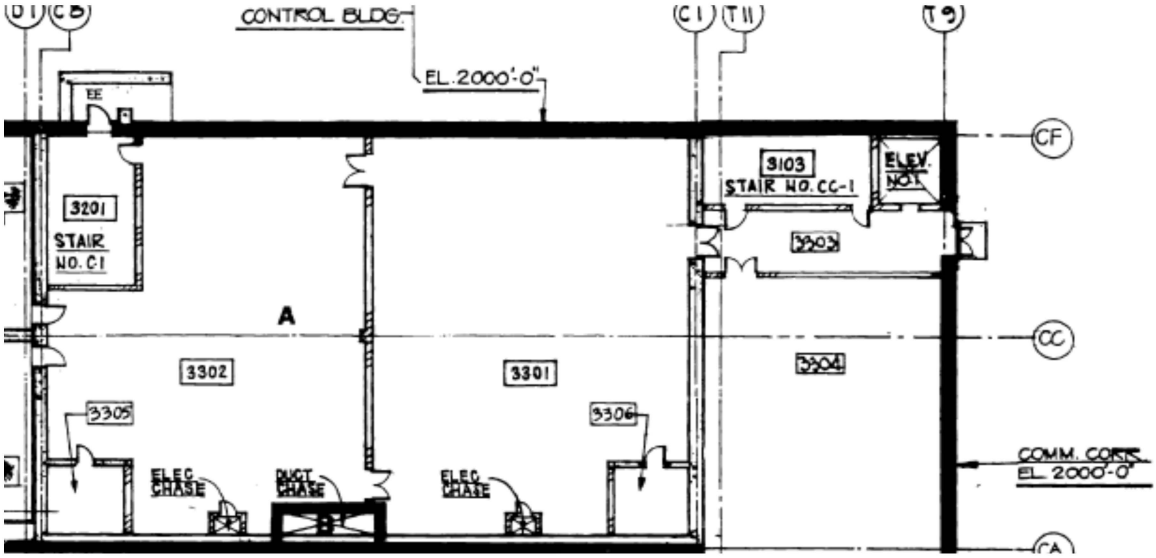
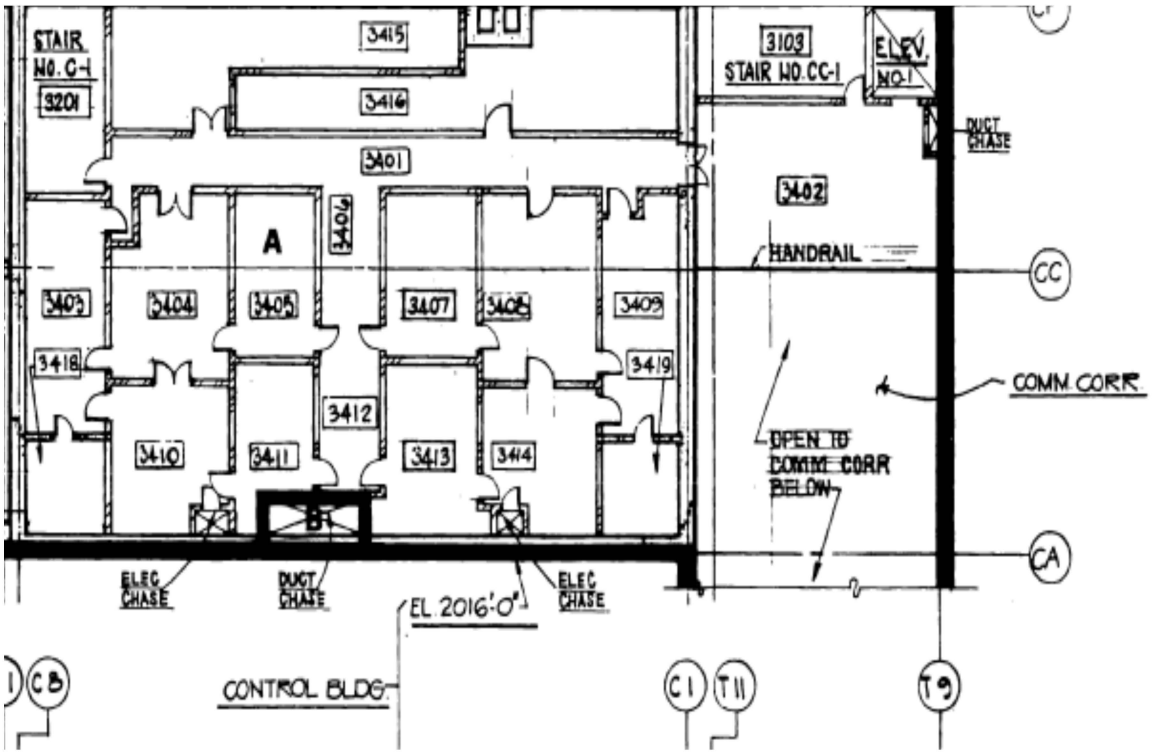
ATTACHMENT 5

CONTROL BUILDING ROOM LOCATIONS AND P&ID EXCERPTS

CONTROL BUILDING ROOM LOCATIONS



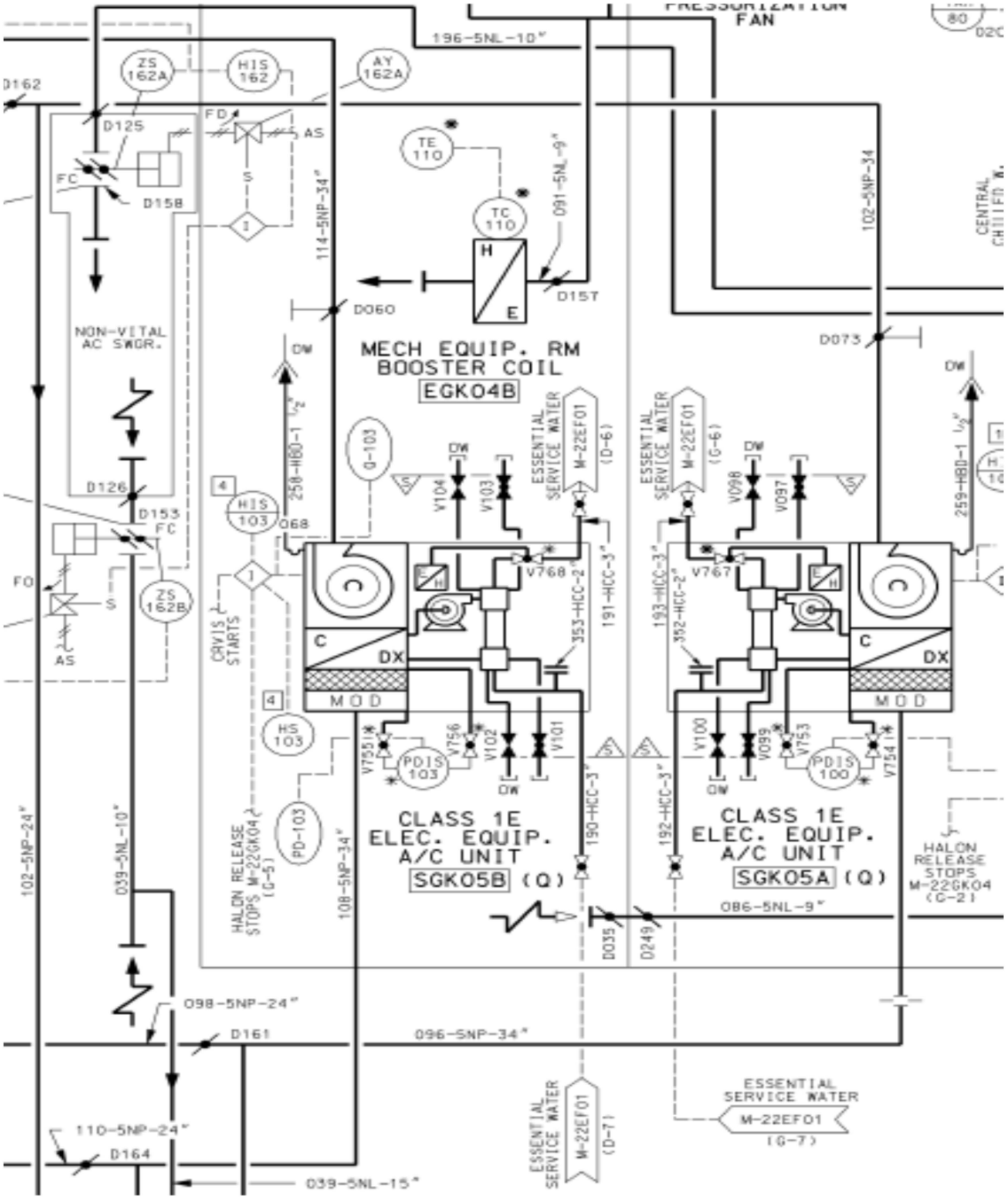


CONTROL BUILDING ROOM LOCATIONS

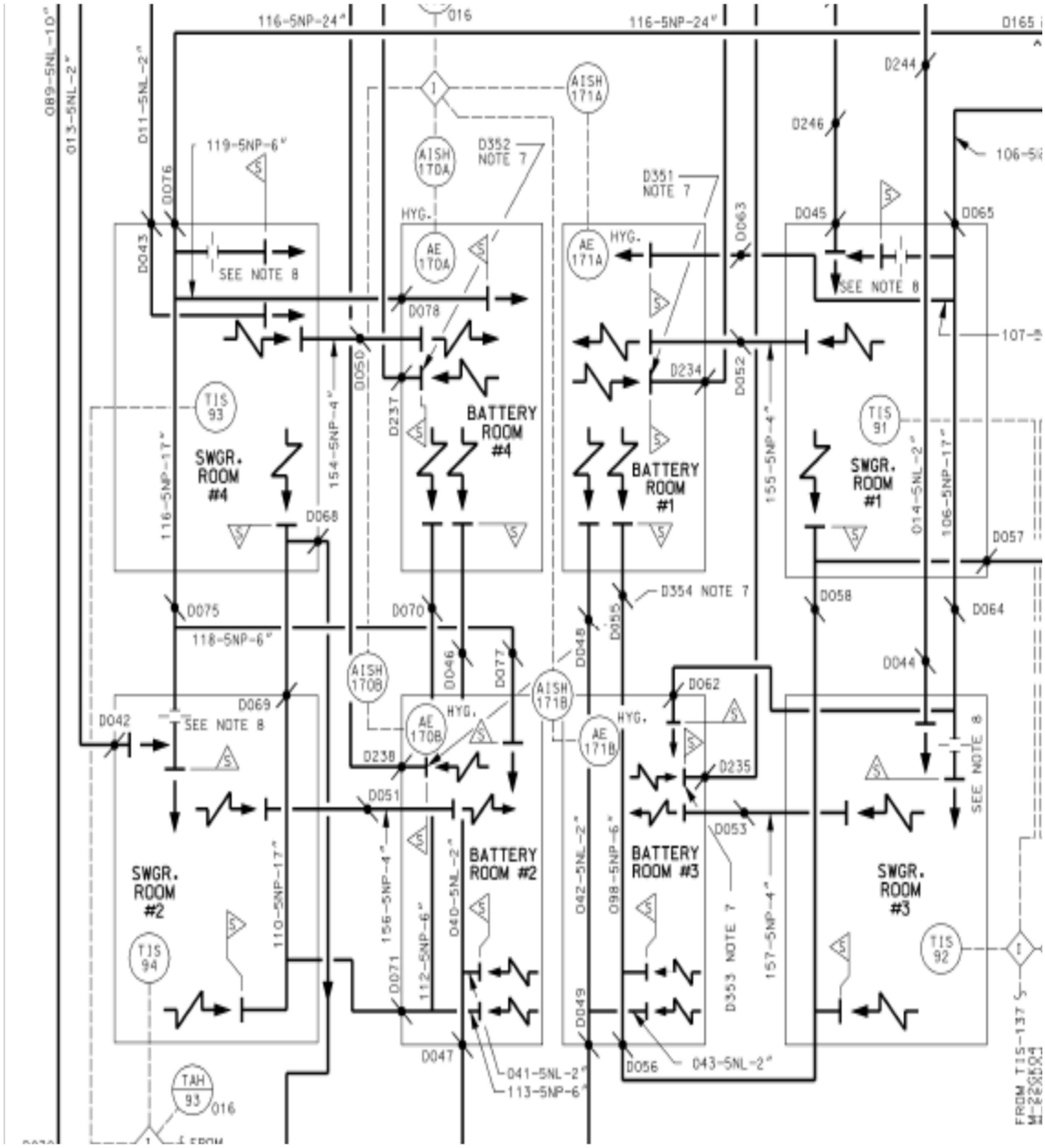
CONTROL BLDG & COMMUNICATION CORRIDOR

3301 ESF SWITCHGEAR RM (NO.1)
3302 ESF SWITCHGEAR RM (NO.2)
3303 CORRIDOR
3304 COMMUNICATION CORRIDOR-GENERAL FL. AREA
3401 CORRIDOR (NO.1)
3402 CORRIDOR (NO.3)
3403 NON-VITAL AC SWGR & TRANS ROOM
3404 SWITCHBOARD RM (NO.4)
3405 BATTERY RM (NO. 4)
3406 CORRIDOR (NO.2)
3407 BATTERY RM (NO. 1)
3408 SWITCHBOARD RM (NO.1)
3409 NON-VITAL AC SWGR & TRANS ROOM
3410 SWITCHBOARD RM (NO.2)
3411 BATTERY RM (NO. 2)
3412 EMERGENCY SHOWER & EYEWASH AREA
3413 BATTERY RM (NO. 3)
3414 SWITCHBOARD RM (NO.3)
3415 ACCESS CONTROL & ELEC. EQUIP. A/C UNITS RM. (NO.1)
3416 ACCESS CONTROL & ELEC. EQUIP. A/C UNITS RM. (NO.2)
3305, 3306, 3418 & 3419 ELEC CHASE

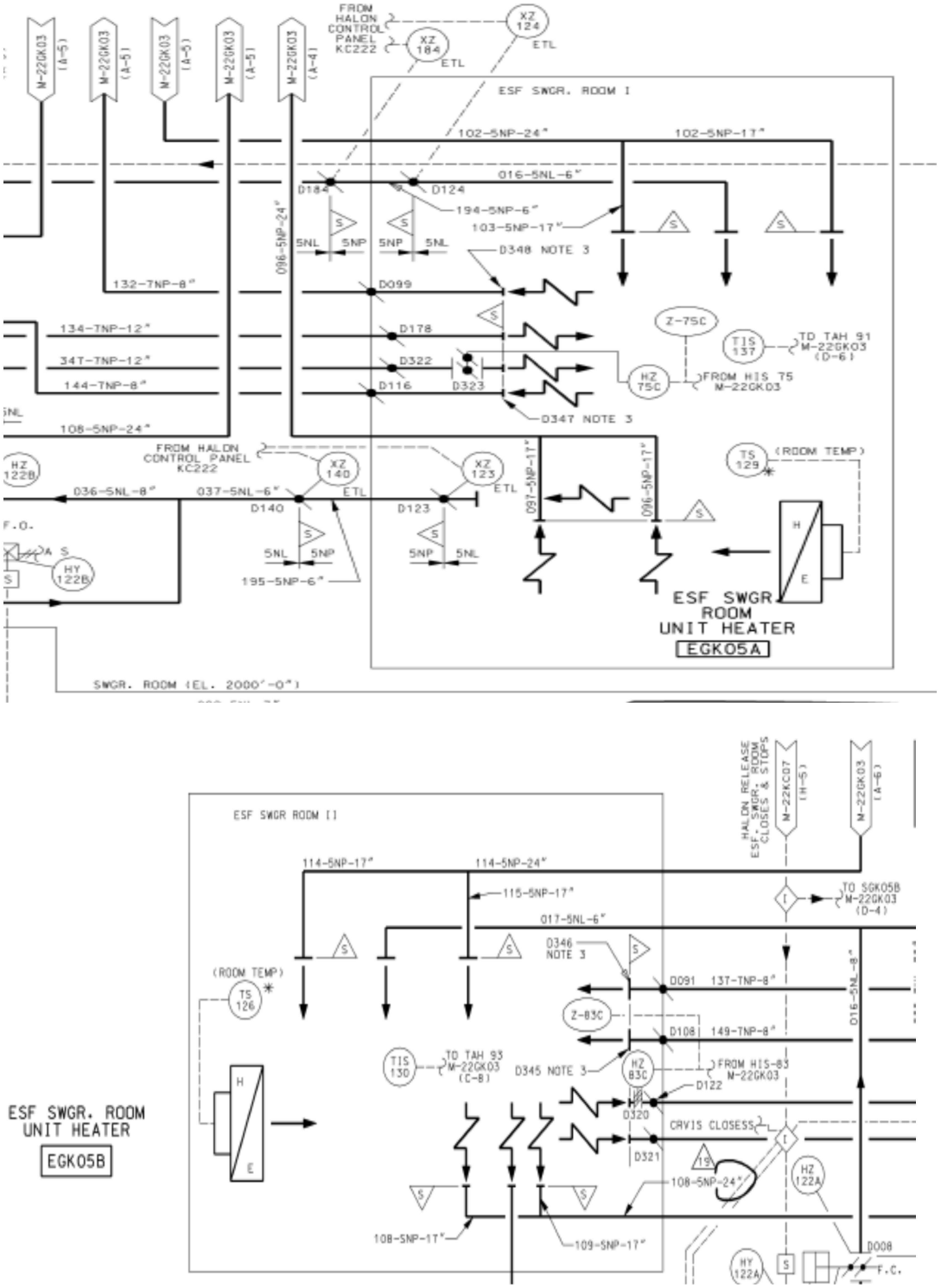
EXCERPT FROM P&ID M-22GK03 (FSAR FIGURE 9.4-1 SHEET 3)



EXCERPT FROM P&ID M-22GK03 (FSAR FIGURE 9.4-1 SHEET 3)



EXCERPT FROM P&ID M-22GK04 (FSAR FIGURE 9.4-1 SHEET 4)



ATTACHMENT 6

CALCULATION GK-19, REVISION 0, ADDENDUM 3,
"2016' AUXILIARY BUILDING BATTERY AND SWITCHBOARD
ROOM GOTHIC TEMPERATURE ANALYSIS"

Calculation: GK-19, Rev. 0 Add. 3

Title: 2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis

- Description: This calculation will model the temperatures of the 2016' Aux. Building Battery and SWBD rooms using the GOTHIC modeling software. This analysis will include the effects of impaired air conditioning and a range of time delays in opening the room doors.

Responsible Engineer:	Kurt Linsenbardt PIN#70901	See electronic signature	6/29/2011
	Name (printed)	Signature	
Reviewing Engineer:	Thomas Carr PIN#990	See electronic signature	6/29/2011
	Name (printed)	Signature	
Supervising Engineer Approval:	Jim Little PIN#3557	See electronic signature	6/29/2011
	Name (printed)	Signature	

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

1.0 PURPOSE

- This calculation will model the temperatures of the 2016' Aux. Building Battery and SWBD rooms using the GOTHIC modeling software. This analysis will include the effects of the loss of one train of Class 1E air conditioning, and a time delay in opening the room doors. This will show how effectively the alternate train rooms are cooled by the airflow through the doors and, ultimately, the other train of Class 1E A/C.

2.0 METHODOLOGY

The methodology used in this calculation will treat each room as a single lumped volume using two one directional flow paths for each major vent path. The thermal hydraulics modeled between and within the lumped volumes will be those integrated into the GOTHIC 7.2a software package. The 2000' ESF Switchgear rooms are also included in the model due to the potential impact of their heat loads.

3.0 ASSUMPTIONS

1. The doorways between the 2016' Battery and SWBD rooms, and the doors leading out to the 2016' hallways are opened simultaneously and instantaneously after a given duration into the event. As long as Operations has all of the doors opened by the point the model specifies, the model will be conservative. This is due to the fact that having some of the doors opened early will give extra cooling to the rooms.
2. The models were run with the doors opening at one and two hour intervals from the start of the accident, and then at two hour intervals from four to eight hours, and then one last run with them opening at the 12 hour mark. These were chosen to allow Operations adequate time to respond in the event of an A/C train failure, while still assuming that they would be able to respond within one shift of the failure.
3. All air and concrete are assumed to start at 80°F.

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

4. HVAC flow to the area is assumed to be at a constant air temperature of 80°F.
5. The surrounding environment on the other side of the concrete walls is assumed to stay at 80°F for the duration of the 30 day run.
6. A 14.7 psia pressure boundary is included to prevent the levels from pressurizing. This is conservative, as the calculation is only concerned with the room temperatures, and not the room pressures. Due to it being a 30 day run, modeling it as an airtight volume would cause issues with pressure transients in the GOTHIC modeling software.
7. All concrete is considered to be homogenous, with properties (such as density) not varying with temperature. As the temperatures only change by ~50°F, the difference in material properties with temperature is negligible.
8. Heat transfer through the closed doors is omitted. After the doors are opened at the six hour mark, they would no longer act as thermal conductors, and the GOTHIC program does not allow conductors to disappear in this fashion. As the temperature increases occur due to the heat sources inside the rooms, by removing a way for heat to escape the room, this will result in a conservative temperature.
9. No fire protection systems were modeled for the sensitivity runs. Due to the maximum temperatures remaining below the actuation temperatures of the fire dampers it is unnecessary to include them in the model.
10. It is assumed that the height of the ceilings in all rooms is 14 1/3 ft. This represents 16 feet nominal between floors, minus the assumed concrete floor thickness of one foot, minus an additional factor of conservation to represent room equipment taking up space in the room. This is conservative due to the fact that minimizing volume limits the mass of air in the room and increases the effects of heat addition on room temperature.
11. Only one door in a set of double doors will be blocked open. This is conservative in reducing the available airflow, and is consistent with past operator instructions.

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
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12. No thermal conductors other than structural concrete are included. This is conservative as the additional conductors would only serve as heatsinks and would remove heat from the atmosphere.
13. No credit is taken for any non-HVAC airflow from the floors (aside from the pressure boundaries). This is conservative as omitting the potential flow from the stairwells reduces the amount of buoyancy driven flow available to cool the areas.
14. Floors and ceilings are modeled as one foot concrete, and external walls are modeled as two foot thick concrete as estimated from floor layout drawings (Reference 1).
15. Each doorway and transfer grill flowpath was given an exit loss coefficient of 2.8 to account for the flow restriction of the path geometry. This is based off of discussion with the makers of GOTHIC. Omitting the exit loss coefficient would allow the airflows to reach unrealistic speeds and would cause greater than normal cooling.

4.0 DESIGN INPUTS

The room dimensions in Table 1 were taken from the Control Building floor layout drawing (Reference 1). The heat loads in Table 2 were taken from GK-10, the previous SWBD room heatup calculation (Reference 2) and the HVAC parameters in Table 3 were found in the Control Building HVAC drawing (Reference 3&4).

The door parameters in Table 4 were found on the Door Schedule drawing (Reference 5). The control building HVAC drawings show a grate in-between the SWBD rooms and their respective Battery rooms. The M-2H3411 drawing (Ref. 4) gives the dimensions of the grates as 12"x12". Similarly, the M-2H3311 HVAC drawing (Ref. 3) indicates the presence of two 24"x24" transfer grills between the two ESF Switchgear rooms.

All internal walls are modeled as 8 inch thick concrete (Note 2, Ref. 1).

In order to properly model the interaction between the two trains Corridor 1 (Room #3401) was divided into north and south halves, as shown in Figure 1. The T junction between Corridor 2 (Room #3406) was modeled by dividing the intersection into a three different flowpaths, one between the N-S halves of Corridor 1, and one from each half of

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

Corridor 1 into Corridor 2. This allows the airflow to flow between all three different hallways.

Rooms	Width (ft)	Length (ft)
SWBD 1	18.7	22.7
SWBD 2	18.5	19.7
-SWBD 2 E. Chase	6.0	4.0
SWBD 3	18.7	19.7
-SWBD 3 E. Chase	8.2	4.0
SWBD 4	18.5	22.7
Battery 1	12.7	20.7
Battery 2	12.8	21.0
-Battery 2 notch	8.4	4.7
Battery 3	12.7	21.0
+Battery 3 S. Alcove	4.2	4.7
+Battery 3 N. Alcove	2.1	3.3
Battery 4	12.8	20.7
Corridor 1N	57.3	6.7
Corridor 1S	31.3	6.7
+Corridor 1S Alcove	4.3	6.4
Corridor 2	12.0	37.0
ESF 1	50.5	66.0
-ESF Elec. Chase 1	6.0	4.0
-ESF Elec. Chase 2	13.0	13.0
ESF 2	48.5	66.0
-ESF Duct Chase	12.9	4.7
-ESF Elec. Chase 1	6.0	4.0
-ESF Elec. Chase 2	13.0	13.0
-2000' SW Stairwell	15.3	25.0

Table 1: Room Parameters

+ means the volume is an addition to the parent room

- means the notch is removed from the parent room

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
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Rooms	DC Load (watts)
SWBD 1&4	13811
SWBD 2&3	2928
Battery 1&4	301
Battery 2&3	161
ESF 1	28968
ESF 2	27988

Table 2: DC heat loads

Rooms	Air In (CFM)	Air Out (CFM)
SWBD 1&4	2100	2100
SWBD 2&3	2000	2000
Battery 1&4	300	300
Battery 2&3	200	200
ESF A&B	6900	6900

Table 3: HVAC flowrates

Door (nominal)	W (ft)	H (ft)
3'-8.5"	3.33	7.17
4'-4.5"	4.00	7.17
5'-4.5"	5.00	7.17
6'-8.5"	6.00	8.00

Table 4: Door parameters

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	CALCULATION NO : GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

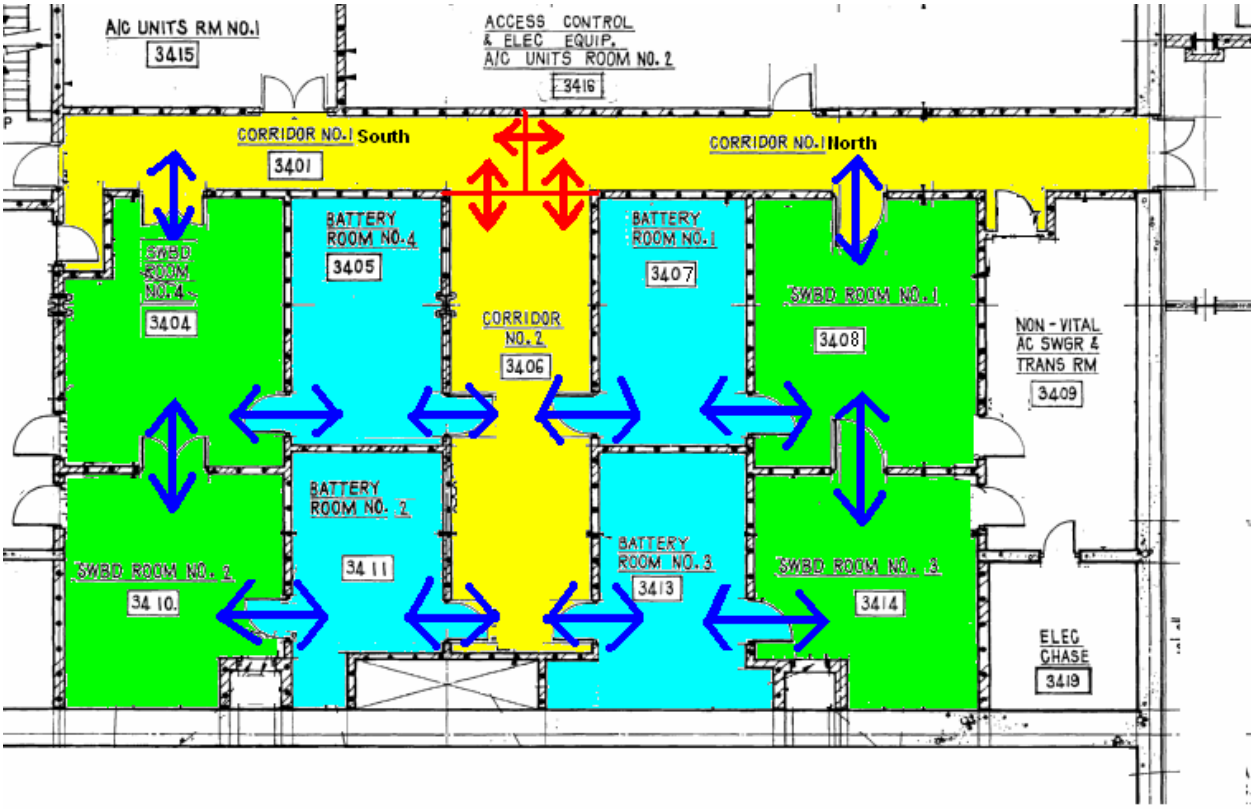


Figure 1 – 2016' Floor layout – Red lines indicate the split corridor flowpaths, Blue lines indicate the flowpaths that come into play when the doors are opened

5.0 CALCULATION

5.1 Areas

Wall areas were calculated by multiplying the various length and width room parameters located in Table 1 by the room height. Areas of the floors and ceilings were found by multiplying the length and width parameters together directly. The areas of the small additional nooks and notches were added or subtracted as dictated by the floorplan, as were the areas of the doors in respect to the wall area. Due to the simple nature of the calculations, and the repetitive nature of then, only the results are shown in Table 5. The areas of the walls, floors, and ceilings were then added into the GOTHIC model as Thermal Conductors, with their thickness determined by their location and orientation, as discussed above.

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

For the floor area of Battery Room 1

$$Area = Width * Length$$

$$Length = 12\frac{2}{3}\,ft$$

$$Width = 20\frac{2}{3}\,ft \qquad \text{Equation 1}$$

$$Area = 20\tfrac{2}{3} * 12\tfrac{2}{3}$$

$$Area = 261.78\,ft^2$$

	Ceiling&Floor	Walls
Room	(ft^2)	(ft^2)
SWBD 1	423.11	1103.67
SWBD 2	339.83	1052.31
SWBD 3	334.44	1046.33
SWBD 4	419.33	1120.39
Battery 1	261.78	907.78
Battery 2	230.42	922.11
Battery 3	292.51	1097.65
Battery 4	265.22	912.56
Corridor 1N	382.22	1710.44
Corridor 1S	236.51	1220.72
Corridor 2	444.00	1137.11
ESF 1	3140.00	3243.67
ESF 2	2566.70	3186.33

Table 5 – Room Areas

5.2 Volumes

The volumes of the rooms and corridors were calculated by multiplying the areas of the floors by the assumed height of the rooms (14 1/3 ft). This method was chosen due to the irregular nature of the 2016' room layouts. Floor areas were taken from Table 5, and the resulting volumes can be found in Table 6. These volumes were then added into the GOTHIC model as Control Volumes. The Hydraulic Diameters of the rooms are

calculated by taking four times the volume of the room and then dividing it by the surface area of the room.

$$Volume = Length * Width * Height$$

$$Length = 12\frac{2}{3}\,ft$$

$$Width = 20\frac{2}{3}\,ft$$

$$Height = 14\frac{1}{3}\,ft$$

Equation 2

$$Volume = 20\tfrac{2}{3} * 12\tfrac{2}{3} * 14\tfrac{1}{3}$$

$$Volume = 3752.15\,ft^3$$

	Volume	Hyd. Diam.
Rooms	ft^3	ft
SWBD 1	6064.59	11.94
SWBD 2	4870.94	10.98
SWBD 3	4793.70	10.85
SWBD 4	6010.44	11.91
Battery 1	3752.15	10.15
Battery 2	3302.64	9.23
Battery 3	4192.69	9.69
Battery 4	3801.52	10.20
Corridor 1N	5478.52	8.75
Corridor 1S	3390.03	7.92
Corridor 2	6364.00	12.00
ESF 1	47773.00	19.86
ESF 2	45881.00	21.81

Table 6 – Room Volumes & Hydraulic Diameters

5.3 Flowpaths

The area of each flowpath (Table 7) was found by multiplying the width and height of the opening. The dimensions of the doors were taken from Table 4, and the grill dimensions were taken from the HVAC drawings (as discussed in Section 4.0). Each flowpath was then divided into a top and a bottom half before being added into the GOTHIC model. This is due to the fact that GOTHIC only allows flow to travel one way in a flowpath at a time. By dividing the flowpath into top and bottom halves, it allows GOTHIC to model

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

two-way flow through the opening. This allows it to properly model the buoyancy driven cooling flow through the rooms, with the hot air rising and flowing out the top half of the opening, and the cold air sinking and flowing in through the bottom half. Hydraulic Diameter is calculated as four times the area divided by the perimeter.

	Width	Height	Area	Area/2	Hyd. Diam.
Flowpaths	ft	ft	ft^2	ft^2	ft
3'-8.5" Door	3.33	7.17	23.89	11.94	4.55
4'-4.5" Door	4.00	7.17	28.67	14.33	5.13
5'-4.5" Door	2.50	7.17	17.92	8.96	3.71
6'-8.5" Door	6.00	8.00	48.00	24.00	6.86
Transfer Grill	0.83	0.83	0.69	0.35	0.83
Corridor 1	6.67	14.33	95.56	47.78	9.10
Corridor 2	12.00	14.33	172.00	86.00	13.06

Table 7 – Flowpath Dimensions & Hydraulic Diameters

6.0 IMPACT ASSESSMENT

The analysis will potentially affect the PRA and EQ analysis of the equipment located in the 2016' Battery and SWBD rooms. The analysis of the margin available in these rooms is beyond the scope of this calculation.

The blocking opening of doors from these volumes into areas with no heat sources or inactive heat sources is allowable under this calculation, due to the fact that the additional airspace and heat sinks will assist in absorbing the heat from the modeled heat loads. This will only serve to decrease the temperature of the Battery and SWBD rooms, thus increasing the margin available.

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

7.0 CONCLUSION

Due to the number of different rooms and run conditions, only the limiting room temperatures will be given. The run results for the sensitivity analysis can be found in Table 8, with the limiting room temperature profiles in Figures 2-5. Additional cases of greater severity were run for the doors remaining closed with both one train and no trains of A/C, along with a run with the A/C disabled but the doors opened at one hour. The room temperatures for these runs can be found in Table 9.

The rooms with the working A/C systems show little heatup due to the large amount of airflow and the battery rooms have less than ten percent of the heat load of the SWBD rooms, so the limiting room temperatures in these models are always a SWBD room on the train with the failed A/C.

Due to the rapid decrease in the failed A/C room temperatures after the opening of the doorways, it is acceptable to interpolate the peak room temperatures for opening the doors between the modeled doors opening times.

Active Trains of HVAC

Doors open at time	A HVAC ESFAS	B HVAC ESFAS	A HVAC Normal	B HVAC Normal
2 hr	130.676	126.964	122.267	119.139
4 hr	130.677	128.559	122.267	120.887
6 hr	130.677	130.65	122.268	122.562
8 hr	132.183	132.628	123.814	124.163
12 hr	135.578	136.307	126.778	127.142

Table 8 – Sensitivity Run results

AC	Doors	24 hr max (°F)	30 day max (°F)
None	Open at 1hr	115.0	154.1
None	Closed	145.7	191.9
A Train	Closed	144.4	183.0
B Train	Closed	145.3	185.1

Table 9 – Alternate Severe Parameter Run results

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	CALCULATION NO : GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

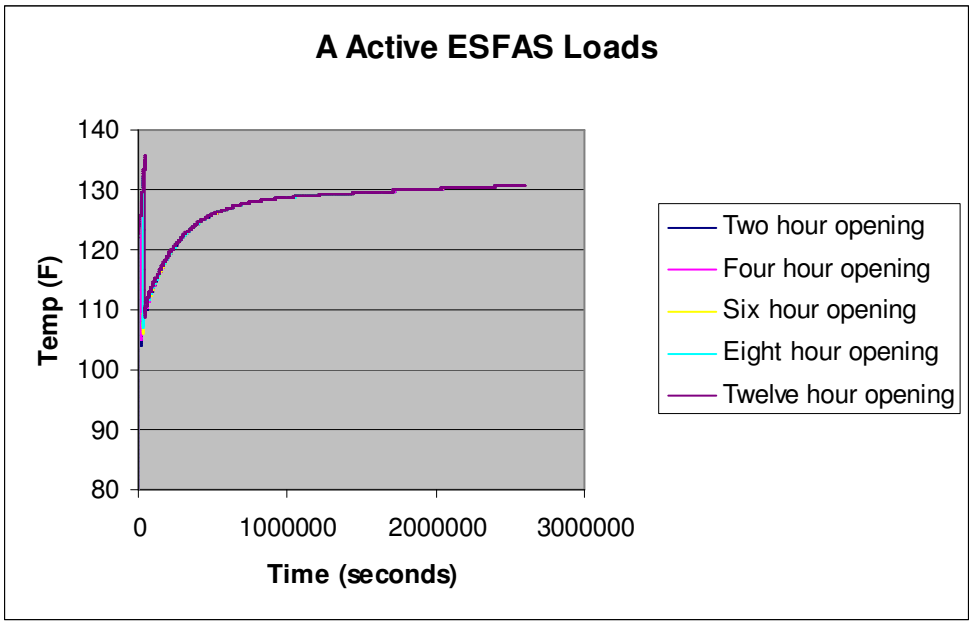


Figure 2a: Limiting room temperatures with A Train HVAC active and ESFAS loads

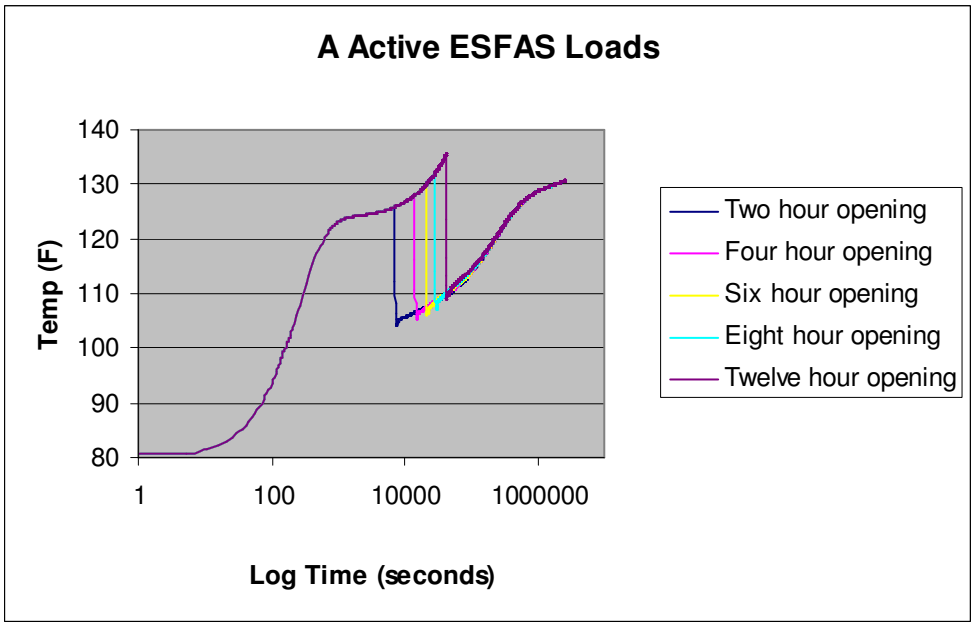


Figure 2b: Limiting temperatures (log scale time) with A Train HVAC and ESFAS loads

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	CALCULATION NO : GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

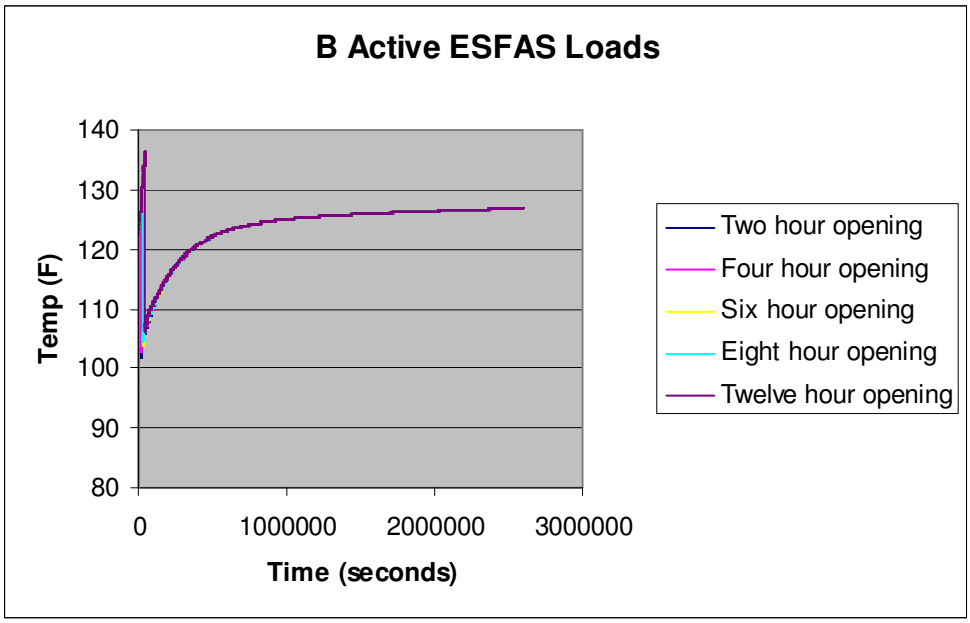


Figure 3a: Limiting room temperatures with B Train HVAC active and ESFAS loads

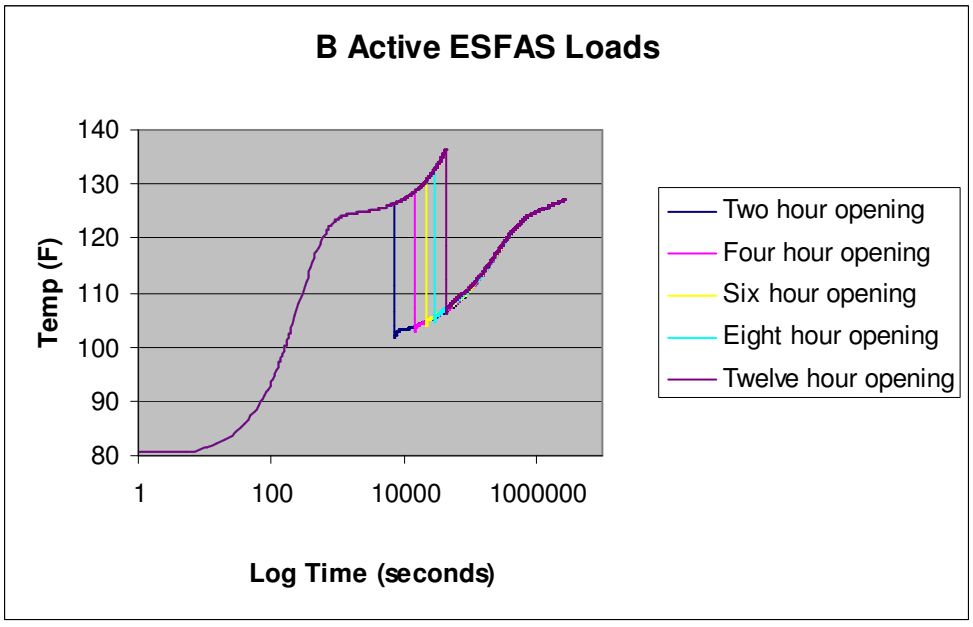


Figure 3b: Limiting temperatures (log scale time) with B Train HVAC and ESFAS loads

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	CALCULATION NO : GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

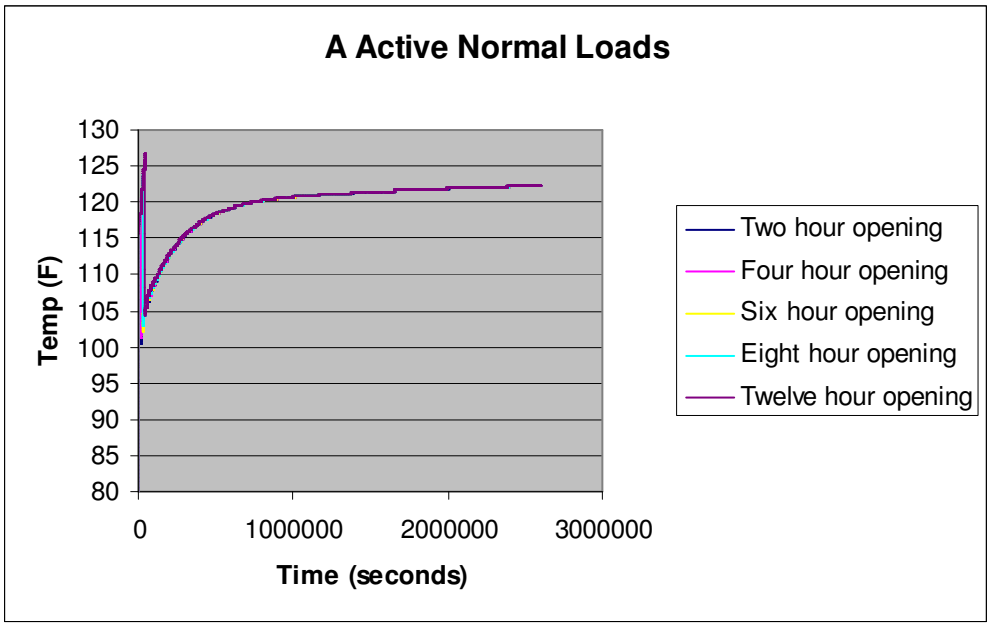


Figure 4a: Limiting room temperatures with A Train HVAC active and normal loads

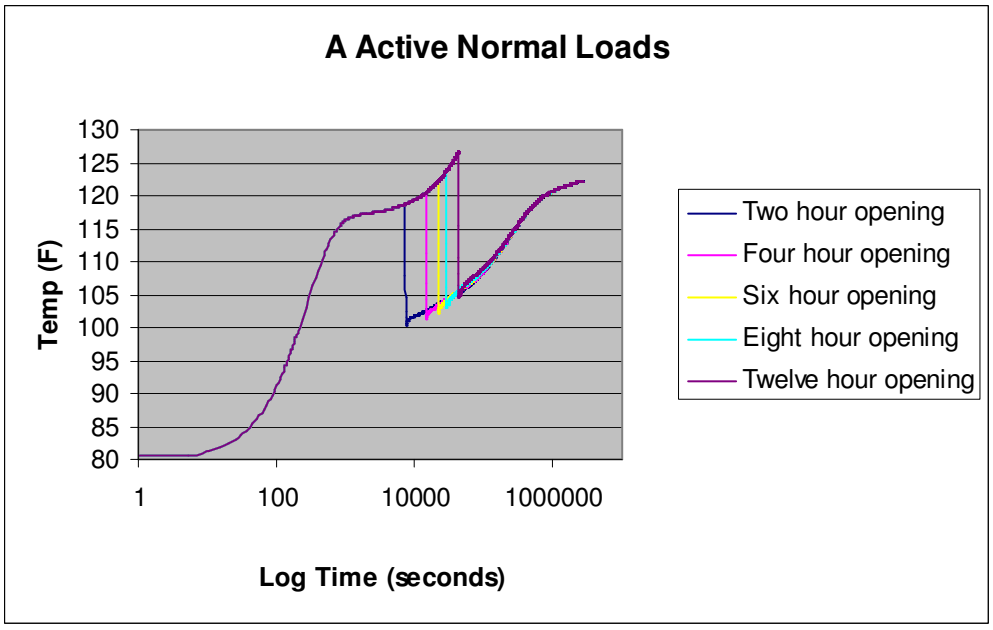


Figure 4b: Limiting temperatures (log scale time) with A Train HVAC and normal loads

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	CALCULATION NO : GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

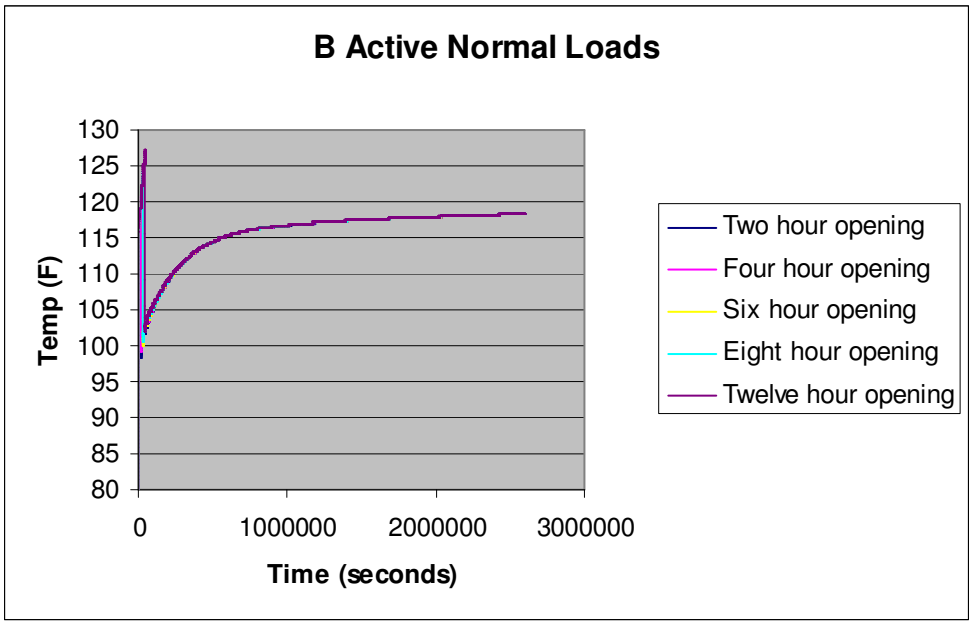


Figure 5a: Limiting room temperatures with B Train HVAC active and normal loads

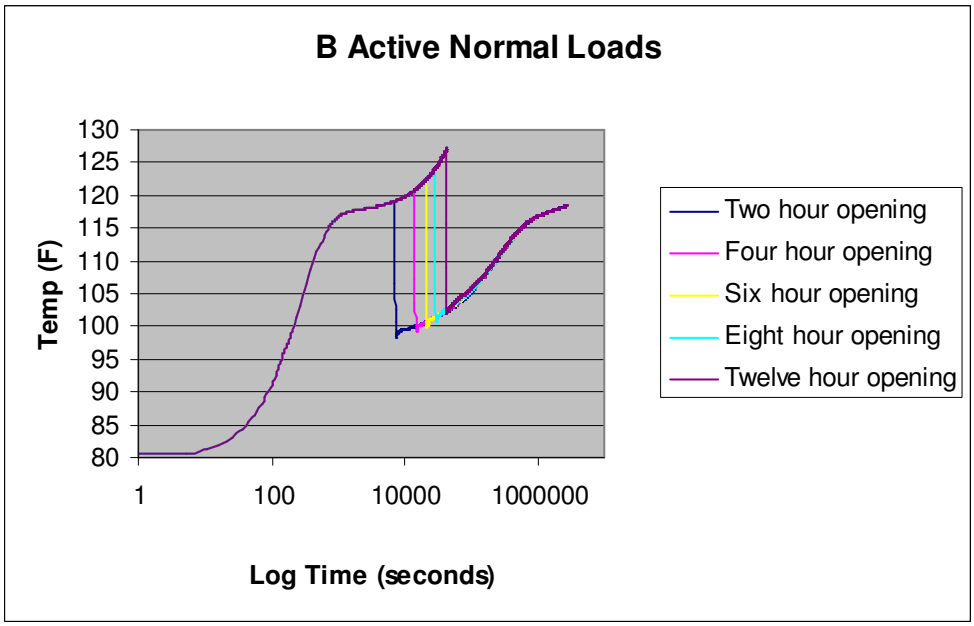


Figure 5b: Limiting temperatures (log scale time) with B Train HVAC and normal loads

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: **Kurt Linsenbardt**	**REVIEWED BY:** **Tom Carr**

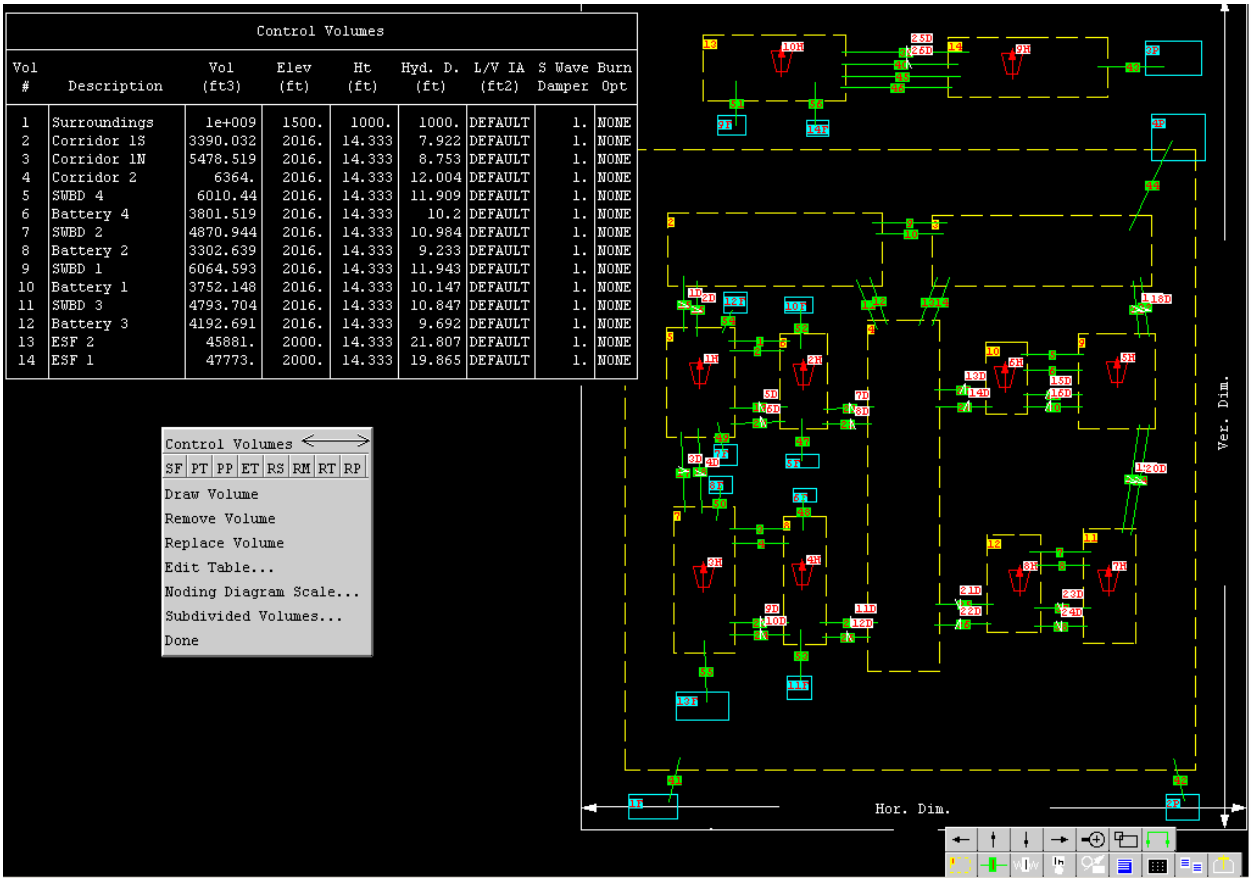
8.0 REFERENCES

1. A-2325 Rev. 3, "Control/Diesel Gen Bldg/Comm Corr - EL 2000 & 2016 Floor Plans"
2. GK-10 Rev. 1, "Switchboard Room Temperature Rise. Determine Action to be Taken to Maintain All DC Switchboard, Battery & ESF Switchgear Rooms Below 104 Deg F. When One 1E A/C Unit is Inoperable."
3. M-2H3311 Rev. 3, "Heating Ventilating & Air Cond. - Control Building - EL 2000'-0" Area 1"
4. M-2H3411 Rev. 4, "Heating Ventilating & Air Cond. - Control Building - EL 2016'-0" Area 1"
5. A-2908 Rev. 24, "Door Schedule"

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

9.0 ATTACHMENTS

Attachment 1 – Excel file of GOTHIC outputs
Attachment 2 – Zipped GOTHIC models



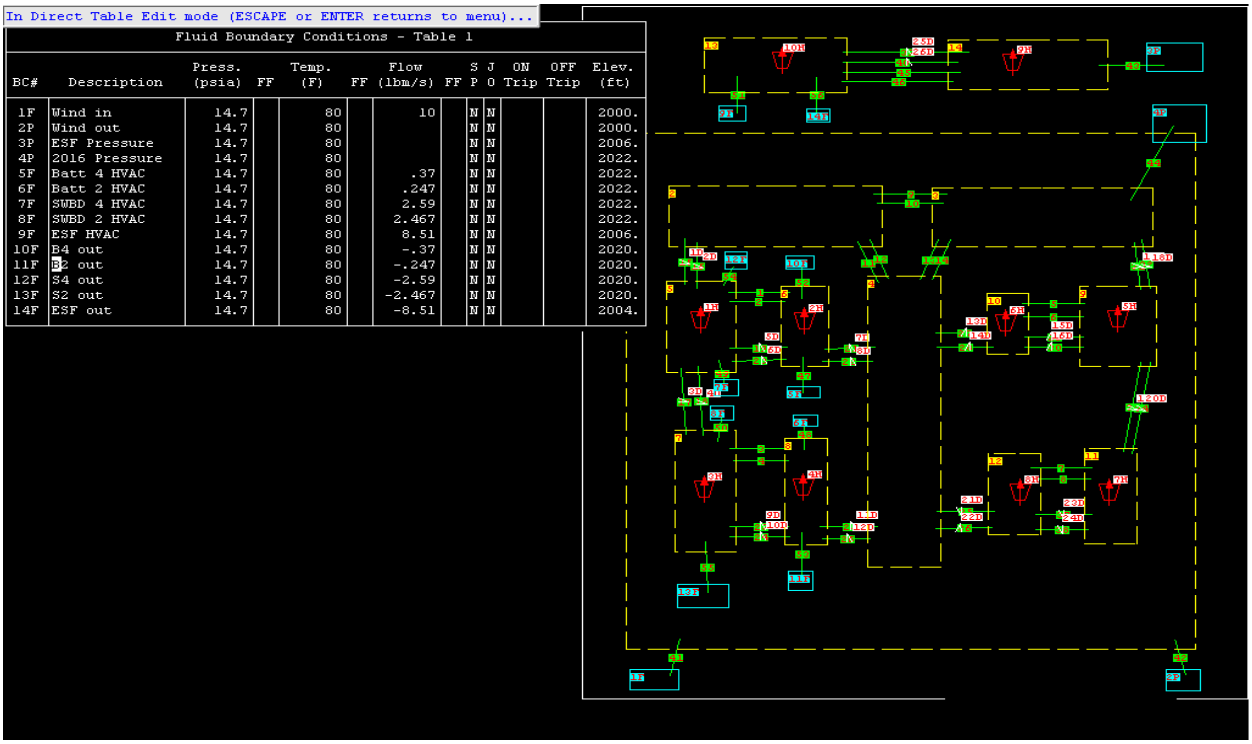
Attachment 3 – GOTHIC Model Control Volumes

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

Fluid Boundary Conditions - Table 1

BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	S P	J O	ON Trip	OFF Trip	Elev. (ft)
1F	Wind in	14.7		80		10		N	N			2000.
2P	Wind out	14.7		80				N	N			2000.
3P	ESF Pressure	14.7		80				N	N			2006.
4P	2016 Pressure	14.7		80				N	N			2022.
5F	Batt 4 HVAC	14.7		80		.37		N	N			2022.
6F	Batt 2 HVAC	14.7		80		.247		N	N			2022.
7F	SWBD 4 HVAC	14.7		80		2.59		N	N			2022.
8F	SWBD 2 HVAC	14.7		80		2.467		N	N			2022.
9F	ESF HVAC	14.7		80		8.51		N	N			2006.
10F	B4 out	14.7		80		-.37		N	N			2020.
11F	B2 out	14.7		80		-.247		N	N			2020.
12F	S4 out	14.7		80		-2.59		N	N			2020.
13F	S2 out	14.7		80		-2.467		N	N			2020.
14F	ESF out	14.7		80		-8.51		N	N			2004.

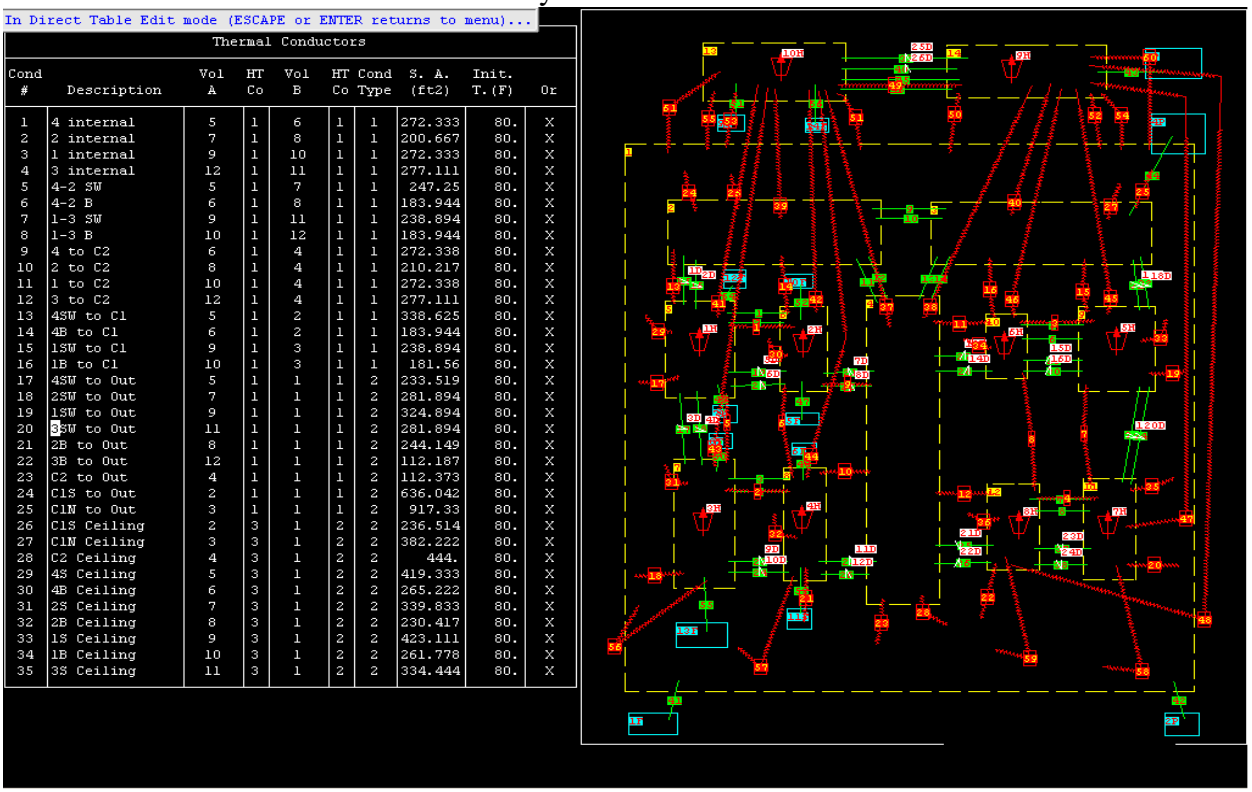


Attachment 4 – GOTHIC Model Boundary Conditions

In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

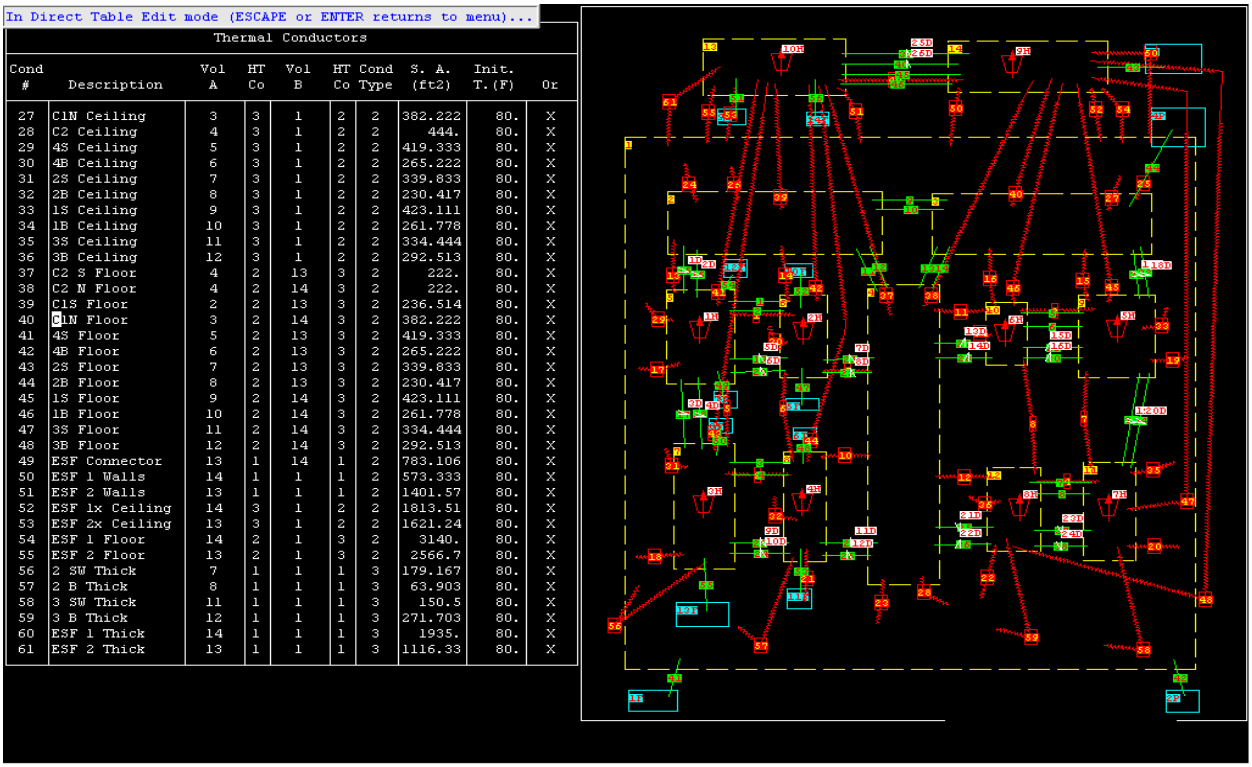
Thermal Conductors

Cond #	Description	Vol A	HT Co	Vol B	HT Co	Cond Type	S. A. (ft2)	Init. T.(F)	Or
1	4 internal	5	1	6	1	1	272.333	80.	X
2	2 internal	7	1	8	1	1	200.667	80.	X
3	1 internal	9	1	10	1	1	272.333	80.	X
4	3 internal	12	1	11	1	1	277.111	80.	X
5	4-2 SW	5	1	7	1	1	247.25	80.	X
6	4-2 B	6	1	8	1	1	183.944	80.	X
7	1-3 SW	9	1	11	1	1	238.894	80.	X
8	1-3 B	10	1	12	1	1	183.944	80.	X
9	4 to C2	6	1	4	1	1	272.338	80.	X
10	2 to C2	8	1	4	1	1	210.217	80.	X
11	1 to C2	10	1	4	1	1	272.338	80.	X
12	3 to C2	12	1	4	1	1	277.111	80.	X
13	4SW to C1	5	1	2	1	1	338.625	80.	X
14	4B to C1	6	1	2	1	1	183.944	80.	X
15	1SW to C1	9	1	3	1	1	238.894	80.	X
16	1B to C1	10	1	3	1	1	181.56	80.	X
17	4SW to Out	5	1	1	1	2	233.519	80.	X
18	2SW to Out	7	1	1	1	2	281.894	80.	X
19	1SW to Out	9	1	1	1	2	324.894	80.	X
20	3SW to Out	11	1	1	1	2	281.894	80.	X
21	2B to Out	8	1	1	1	2	244.149	80.	X
22	3B to Out	12	1	1	1	2	112.187	80.	X
23	C2 to Out	4	1	1	1	2	112.373	80.	X
24	C1S to Out	2	1	1	1	2	636.042	80.	X
25	C1N to Out	3	1	1	1	2	917.33	80.	X
26	C1S Ceiling	2	3	1	2	2	236.514	80.	X
27	C1N Ceiling	3	3	1	2	2	382.222	80.	X
28	C2 Ceiling	4	3	1	2	2	444.	80.	X
29	4S Ceiling	5	3	1	2	2	419.333	80.	X
30	4B Ceiling	6	3	1	2	2	265.222	80.	X
31	2S Ceiling	7	3	1	2	2	339.833	80.	X
32	2B Ceiling	8	3	1	2	2	230.417	80.	X
33	1S Ceiling	9	3	1	2	2	423.111	80.	X
34	1B Ceiling	10	3	1	2	2	261.778	80.	X
35	3S Ceiling	11	3	1	2	2	334.444	80.	X



Attachment 5a – GOTHIC Model Conductors, page 1

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

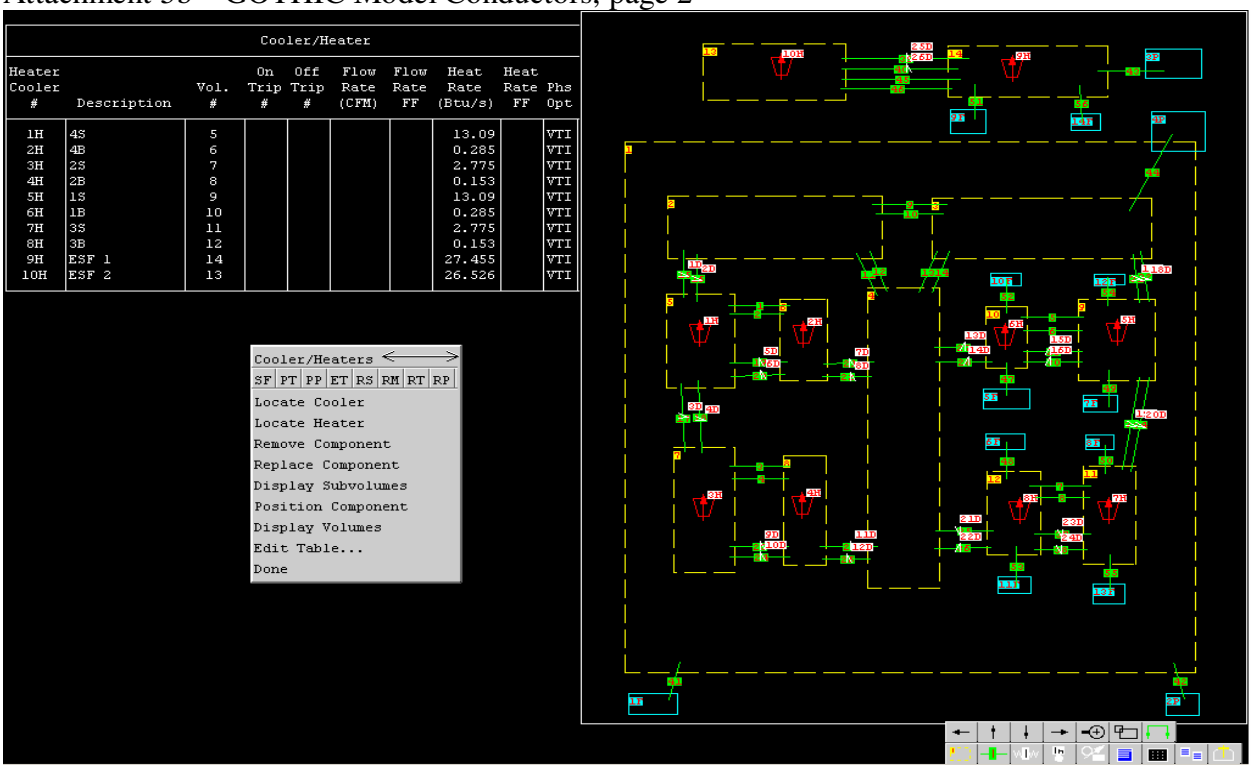


In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

Thermal Conductors

Cond #	Description	Vol A	HT Co	Vol B	HT Co	Cond Type	S. A. (ft2)	Init. T.(F)	Or
27	C1N Ceiling	3	3	1	2	2	382.222	80.	X
28	C2 Ceiling	4	3	1	2	2	444.	80.	X
29	4S Ceiling	5	3	1	2	2	419.333	80.	X
30	4B Ceiling	6	3	1	2	2	265.222	80.	X
31	2S Ceiling	7	3	1	2	2	339.833	80.	X
32	2B Ceiling	8	3	1	2	2	230.417	80.	X
33	1S Ceiling	9	3	1	2	2	423.111	80.	X
34	1B Ceiling	10	3	1	2	2	261.778	80.	X
35	3S Ceiling	11	3	1	2	2	334.444	80.	X
36	3B Ceiling	12	3	1	2	2	292.513	80.	X
37	C2 S Floor	4	2	13	3	2	222.	80.	X
38	C2 N Floor	4	2	14	3	2	222.	80.	X
39	C1S Floor	2	2	13	3	2	236.514	80.	X
40	C1N Floor	3	2	14	3	2	382.222	80.	X
41	4S Floor	5	2	13	3	2	419.333	80.	X
42	4B Floor	6	2	13	3	2	265.222	80.	X
43	2S Floor	7	2	13	3	2	339.833	80.	X
44	2B Floor	8	2	13	3	2	230.417	80.	X
45	1S Floor	9	2	14	3	2	423.111	80.	X
46	1B Floor	10	2	14	3	2	261.778	80.	X
47	3S Floor	11	2	14	3	2	334.444	80.	X
48	3B Floor	12	2	14	3	2	292.513	80.	X
49	ESF Connector	13	1	14	1	2	783.106	80.	X
50	ESF 1 Walls	14	1	1	1	2	573.333	80.	X
51	ESF 2 Walls	13	1	1	1	2	1401.57	80.	X
52	ESF 1x Ceiling	14	3	1	2	2	1813.51	80.	X
53	ESF 2x Ceiling	13	3	1	2	2	1621.24	80.	X
54	ESF 1 Floor	14	2	1	3	2	3140.	80.	X
55	ESF 2 Floor	13	2	1	3	2	2566.7	80.	X
56	2 SW Thick	7	1	1	1	3	179.167	80.	X
57	2 B Thick	8	1	1	1	3	63.903	80.	X
58	3 SW Thick	11	1	1	1	3	150.5	80.	X
59	3 B Thick	12	1	1	1	3	271.703	80.	X
60	ESF 1 Thick	14	1	1	1	3	1935.	80.	X
61	ESF 2 Thick	13	1	1	1	3	1116.33	80.	X

Attachment 5b – GOTHIC Model Conductors, page 2



Cooler/Heater

Heater Cooler #	Description	Vol. #	On Trip #	Off Trip #	Flow Rate (CFM)	Flow Rate FF	Heat Rate (Btu/s)	Heat Rate FF	Phs Opt
1H	4S	5					13.09		VTI
2H	4B	6					0.285		VTI
3H	2S	7					2.775		VTI
4H	2B	8					0.153		VTI
5H	1S	9					13.09		VTI
6H	1B	10					0.285		VTI
7H	3S	11					2.775		VTI
8H	3B	12					0.153		VTI
9H	ESF 1	14					27.455		VTI
10H	ESF 2	13					26.526		VTI

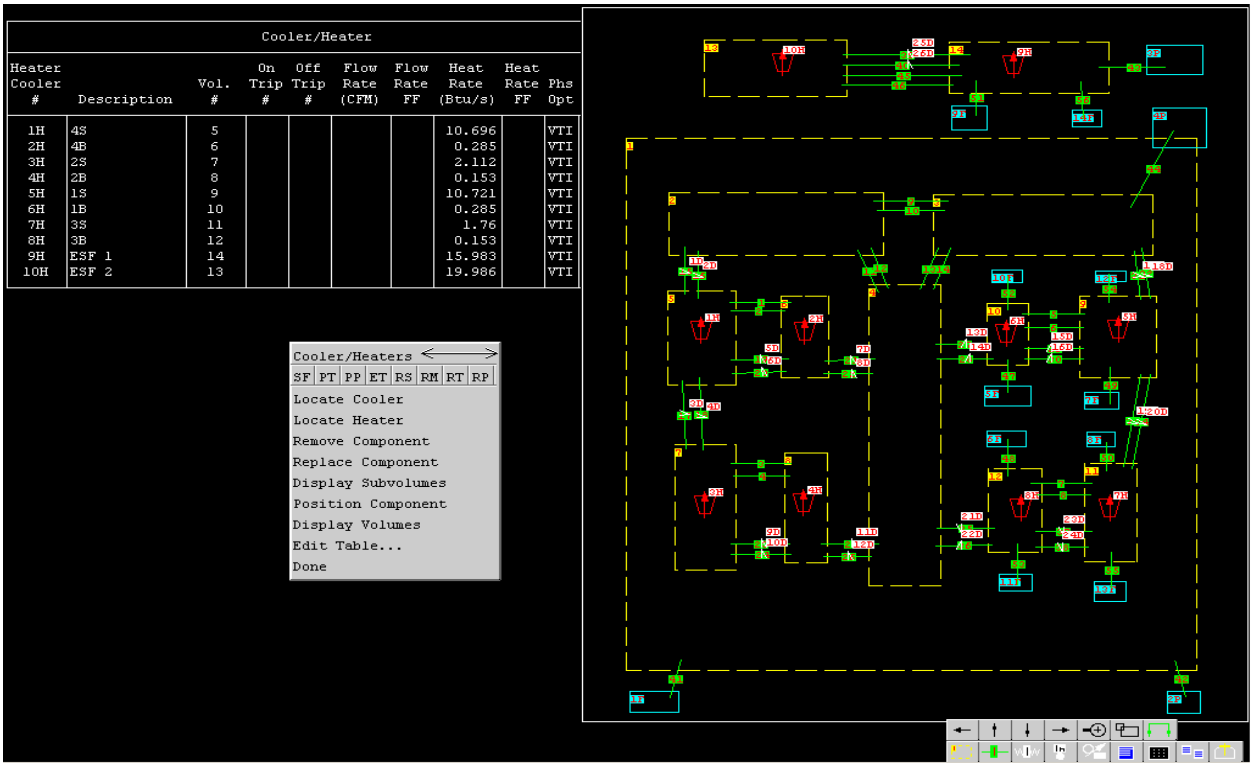
Cooler/Heaters

SF | PT | PP | ET | RS | RM | RT | RP

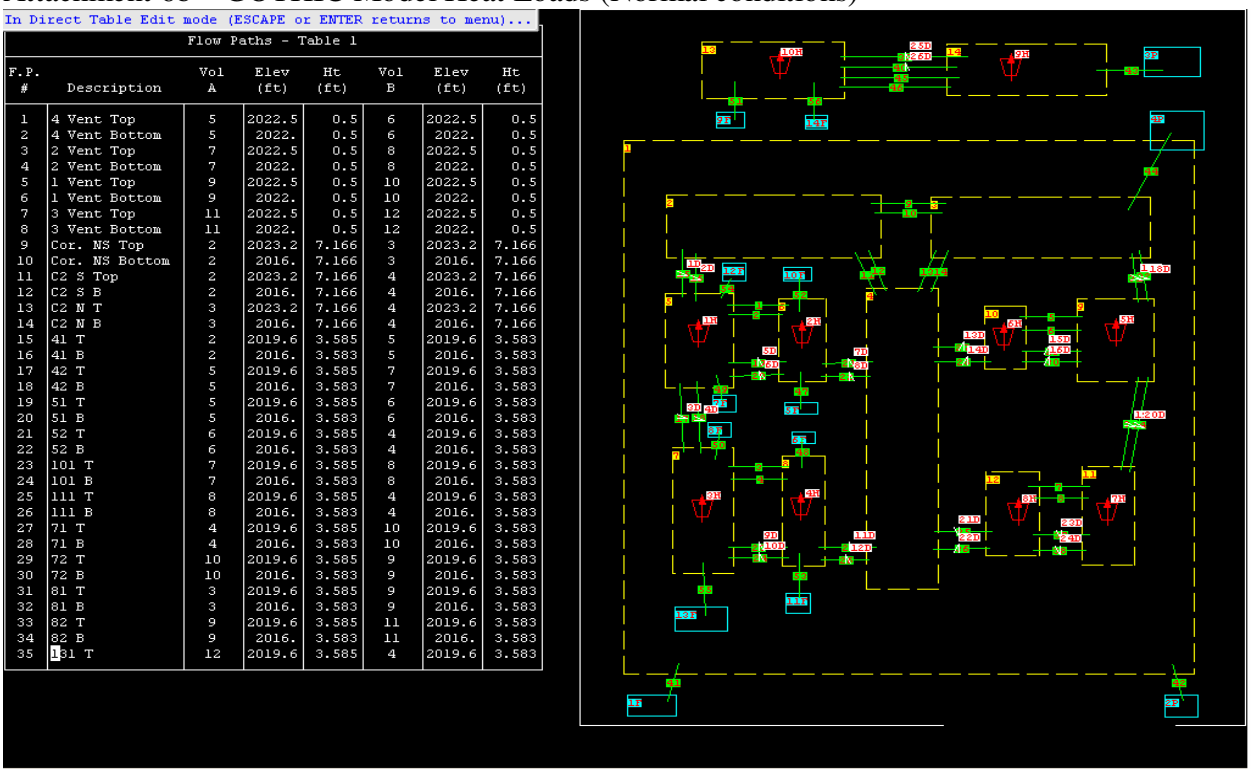
Locate Cooler
Locate Heater
Remove Component
Replace Component
Display Subvolumes
Position Component
Display Volumes
Edit Table...
Done

Attachment 6a – GOTHIC Model Heat Loads (ESFAS conditions)

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr



Attachment 6b – GOTHIC Model Heat Loads (Normal conditions)



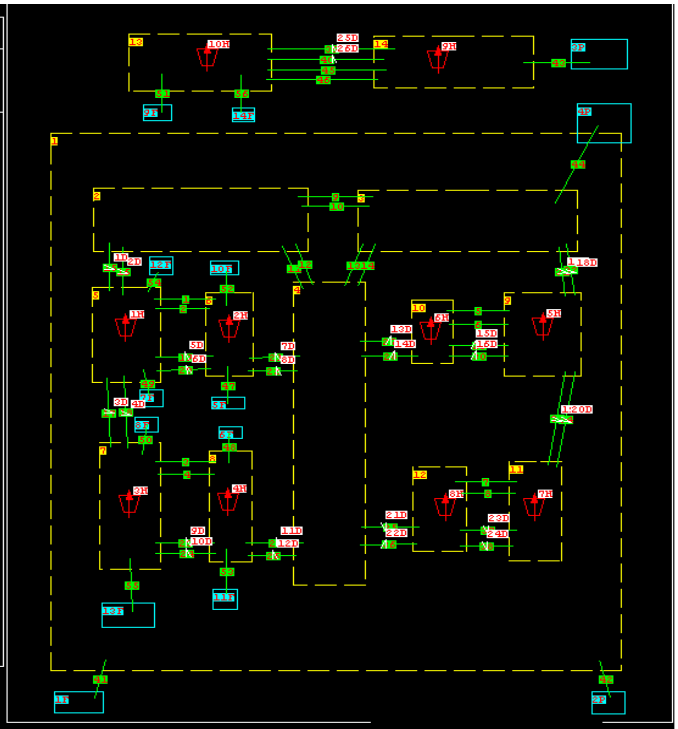
Attachment 7a – GOTHIC Model Flowpaths page 1a

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

Flow Paths - Table 2

Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Dep Bend (deg)	Mom Trn Opt	Strat Flow Opt
1	0.347	0.833	15.7				-	NONE
2	0.347	0.833	15.7				-	NONE
3	0.347	0.833	15.7				-	NONE
4	0.347	0.833	15.7				-	NONE
5	0.347	0.833	15.7				-	NONE
6	0.347	0.833	15.7				-	NONE
7	0.347	0.833	15.7				-	NONE
8	0.347	0.833	15.7				-	NONE
9	47.778	9.101	44.				-	NONE
10	47.778	9.101	44.				-	NONE
11	43.	13.063	21.8				-	NONE
12	43.	13.063	21.8				-	NONE
13	43.	13.063	21.8				-	NONE
14	43.	13.063	21.8				-	NONE
15	8.958	3.707	14.666				-	NONE
16	8.958	3.707	14.666				-	NONE
17	8.958	3.707	21.166				-	NONE
18	8.958	3.707	21.166				-	NONE
19	11.944	4.55	15.666				-	NONE
20	11.944	4.55	15.666				-	NONE
21	11.944	4.55	12.417				-	NONE
22	11.944	4.55	12.417				-	NONE
23	11.944	4.55	15.666				-	NONE
24	11.944	4.55	15.666				-	NONE
25	11.944	4.55	12.417				-	NONE
26	11.944	4.55	12.417				-	NONE
27	11.944	4.55	12.333				-	NONE
28	11.944	4.55	12.333				-	NONE
29	11.944	4.55	15.666				-	NONE
30	11.944	4.55	15.666				-	NONE
31	14.333	5.134	14.666				-	NONE
32	14.333	5.134	14.666				-	NONE
33	14.333	5.134	21.166				-	NONE
34	14.333	5.134	21.166				-	NONE



Attachment 7b – GOTHIC Model Flowpaths page 1b

In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

Flow Paths - Table 1

F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
22	52 B	6	2016.	3.583	4	2016.	3.583
23	101 T	7	2019.6	3.585	8	2019.6	3.583
24	101 B	7	2016.	3.583	8	2016.	3.583
25	111 T	8	2019.6	3.585	4	2019.6	3.583
26	111 B	8	2016.	3.583	4	2016.	3.583
27	71 T	4	2019.6	3.585	10	2019.6	3.583
28	71 B	4	2016.	3.583	10	2016.	3.583
29	72 T	10	2019.6	3.585	9	2019.6	3.583
30	72 B	10	2016.	3.583	9	2016.	3.583
31	81 T	3	2019.6	3.585	9	2019.6	3.583
32	81 B	3	2016.	3.583	9	2016.	3.583
33	82 T	9	2019.6	3.585	11	2019.6	3.583
34	82 B	9	2016.	3.583	11	2016.	3.583
35	131 T	12	2019.6	3.585	4	2019.6	3.583
36	131 B	4	2016.	3.583	12	2016.	3.583
37	141 T	11	2019.6	3.585	12	2019.6	3.583
38	141 B	11	2016.	3.583	12	2016.	3.583
39	11+23 T	13	2004.	4.	14	2004.	4.
40	11+23 B	13	2000.	4.	14	2000.	4.
41	Wind in	1	2000.	100.	1F	2000.	100.
42	Wind out	1	2000.	100.	2P	2000.	100.
43	ESF Pressure	14	2006.	1.	3P	2006.	1.
44	2016 Pressure	3	2022.	1.	4P	2022.	1.
45	Grill Top	13	2008.	2.	14	2008.	2.
46	Grill Bottom	13	2006.	2.	14	2006.	2.
47	B4 in	6	2022.	2.	5F	2022.	2.
48	B2 in	8	2022.	2.	6F	2022.	2.
49	S4 in	5	2022.	2.	7F	2022.	2.
50	S2 in	7	2022.	2.	8F	2022.	2.
51	ESF in	13	2006.	2.	9F	2006.	2.
52	B4 out	6	2020.	2.	10F	2020.	2.
53	B2 out	8	2020.	2.	11F	2020.	2.
54	S4 out	5	2020.	2.	12F	2020.	2.
55	S2 out	7	2020.	2.	13F	2020.	2.
56	ESF out	13	2004.	2.	14F	2004.	2.

Attachment 7c – GOTHIC Model Flowpaths page 2a

2016' Aux. Building Battery and SWBD room GOTHIC temperature analysis	**CALCULATION NO :** GK-19, Rev. 0 Add. 3	
	PREPARED BY: Kurt Linsenbardt	**REVIEWED BY:** Tom Carr

In Direct Table Edit mode (ESCAPE or ENTER returns to menu)...

Flow Paths - Table 2

Flow Path #	Flow Area (ft2)	Hyd. Diam. (ft)	Inertia Length (ft)	Friction Length (ft)	Relative Rough-ness	Dep Bend (deg)	Mom Trn Opt	Strat Flow Opt
23	11.944	4.55	15.666				-	NONE
24	11.944	4.55	15.666				-	NONE
25	11.944	4.55	12.417				-	NONE
26	11.944	4.55	12.417				-	NONE
27	11.944	4.55	12.333				-	NONE
28	11.944	4.55	12.333				-	NONE
29	11.944	4.55	15.666				-	NONE
30	11.944	4.55	15.666				-	NONE
31	14.333	5.134	14.666				-	NONE
32	14.333	5.134	14.666				-	NONE
33	14.333	5.134	21.166				-	NONE
34	14.333	5.134	21.166				-	NONE
35	11.944	4.55	12.333				-	NONE
36	11.944	4.55	12.333				-	NONE
37	11.944	4.55	15.666				-	NONE
38	11.944	4.55	15.666				-	NONE
39	24.	6.857	49.5				-	NONE
40	24.	6.857	49.5				-	NONE
41	10000.	100.	500.				-	NONE
42	10000.	100.	500.				-	NONE
43	1.	1.	20.				-	NONE
44	1.	1.	20.				-	NONE
45	4.	2.	49.5				-	NONE
46	4.	2.	49.5				-	NONE
47	4.	2.	5.				-	NONE
48	4.	2.	5.				-	NONE
49	4.	2.	5.				-	NONE
50	4.	2.	5.				-	NONE
51	4.	2.	5.				-	NONE
52	4.	2.	5.				-	NONE
53	4.	2.	5.				-	NONE
54	4.	2.	5.				-	NONE
55	4.	2.	5.				-	NONE
56	4.	2.	5.				-	NONE

Attachment 7d – GOTHIC Model Flowpaths page 2b

ATTACHMENT 7

USE OF GOTHIC 7.2a

Numerical Applications, Inc. (NAI) is the developer of the GOTHIC thermal hydraulics analysis code which has been used previously for Callaway containment pressure/temperature analyses and numerous other nuclear plant related analysis tasks. (See the discussion of License Amendment 168 below.) GOTHIC is developed and maintained under NAI's QA Program that conforms to the requirements of 10CFR50 Appendix B and 10CFR Part 21. Detailed descriptions of available GOTHIC user options and models are included in References 1 and 2 below. Information about GOTHIC qualification is available in Reference 3. The Callaway engineers qualified to use GOTHIC document their proficiency via the Engineering Support Personnel (ESP) qualification card requirement titled "ESP/504A, Perform Containment Pressure / Temperature Calculation Using the GOTHIC Computer Code."

1. George, TL, et al., *GOTHIC Containment Analysis Package User Manual,* Version 7.2a(QA), NAI 8907-02, Rev. 17, Numerical Applications, Inc., Richland, WA, January 2006.

2. George, TL, et al., *GOTHIC Containment Analysis Package Technical Manual,* Version 7.2a(QA), NAI 8907-06, Rev. 16, Numerical Applications, Inc., Richland, WA, January 2006.

3. George, TL, et al., *GOTHIC Containment Analysis Package Qualification Report,* Version 7.2a(QA), NAI 8907-09, Rev. 9, Numerical Applications, Inc., Richland, WA, January 2006.

The following discussion of GOTHIC 7.2a was provided in ULNRC-05734 dated October 26, 2010:

> **"GOTHIC 7.2a (Callaway 50.59 Evaluation Log No. 06-02)**
>
> GOTHIC 7.2a Software Documentation Package
>
> Activity Description:
>
> Current Containment/Main Steam Tunnel temperature/pressure analyses performed for FSAR Chapters 3.B and 6.2 were completed by Westinghouse using version 7.1pl of the GOTHIC code. However, future analyses will be performed by Callaway personnel on site, and GOTHIC version 7.1 p1 is no longer distributed by EPRI. GOTHIC version 7.2 replaced version 7.1 p1, but version 7.2a will be considered since most of the changes were corrections of errors from version 7.2. A software documentation package has been prepared to enable the use of GOTHIC version 7.2a per procedure EDP-ZZ-04011, "Nuclear Engineering Analytical Software Controls." This 10 CFR 50.59 Evaluation is being performed as part of the 10 CFR 50.59 review of the Software Documentation Package.

Summary of Evaluation:

Evaluation question 8, "Does the proposed activity result in a departure from a method of evaluation described in the FSAR used in establishing the design bases or in the safety analyses?" is applicable to this change. GOTHIC 7.2a calculates some results that are conservative and some that are non-conservative with respect to results from version 7.1p1. A review of the change in these results indicates that the results are conservative or essentially the same as those from GOTHIC version 7.1 p1 and thus do not represent a departure from a method of evaluation described in the FSAR and do not require prior NRC approval. Other limitations on the use of GOTHIC remain consistent with NRC approval of the use of GOTHIC in previous applications. In addition, user-controlled enhancements which could impact the results in GOTHIC 7.2a will not be used for Callaway calculations."

The validation of GOTHIC 7.2a included the comparison of peak containment temperatures calculated for 3 LOCA cases and 3 MSLB cases approved by the NRC in LA168 using GOTHIC 7.1p1.

Summary of Changes in Peak Containment Temperatures from GOTHIC 7.1p1 to GOTHIC 7.2a						
	LOCA DEPSG (pump suction) MaxSI	LOCA DEPSG (pump suction) MinSI	LOCA DEHL (hot leg)	MSLB DER 102% RTP failed MSIV	MSLB Split Break 2% RTP failed EDG	MSLB Main Steam Tunnel 1.0 sq.ft. one SI train
Peak Temperature Change	-0.22%	-0.19%	-0.18%	-0.19%	-0.18%	0.01%

The following is an excerpt approving GOTHIC 7.1p1 from the Safety Evaluation for Callaway License Amendment 168 dated September 29, 2005 (Callaway Plant, Unit 1 – Issuance of Amendment Regarding the Steam Generator Replacement Project (TAC NO. MC4437), ADAMS ACCESSION Numbers: ML052570054, Package ML052570086, TS ML052730083):

"3.6.3.3 Application of GOTHIC to Callaway Containment Safety Analyses

The GOTHIC code is a general purpose thermal hydraulics computer program for the analysis of a nuclear power plant containment. GOTHIC was developed for the Electric Power Research Institute (EPRI) by Numerical Applications, Incorporated (NAI). NAI validated GOTHIC by comparison with analytical solutions and experimental data. The NRC has previously approved containment analyses using the GOTHIC code. The licensee stated that it has used GOTHIC 7.1p1 for the containment analyses and these analyses are consistent with the conditions and limitations of a previous staff review of GOTHIC (Reference 6.3).

In the following statement, the licensee described the quality assurance program used for the application of the GOTHIC code to Callaway.

> The GOTHIC computer code for the Callaway RSG [replacement steam generator] Program was developed and implemented by Westinghouse in accordance with their Quality Assurance program. That invokes the requirements of 10 CFR 21 and 10 CFR 50 Appendix B. Westinghouse is currently listed on the AmerenUE Qualified Supplier List for Engineering Services.

Based on this quality control on the application of the GOTHIC code to Callaway, the NRC staff finds that the licensee's use of GOTHIC in the Callaway containment analyses is acceptable."

"8.0 REFERENCES

Section 3.6 of this SE:

6.1 Westinghouse LOCA Mass and Energy Release Model for Containment Design, WCAP- 10325-P-A, May 1983 (Proprietary), WCAP 10326-A (Non-Proprietary) March 1979.

6.2 GOTHIC Containment Analysis Package, Version 7.0, Electric Power Research Institute.

6.3 Issuance of Kewaunee Nuclear Power Plant License Amendment No. 169, September 29, 2003."