5	1.47	0.311	0.74	928	85	11.2	291021	0.3	0.15	43653
3	0.08	1.47	0.311	0.12	188	85	11.2	58957	0.9	0.45	26531
4	0.08	1.47	0.311	0.12	157	97	-0.8	-3517	0.9	0.45	-1583
5	0.5	1.47	0.311	0.12	587	92	4.2	69031	0.9	0.45	31064
Floor	0.33	1.09	0.171	0.36	3272	80	16.2	1484179	0	0	0
Ceiling	0.5	1.64	0.387	0.82	4958	74	22.2	3081893	0.3	0.15	462284

Qconc(total) = 592243

Qgen = 430164 Qout = -194414 Qair = 32335

$\boxed{\text{Tair(t)} = 113\text{F}}$

C1 = 4.44973 Tair,avg(calc) = 96.1F

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Unit 3 Electrical Equipment Room ($T_{AIR,i}$ = 86 °F)

$\dot{Q}_{gen}$ = 74,900 Btu/hr Q_{gen} = 74,900 (4 hr) = 299600 Btu

$\dot{Q}_{OUT} = T_{AIR} \Sigma UA - \Sigma UA T_{surr}$

Section	Thickness	Resistance Air	Wall	Air	U (Btu / hr ft² °F)	A (ft²)	T_{surr} (°F)
① Aux Wall (Block)	8"	.68	1.72	.68	.32	120	95
② Aux Wall	12"	.68	.96	.68	.43	1272	95
③ Turb Wall (Block)	4" *	.68	.71*	.68	.48	576	120
Floor	36"	.92	2.88	.92	.21	3215	95
Ceiling	8"	.61	.64	.61	.54	3215	105

* See note under Unit 1 Elect Equip Room calc

$\dot{Q}_{OUT} = (.21 * 3215 + .32 * 120 + .43 * 1272)(T_{AIR} - 95)$

$+ (.54 * 3215)(T_{AIR} - 105) + (.48 * 576)(T_{AIR} - 120)$

$\dot{Q}_{OUT} = 1260 (T_{AIR} - 95) + 1736 (T_{AIR} - 105) + 276 (T_{AIR} - 120)$

$\dot{Q}_{OUT} = 3772\ T_{AIR} - 335100$, Btu/hr

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DUKE POWER COMPANY

Station ________ Unit ____ Rev. ____ File No. ________ Sheet 38 Of 43

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Unit 3 Elect. Equip Room cont.

$$T_{AIR,SS} = \frac{\dot{Q}_{gen} + \Sigma UA T_{surr}}{\Sigma UA}$$

$$= \frac{85575 + 335100}{3272}$$

$$T_{AIR,SS} = 129\,°F$$

Volume of Unit 3 Elect. Equip Room

$$V = 3215\ ft^2\ (12\ ft)(0.80) = 30864\ ft^3$$

Unit 3 Equipment Room

Tair,avg(assumed) = 100.44F

Time = 4hr
Tair,ss = 129F
Tair,ss-Tair,i = 43F

Section	L	h	$\frac{h^2 \alpha t}{k^2}$	$\frac{hL}{k}$	Volume	Twall,i	Twall,i - Tair,avg	Qo	Q/Qo	Q/Qo/2	Qconc
1	0.08	1.47	0.311	0.12	20	91	9.44	5286	0.9	0.45	2379
2	0.5	1.47	0.311	0.74	1272	91	9.44	336215	0.3	0.15	50432
3	0.08	1.47	0.311	0.12	96	103	-2.56	-6881	0.9	0.45	-3097
Floor	1.5	1.09	0.171	1.64	9645	91	9.44	2549366	0	0	0
Ceiling	0.33	1.64	0.387	0.54	2121	80	20.44	1213891	0.42	0.21	254917

Qconc(total) = 304632

Qgen = 299600 Qout = -25841 Qair = 20810

$\boxed{\text{Tair(t) = 111F}}$

C1 = 4.4614 Tair,avg(calc) = 100.6F

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DUKE POWER COMPANY

Station ______ Unit ______ Rev. ______ File No. ______ Sheet 40 Of 43

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By JDA Date 6-16-92

Prob No. OSC-4747 Checked By ______ Date ______

Control Battery Rooms ($T_{AIR,i} = 74°F$)

$Q_{gen} = 0$

$Q_{OUT} = T_{AIR} \Sigma UA - \Sigma UA T_{surr}$

Section	Thickness	Resistance Air	Resistance Wall	Resistance Air	U ($\frac{Btu}{hr\ ft^2\ °F}$)	A (ft^2)	T_{surr} (°F)
Exterior Wall	8"	.68	.64	.25	.65	168	95
Aux Wall	8"	.68	.64	.68	.50	156	95
Pen Wall (Block)	8"	.68	1.72	.68	.32	720	110
Turb Wall (Block)	8"	.68	1.72	.68	.32	480	95
Aux Wall (Block)	8"	.68	1.72	.68	.32	372	95
Floor	8"	.92	.64	.92	.40	1066	95
Ceiling	8"	.61	.64	.61	.54	1066	95

$$Q_{OUT} = (.65*168 + .50*156 + .32*480 + .32*372 + .40*1066 + .54*1066)(T_{AIR} - 95)$$

$$+ (.32*720)(T_{AIR} - 110)$$

$$Q_{OUT} = 1462(T_{AIR} - 95) + 230(T_{AIR} - 110)$$

$$Q_{OUT} = 1692(T_{AIR}) - 164190$$

$$T_{AIR,ss} = \frac{Q_{gen} + \Sigma UA T_{sur}}{\Sigma UA}$$

$$T_{AIR,ss} = \frac{0 + 164190}{1692}$$

Station ______ **Unit** ______ **Rev.** ______ **File No.** ______ **Sheet** 41 **Of** 43
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Control Battery Rooms cont.

$T_{AIR,SS} = 97°F < 107°F$

Hydrogen concentration

Hydrogen generation = 1.198 ft³/hr (4 hrs) Attach. 3

= 4.8 ft³

Avg. Room concentration : $\frac{4.8}{1066\ ft^2\ (12\ ft)} = 0.04\%$

Since H_2 is less dense than air, assume H_2 is concentrated in top 6 inches of room.

$\%\ Conc = \frac{4.8}{1066\ (.5)} = 0.9\%$

Explosive Limit for H_2 is 4% concentration

0.9% is o.k.

10.0 CONCLUSIONS

The room temperatures determined by the method in section 3.0 of this calculation are shown in the table below. These are the expected temperatures four hours after the beginning of a station blackout unless otherwise indicated.

Room	T (°F)
Unit 1&2 Control Rooms	115[1]
Unit 1 Cable Room	129
Unit 1 Elect. Equip. Room	111
Unit 3 Control Room	111
Unit 3 Cable Room	113
Unit 3 Elect. Equip. Room	111
Control Battery Rooms	97[2]

Notes:

[1]Unit 1&2 Control Room temperature is maximum at 45 minutes after the blackout begins.

[2]This is the final steady state room temperature for the Control Battery Room. The temperature four hours after the start of a station blackout will be less than this.

The Unit 2 Cable and Electrical Equipment Rooms had less internal heat generation than the Unit 1 Rooms. Because of this the temperatures in the Unit 2 rooms are expected to be less than the temperatures determined for the Unit rooms. All three of the Control Battery Rooms are similar in construction and none have any internal heat generation. Therefore, all three rooms can expect similar temperature rises.

NUMARC 87-00 (Reference 8.3) provides an alternative method for calculating the steady state room temperature following a station blackout. This method was not utilized since it could not account for load stripping at an intermediate time step prior to steady state conditions being met. It can also be seen from this calculation that steady state conditions have yet to be met at the end of the 4 hour blackout period. This method is used however below as a quick check to determine if the steady state conditions would still fall below this maximum allowable temperatures in each of the room. It used the following correlation to calculate this final temperature.

$$T_f = (Q/A)^{3/4} + T_i$$

where:

T_i = initial wall temperature (°C) (use initial room temp)
Q = internal heat generation (Watts)
A = surface area of walls and ceiling (m^2)
T_f = final steady state room temperature (°C)

As a check the following table shows the room temperatures to be expected using this method.

Room	T_i(°C)	Q (watts)	A (m^2)	T_f(°C)	T_f(°F)
Unit 1&2 Control	23	34,197[1]	1239	35	95
Unit 1 Cable	23	41,116	469	52	126
Unit 1 Equipment	30	19,165	522	45	113
Unit 3 Control	23	22,324[1]	971	34	93
Unit 3 Cable	23	31,537	845	38	100
Unit 3 Equipment	30	21,965	482	48	118
Control Battery	23	0	-	23	74

Note:

1The internal heat generation used for the Control Rooms is the average rate over the 4 hour period taking into account load stripping. The actual final room temperatures can be expected to be higher since the actual load is concentrated over the first 30 minutes.

The above table shows that the method used in Section 3.0 of this calculation is sometimes more conservative than the NUMARC method and in other cases it is not. In either case the predicted temperatures are always lower than the maximum allowable temperatures indicated in attachment 1 of this calculation.

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June 11, 1992

B. J. Dolan, Manager
Mechanical/Nuclear Engineering

Attention: D. K. Harrelson
J. D. Heminger

Subject: Oconee Nuclear Station
Electrical Equipment Heat Loads For Station Blackout Response
File OS-243-A

Per your request, Oconee Electrical Design has completed summaries of the electrical equipment heat loads in the control rooms, cable rooms, and equipment rooms at Oconee. Please note that the worst case of the conservative, priliminary estimates used in the SBO heat calculations enveloped the computed heat loads. Therefore, the heat calculations using the estimated electrical equipment heat loads offers an extra measure of conservatism and confidence.

The data shown on the attachment were derived from the "OSC-2790: Oconee A & B Chiller HVAC Calculations" revision 10 and the J. C. Mumford memo to M. M. Self, dated July 13, 1989. The results are shown in two columns. The first column reflects the heat loads at time zero of the SBO event; the second column reflects the loads manually stripped from the non-essential KI, KX, & KU panelboards at 30 minutes into the event.

The NUREG 87-00 established the criterion for temperatures in the Control Rooms not exceed 120 degrees F. The temperature limits for the Equipment Rooms are noted in OSSD-0129.01-03 to be 137 degrees F. According to the manufacturer's data, the Control Battery Room should be maintained below the maximum operating temperature of 107 degrees F during charging which will prevent electrolyte boiling. However, during discharging, the performance of the batteries actually improves with temperature increases of unspecified limits. Since no specific temperature data exists for battery discharging conditions, the temperature limit of 107 degrees F will be assumed for the SBO event.

If you have any questions or comments, please call Jay Bryan at 373-3329.

J. H. Bryan
Design Engineer
Oconee Electrical Design Engineering

Attachment

cc: D. M. Jamil
S. L. Nader
M. E. Patrick ONS/Reg. Compliance
Central Records

DUKE POWER COMPANY

Form 00184 (R4-88)

Station OCONEE Unit 1&2 Rev.____ File No.____ Sheet 1 Of 10

Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR STATION BLACKOUT By JAY BRYAN Date 6-10-92

Attachment #1
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Unit 1 & 2 CONTROL ROOM

		WATTS	After 30 min	
COMPUTER	1C1	4950	0	
	1D1	~~3429~~ + 500	0	* ref JCM 7-13-89
	1D2	3015	0	
	2C1	4950	0	
	2D1	~~3429~~ + 500	0	* ref JCM 7-13-89
	2D2	3015	0	
Unit Board	Un.1	180	180	
	Un.2	180	180	
Vert. Bd	Un.1	915	915	
	Un.2	915	915	
Aux Bnch Bd	Un.1	~~100~~ 97	~~100~~ 97	
	Un.2	~~100~~ 97	~~100~~ 97	
Un & Aux Bd	Un.1	1654	1654	
	Un.2	1654	1654	
Elect. Cntl Bd	Un.1	750 + 450	750 + 450	
	Un.2	750 + 450	750 + 450	
NI/RPS	Un.1	4800 + 180	4800 + 180	
	Un.2	4800 + 180	4800 + 180	
ICS	Un.1	5400 + 420	0	
	Un.2	5400 + 420	0	
ES Cab.	Un.1	1010	1010	
	Un.2	1010	1010	
RZ	Un.1 & 2	700	700	
Aux Cab.	Un.1	2600	2600	
	Un.2	2600	2600	
Fire Detect.		1000	0	

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DUKE POWER COMPANY

Station ______ Unit ______ Rev. ______ File No. ______ Sheet 2 Of 10

Subject ______

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UNIT 1 & 2 Control Room (cont.)

		WATTS	After 30 min.
Data-Net	Un. 1	700 + 850	0
	Un. 2	700 + 850	0
ICCM Cab.	Un. 1	500	500
	Un. 2	500	500
Electr.	Un. 1	200	200
	Un. 2	200	200
Transient Mon.	Un. 1	1000	1000
	Un. 2	1000	1000
Computer 45000 Equip			
	CPU	1500	0
	Aux	1500	0
	LCS	776	0
	CRT's	234	0
	Matrix Printer	213	0
	Eng/OP Panel	44	0
	I/O Cab.	776	0
	MH Disk	1406	0
	Video Copier	542	0
Computer 4020 Equip			
	CPU	1460	0
	Aux	776	0
	Pcf. Video	315	0
	Perf. Panel	88	0
	Perf. Printer	213	0
	Line printer	496	0
	Recorder	117	0
	Floppy Disk	286	0

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UNIT 1&2 CONTROL ROOM (cont.)

	Watts	After 30 min
PERF. STATIONS #1	362	0
#2	362	0
Table #1	486	0
Table #2	486	0
South Entrance Vert. Bd.	762	762

TOTAL UNIT 1&2 Equipment Heat Load

At onset of SBO: ~~82,100~~ 75,242 W

After load stripping
at t = 30 minutes : 28,334 W

Form 00184 (R4-88)

DUKE POWER COMPANY

Station Oconee Unit ______ Rev. ______ File No. ______ Sheet 4 Of 10

Subject Electrical Equipment Heat Loads For Station Blackout

By JAY BRYAN Date 6-11-92

Attachment #1
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UNIT 1 CABLE ROOM

		Watts		After 30 min
LIGHTS (assumes 50% reduction)		11,500		11,500
Computer Cab. 1E1, 2E1, 1G1, 2G1, 1G4, 2G4, 1I1, 2I1, 1I9, 2I9		20,286		0
Turb. Super. Panel		500		0
Events Recorder		300		300
EHC Cab.		1500		1500
Transducer Cab.		600		600
ESGLC		500		500
Switch Logic		400		400
Plant TV		930		0
Statalarm Cab.		500		300
Load Freq.		600		600
Cables	2500	~~5000~~	$\xrightarrow{70\%}$	1750
ES Term. Cab.		400		400
		~~43,516~~		~~17,600~~
		41,116		~~16,850~~
				17,850

Station Oconee Unit 1 Rev. File No. Sheet 5 Of 10
Subject Electrical Equipment Heat Loads For Station Blackout
By Jay Bryan Date 6-11-92
Proj. No. Checked By

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UNIT 1 EQUIPMENT ROOM

	Watts		After 30 min.
9.3 KVA Static Inverters 1DIA, 1DIB, 1DIC, 1DID 1KI, 1KX	5600		3733
Iso. Diodes	1300		743
DC Distr. Cntr 1DCA & 1DCB	565		565
25 KVA Inverter 1KU	3000		0
Cables	2500	70%	1750
Lighting (assumes 50% reduction)	~~9000~~ 6200		~~9000~~ 6200
	~~21,465~~ 19,165		~~15,791~~ 12,991

Station OCONEE Unit______ Rev.______ File No.______ Sheet 6 Of 10
Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR S.B.O.
By JH Bryan 6-11-92

Attachment #1
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UNIT 2 CABLE ROOM

	Watts	After 30 min.
Lights (assumes 50% reduction)	10.900	10,900
Turb. Super. Cab.	500	0
Events Recorder	300	300
EHC Cab.	1500	1500
Transducer Cab.	600	600
ESGLC	500	500
Switch Logic	400	400
Statalarm Cab.	500	300
Load Freq.	~~600~~ 0	0
Cables (assumes 50% reduction)	2500 $\xrightarrow{70\%}$	1750
	17.700	16,250
ES Term. Cab.	400	400
	18,100	16.650

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DUKE POWER COMPANY

Station OCONEE Unit ____ Rev. ____ File No. ____ Sheet 7 Of 10

Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR S.B.O.

By JH Bryan Date 6-11-92

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UNIT 2 EQUIPMENT ROOM

	Watts	After 30 min.
Lighting (assumes 50% reduction)	6200	6200
9.3 KVA Inverters 2DIA, 2DIB, 2DIC, 2DID, 2KI, 2KX	5600	3733
Iso. Diodes	1300	743
DC Distr. Cntr. 2DCA & 2DCB	565	565
25 KVA Inverter 2KU	3000	0
Cables (assumes 50% reduction)	2500 $\xrightarrow{70\%}$	1750
	19,165 W	12,991 W

DUKE POWER COMPANY

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Station OCONEE Unit ______ Rev. ______ File No. ______ Sheet 8 Of 10

Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR STATION BLACKOUT

By JAY BRYAN Date 6-11-92

Prob No. ______ Checked By ______ Date ______

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UNIT 3 CONTROL ROOM

		WATTS	After 30 min
	COMPUTER	13,850	0
Assumes 30% reduction	Unit Control Bd.	717 + 450	1167
	Aux Bench Bd.	360	360
	Aux Bench Bd Typers	105	105
	Vertical Bd	1500	1500
	NI/RPS	4800 + 180	0
	ICS	5400 + 420	5820
	Future Cab.	3000	3000
	ES Cab.	1010	1010
	RZ	350	350
	Aux Cab.	2600	2600
	Data-Net	700 + 850	0
	ICCM Cab.	500	500
	Elect.	200	200
	Transient Monitor	1000	1000
	45000 Computer Equip.	6991	0
	4020 Computer Equip.	4229	0
	South Entrance Vert. Bd.	762	762
		49,974 W	18,374 W

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Station OCONEE Unit _____ Rev. _____ File No. _____ Sheet 9 Of 10

Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR S.B.O.

JH BRYAN 6-11-92

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UNIT 3 CABLE ROOM

	Watts		After 30 min
Lights (assumes 50% reduction)	15,275		15,275
EHC Cab.	500		500
Events Recorder	1800		1800
ESGLC	500		500
Switch Logic	400		400
ES Term. Cab.	400		400
Plant TV	930		0
Statalarm	500		300
Load Freq.	600		600
Turb. Super. Cab.	360		0
Computer Cab.	7000		0
Cables (assumes 50% reduction)	2500	$\xrightarrow{70\%}$	1750
Misc. Cabinets (ref. JCM letter)	772		772
	31,537 W		21,797 W

Station OCONEE Unit ____ Rev. ____ File No. ____ Sheet 10 Of 10
Subject ELECTRICAL EQUIPMENT HEAT LOADS FOR S.B.O.
By JH Bryan Date 6-11-92

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UNIT 3 EQUIPMENT ROOM

	Watts	After 30 min.
Lights (assumes 50% reduction)	9000	9000
9.3 KVA Inverters 3DIA, 3DIB, 3DIC, 3DID, 3KI, 3KX	5600	3733
Iso. Diodes	1300	743
DC Distr. Cntr 3DCA & 3DCB	565	565
25 KVA Inverter 3KU	3000	0
Cables (assumes 50% reduction)	2500 $\xrightarrow{70\%}$	1750
	21,965 W	15,791 W

Form 00184 (R4-88)

DUKE POWER COMPANY

Station ______ Unit ______ Rev. ______ File No. ______ Sheet ______ Of ______

Subject ______

______ By ______ Date ______

Prob No. ______ Checked By ______ Date ______

Attachment 2

OSC-4747

1/4 6-16-92

Assumed Temperatures

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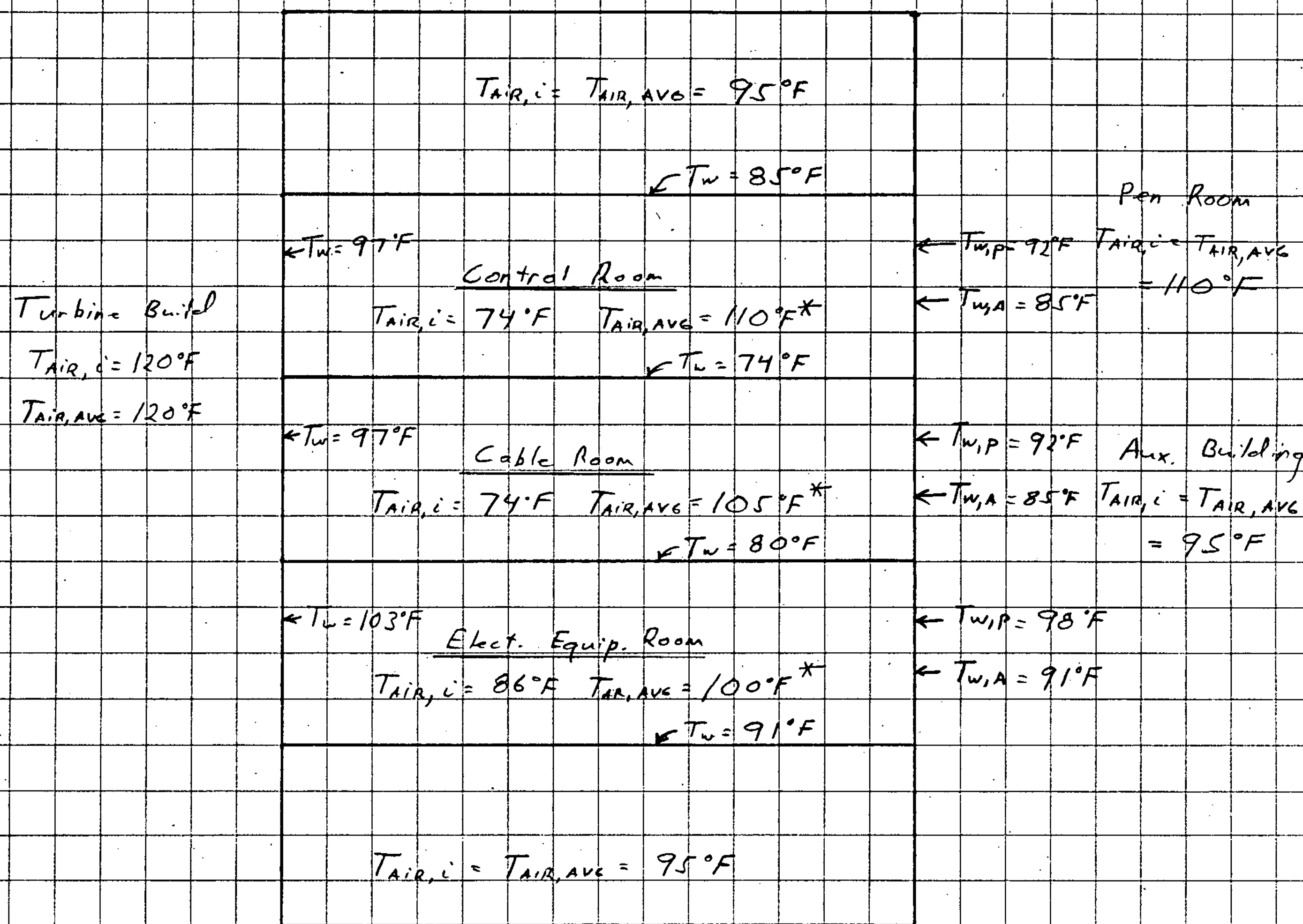


T_w = Initial Assumed Wall/Ceiling Temp

$T_{w,P}$ = " " " " " Adjacent to Pen Room

$T_{w,A}$ = " " " " " Adjacent to Aux Build

* $T_{AIR,AVG}$ temperatures assumed for the Control, Cable + Elect. Equipment Rooms are used to calculate conduction heat transfer to adjacent areas. These numbers are only estimates and may differ from the final $T_{AIR,AVG}$ assumed + later calculated in steps 4-8 of this calculation method.

L.S. Anderwood
5-14-92

Hydrogen generation with batteries at full charge

Assume T = 100°F

$$C = \frac{FC}{1000} \times \frac{AH}{100} \times K \times N$$

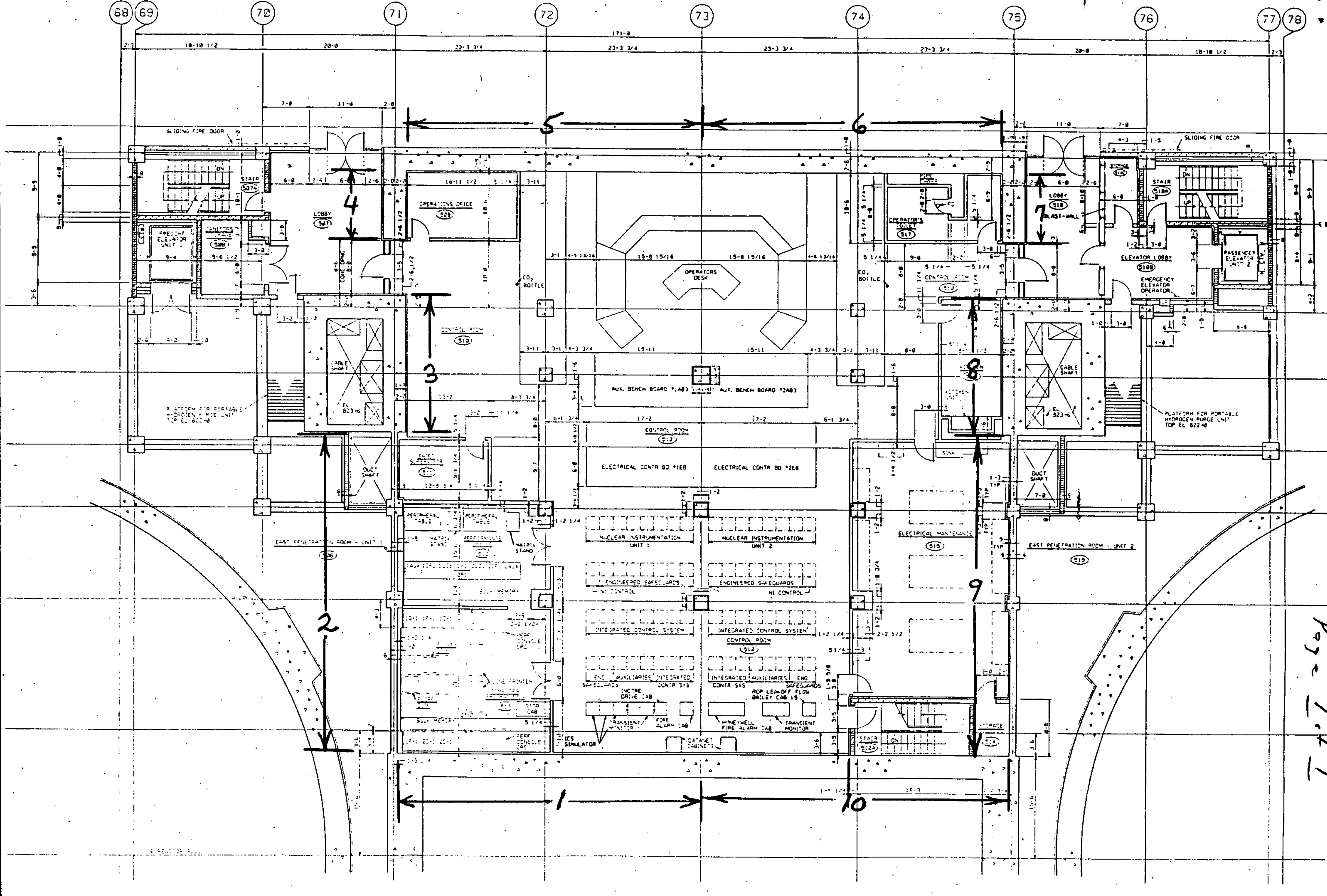
C = ft^3 of hydrogen per hour
FC = float current per 100 A-H in ma
A·H = amp hours @ 8-hr rate
K = 0.016 ft^3
N = number of cells

FC = 11 ma per 100 AH @ 8 hr rate $\times 2^{\left(\frac{100° - 77°}{15°}\right)}$
= 33.7 ma per 100 A·H

AH = 1850 amp-hours @ 8 hr rate   N = 120 cells per room (60 cells/battery)

$$C = \frac{33.7 \text{ ma}}{1000} \times \frac{1850 \text{ A·H}}{100} \times \underline{0.016\ ft^3} \times 120$$

C = 1.198 ft^3 hydrogen per hour per battery room (2 batteries) when batteries are on float (power is available to chargers) generation will be reduced during a blackout when batteries are not being charged.



ATTACHMENT 4

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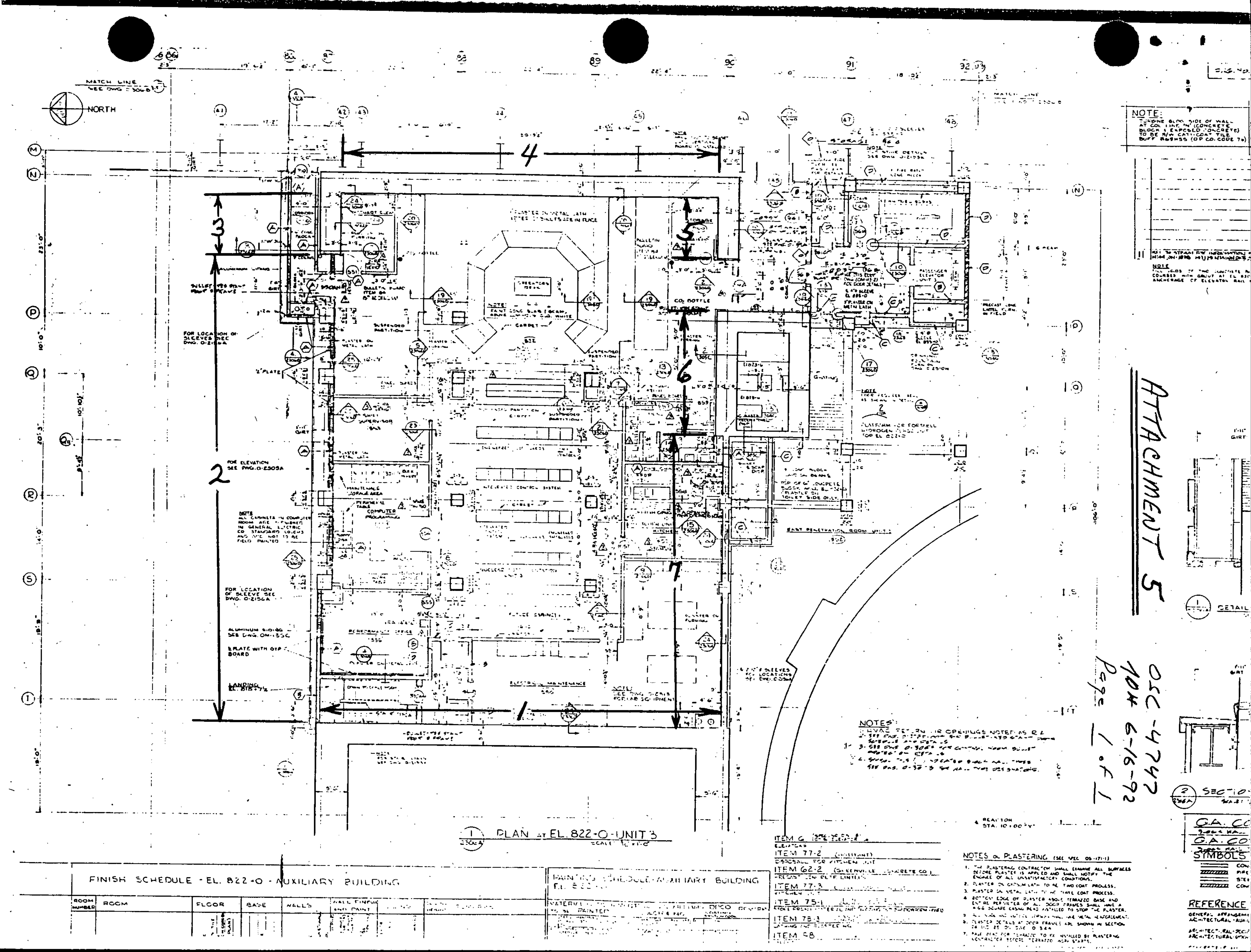
ATTACHMENT 5
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PLAN AT EL. 822-0-UNIT 3
NORTH
MATCH LINE
NOTES
NOTES ON PLASTERING
FINISH SCHEDULE - EL. 822-0 - AUXILIARY BUILDING
PAINTING SCHEDULE-AUXILIARY BUILDING
ELECTRICAL MAINTENANCE
REFERENCE
SYMBOLS

ATTACHMENT V

HISTORICAL SSF UNAVAILABILITY

YEAR	ORIGINAL	REVISED *
1985	2.7%	2.3%
1986	4.3%	3.2%
1987	3.7%	3.2%
1988	3.3%	2.8%
1989	13.0%	11.7%
1989**	N/A	3.6%
1990	3.9%	2.4%
1991	N/A	1.0%
1992	N/A	4.0%

* Difference from the original due to treatment of operable/standby rather than available

** Unwatering not considered for comparison

Historical availability has averaged 96.175%

CORE DAMAGE FREQUENCY - CDF

SSF UNAVAILABILITY & UNRELIABILITY	CHANGE IN CDF
5%	Base Case (4E-06)
8%	Increase < 1E-06
11%	Increase < 1E-06

ATTACHMENT VI

OCONEE NUCLEAR SITE
STANDBY SHUTDOWN FACILITY
DIESEL GENERATOR RELIABILITY PROGRAM

OCONEE NUCLEAR SITE
STANDBY SHUTDOWN FACILITY
DIESEL GENERATOR RELIABILITY PROGRAM

1.0 PURPOSE:

The SSF Diesel Generator program is intended to provide a high availability and reliability in accordance with good operating and maintenance practices. With maintaining an availability greater than 95% and ensuring high reliability, the intention is that the D/G will be "there for use" when needed.

This program will trend the inoperability, unavailability and the trigger values as defined by 10CFR50.63, NSAC-108 and NUMARC 87-00 Rev. 1 document. This information once compiled will be compared to industry standards and ensure we are meeting our equipment operability and regulatory commitments.

The SSF D/G is designed to provide electrical support for the equipment necessary to maintain the Oconee Units in stable hot shutdown conditions following a "Fire/Flood/Sabotage" event as described in 10CFR50, Appendix "R" and as a alternate means of maintaining hot shutdown in the event there is a "Loss of Offsite Power" in combination with the loss of both Keowee Hydro units as reviewed by the station blackout submittal to the NRC for 10CFR50.63.

2.0 DEFINITIONS:

2.1 Operability: Refers to Tech Spec definitions and requirements.

2.2 Availability: Measured by the number of hours the equipment is able to perform its function if called upon.

2.3 Reliability: Measured by the number of successful starts in a given period.

2.4 Load Demand: Counts as one load and one start demand.

2.5 Idle Start: The D/G is started and maintains a speed of 450 rpm within an acceptable range.

2.6 Auto-Idle Start: Demonstrate proper start from standby conditions and verify that the required design voltage and frequency is attained. For these tests, the SSF D/G can be IDLE started and reach rated speed on a prescribed schedule that is selected to minimize stress and wear.

2.7 Loaded Run: Demonstrate $\geq$3100 kW continuous rating of the SSF D/G, for an interval of not less than 1 hour after equilibrium has been attained. This test may be accomplished by synchronizing the generator with Unit-2 Main Feeder Bus. The loading and unloading of the SSF D/G during these test should be gradual and based on a prescribed schedule that is selected to minimize stress and wear.

2.8 Emergency Start Test: Demonstrate that the SSF D/G Emergency starts from the standby condition and verify it reaches required voltage and frequency within acceptable limits and time. The generator should be loaded with the SSF ASWP placed in recirc. and separated from Unit-2 main feeder bus and run for greater than 1 hour.

2.9 Desoup Run: This is a loaded run of the SSF D/G for greater than 30 minutes at greater than 1600kW to ensure all unburned fuel is removed from the exhaust system. The loading and unloading of the SSF D/G during these test should be gradual and based on a prescribed schedule that is selected to minimize stress and wear.

3.0 FORMULAS:

3.1 Reliability = (Start Reliability) x (Load Reliability)

3.2 $\text{Start Reliability} = \dfrac{\text{\# of Successful Starts}}{\text{Total \# of valid demands to start}}$

3.3 $\text{Load Reliability} = \dfrac{\text{\# of successful load-runs}}{\text{Total \# of valid demands to load}}$

4.0 DATA ACCEPTANCE and TESTING CRITERIA:

4.1 A START is not counted if:

4.1.1 An operator error that would not have prevented the D/G from being restarted and brought to load in a few minutes without corrective maintenance.

4.1.2 A failure to start in the control room provided the D/G could be started locally.

4.1.3 An incorrect trip signal that would not be operative in the emergency start mode.

4.1.4 A malfunction of equipment that would not be operative in the emergency start mode.

4.1.5 Minor water leaks and minor oil leaks that would not preclude operation of the D/G in an emergency.

4.1.6 Intentional termination of the test because of alarmed or observed abnormal conditions that would not have ultimately resulted in significant emergency generator damage or failure.

4.1.7 A failure to start because a portion of the starting system was disabled for test purposes, provided it is followed by a successful start with the starting system in its normal alignment.

4.2 A LOADED RUN is <u>not</u> counted if:

4.2.1 An operator error that would not have prevented the D/G from being restarted and brought to load in a few minutes without corrective maintenance.

4.2.2 An incorrect trip signal that would not be operative in the emergency start mode.

4.2.3 A malfunction of equipment that would not be operative in the emergency start mode.

4.2.4 Minor water leaks and minor oil leaks that would not preclude operation of the D/G in an emergency.

4.2.5 Intentional termination of the test because of alarmed or observed abnormal conditions that would not have ultimately resulted in significant emergency generator damage or failure.

4.2.6 A failure to load because a portion of the generator system was disabled for test purposes, provided it is followed by a successful loading with the generator system in its normal alignment.

4.3 **Troubleshooting Test:**

4.3.1 Troubleshooting tests during corrective maintenance (after a failure) should not be counted as demands or failures, except for the final successful test.

4.3.2 Test to discover the cause of a prior failure are not valid demands.

4.3.3 Test to prove the failed component has been repaired are not valid demands.

4.4.4 Test performed immediately after the D/G overhaul need not be considered valid.

4.4 **Acceptable Data Values:**

4.4.1 The standard for our SSF D/G to maintain is:

4.4.1.1 Availability of greater than 95%.

4.4.1.2 Reliability which does not exceed the double trigger value of 5/50, 8/100 demand failures from 10CFR50.63.

4.4.2 If the D/G exceeds the standard trigger value of 3 out of 20 demand failures then immediately corrective action should ensure common cause failure is not occurring.

4.4.3 If the D/G exceeds the double trigger value immediately a form of root cause analysis evaluation should occur to identify and correct the problem.

5.0 Corrective Action Testing:

5.1 The D/G shall demonstrate satisfactory performance after any repair which could affect its operability .

5.2 The D/G shall not be tested in any way beyond its design basis without a written engineering review.

6.0 Surveillance Testing:

Periodic surveillance testing must demonstrate continued capability and reliability of the SSF D/G to perform its intended function. The SSF D/G is considered operable if all monthly, quarterly and annually testing is current and satisfactorily complete by this program and Technical Specifications.

6.1 Monthly: Monthly testing of the SSF D/G shall demonstrate reliability per an Auto-Idle start.

6.2 Quarterly: Every quarter the SSF D/G shall be Auto-Idle started and Load tested.

6.3 Annually: Annually the SSF D/G shall demonstrate the capability by performing the following tests:

6.3.1 Auto-Idle Start.

6.3.2 Loaded Run.

6.3.4 Emergency Start Test.

7.0 Maintenance and Surveillance Program:

7.1 The preventative maintenance and surveillance program on the SSF Diesel Generator and associated equipment required for operation will be per the manufacturers (OM.351-164) and Electro-Motives Owners Group recommendations based upon industry historical data.

7.2 Deviations will be allowed from the programs as described in step 7.1, due to specific Oconee Nuclear Site's design, installation and the D/G's intended purpose.

7.3 Maintenance activities shall not be planned when either or both Keowee units are not available.

7.4 The Component Engineers shall maintain and trend D/G parameter data for equipment degradation / unreliability.

7.5 Unwatering of the Unit-2 CCW Intake piping should be kept to a minimum to ensure maximum SSF availability.

8.0 <u>Data Trending</u>:

8.1 **Data Sources:**

8.1.1 Unit 2 Unit Supervisors Logbook Diesel Generator Logbook

8.1.2 WMS Work Request Database

8.1.3 Completed Operations and Performance Procedures

8.2 Reliability information will be monitored and kept current by the System Engineer. This will require maintaining records on the SSF availability and operability times, recording reliability, trending equipment performance as recorded by the Testing Technicians and parameter monitoring program by the Component Engineers.

8.3 Operability time periods will be determined upon the definitions in the Technical Specifications and in the Operations Management Procedures.

8.4 Availability time periods will be determined as defined by INPO and in step 2.2.

8.5 Reliability will be calculated based on the last 20, 50, and 100 attempted starts and/or loaded runs of the D/G. These values, once calculated by Section 3.0, will be compared to the current acceptance criteria.

8.6 Assumptions on "Historical Data", prior 1/92, were made to complete the the SSF D/G Database. The following are the assumptions made when exact times could not be found in historical data.

8.6.1 Tagouts for D/G PM's began at time 0500.

8.6.2 Other equipment tagouts affecting D/G start time were at 0800.

8.6.3 D/G Quarterly and Monthly PM's last 10 hours.

8.6.4 Desoup Procedure last 1 hour.

8.6.5 Loaded Run performance testing last 1.5 hours.

8.6.6 Desoup and Loaded Runs performance testing last 2.5 hours.

8.6.7 D/G becomes Available at the time of D/G start following PM's.

8.6.8 D/G becomes Available at the time of D/G following known repairs.

8.6.9 D/G becomes Operable when D/G is returned to Standby mode.

8.6.10 Concurrent component failures causing a start failure count as one failure.

8.6.11 Concurrent component failures causing a load run failure count as one failure.

8.6.12 A start failure and a load run failure during the same test each count as separate failures.

8.6.13 Demands and failures during tests following maintenance where no failure was being repaired are generally valid(i.e. can be considered not valid where it is certain that the maintenance work itself caused the failure, and it is detected before returning the D/G to service).

ATTACHMENT VII

Historically, Keowee availability has been maintained in accordance with INPO PPIP methodology. In order to meet the recommendations of NUMARC 87-00, Appendix D, the following will be implemented at Oconee:

1) An accountable individual assigned to maintain reliability, availability and trigger value comparisons.

2) Development of reliability figures utilizing existing Keowee data.

3) Define the Keowee reliability and availability nomenclature in the program.

4) Define the data acquisition roles in terms of positions for program consistency which is independent of specific personnel.

5) Define Keowee subcomponents and support systems.

6) Develop the methodology within the program to document action required and that taken based on trigger values.

7) Establish and maintain Keowee equipment failure history.

8) Develop a Keowee reliability data system for access to reliability / availability figures, and equipment failure history.

Programs are in place which perform the required testing, maintenance, and data acquisition. Problem reporting and close out processes which ensure resolution are in use, with the information retained and retrievable in data bases. In order to meet Appendix D, the current activities will be defined in a Keowee specific program and reliability / availability numbers will be generated.