FirstEnergy

CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

☐ BV1	☐ BV2	☐ DB	☒ PY

Category	☒ Active	☐ Historical	☐ Study
Classification	☒ Safety-Related/Augmented Quality	☐ Nonsafety-Related	
Open Assumptions?	☐ Yes ☒ No	If Yes, Enter CR Tracking Number	
System Number:	E31		
Asset Number:	1E31N0361A/B/C/D		
Commitments:	None		
(Perry Only)	Calculation Type: CALCA	Referenced In Atlas?	☐ Yes ☒ No
		Referenced In USAR Validation Database	☐ Yes ☒ No

Computer Program(S)

Program Name	Version / Revision	Category	Status	Description
GOTHIC	7.0	B	Active	Thermal Analysis
Microsoft Excel	1997 SR-2	C	Active	Spreadsheet Computations

Revision Record

Rev.	Affected Pages	Originator/Date	Reviewer/Date	Design Verifier/Date	Approver/Date
0	All	James E. Praser 06/11/2003 F. Bivins Calhoun 06/11/2003	David J. Godshalk 06/11/2003	David J. Godshalk 06/11/2003	Tom O'Reilly 06/11/2003
	Description of Change: N/A				
	Describe where the calculation has been evaluated for 10CFR50.59 applicability. 50.59 written by Bob Stackenborghs Doc. #?				
Rev.	Affected Pages	Originator/Date	Reviewer/Date	Design Verifier/Date	Approver/Date
	Description of Change:				
	Describe where the calculation has been evaluated for 10CFR50.59 applicability.				
Rev.	Affected Pages	Originator/Date	Reviewer/Date	Design Verifier/Date	Approver/Date
	Description of Change:				
	Describe where the calculation has been evaluated for 10CFR50.59 applicability.				
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	Description of Change:				
	Describe where the calculation has been evaluated for 10CFR50.59 applicability.				

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TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

OBJECTIVE OR PURPOSE:

The purpose of this calculation is to evaluate the temperature response in the Turbine Building to a Main Steam leak. This information will aid in determining the feasibility of increasing the setpoint limit for the turbine building temperature switches (1E31N0361A/B/C/D) that trigger MSIV isolation. It is desired to raise the current setpoint limit of 145°F to 160°F for leak detection temperature detectors 1E31N0361A/B/C/D, in order to avoid nuisance trips during the hot summer months.

Evaluation of the temperature responses at different values of steam line leak rates may also provide the necessary supporting data to help justify a change to the limiting leak rate that the temperature switches are designed to detect.

SCOPE OF CALCULATION/REVISION:

This calculation will re-establish the design basis for the temperature detectors, and supports a justification for selecting a new, higher leak rate value. A new, higher leak rate can be established such that the total mass effluent from the steam line leak would not exceed the total mass release from the main steam line break (141,687 lb_m) within two hours. A leak rate that satisfies this criterion would ensure that the 10CFR100 site boundary dose limit is not exceeded.

This calculation will also serve as the basis for the license amendment that will raise the setpoint limit for switches 1E31N0361A/B/C/D to 160°F. The calculation will show that temperature increases to 145°F and 160°F will not result in exceeding the 10CFR100 dose limits at the site boundary.

SUMMARY OF RESULTS/CONCLUSIONS: The analysis results indicate that neither a 2.9468 Lb_m/sec leak, nor a 10.99 Lb_m/sec leak, will result in an elevated temperature of 145°F near the E31 temperature detectors for any analyzed condition. A 19.68 Lb_m/sec leak will result in an elevated temperature of 145°F under the required 2 hrs, but not 160°F, for all analyzed conditions. Of the four leak rates, only a 45.11 Lb_m/sec leak will result in an elevated temperature of 160°F near the E31 temperature detectors for the analyzed conditions. It does so in less time than the required limit of 52 minutes 21 seconds.

LIMITATIONS OR RESTRICTIONS ON CALCULATION APPLICABILITY:

Evaluations are not performed for any proposed future power uprate conditions.

IMPACT ON OUTPUT DOCUMENTS:

N/A

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DOCUMENT INDEX

DIN No.	Document Number/Title	Revision, Edition, Date	Reference	Input	Output
1	ASHRAE Handbook, Fundamentals, I-P Edition	2001	☒	☐	☐
2	AISC, "Manual of Steel Construction"	Ninth Edition	☒	☐	☐
3	GE Energy Services, “Thermal Kit – First Energy Corporation – Perry #1 – Turbine 170X655”, 1LU0229	April 12, 2000	☐	☒	☐
4	GOTHIC Containment Analysis Package Users Manual	Version 7.0, July, 2001	☒	☐	☐
5	B-022-006	H	☐	☒	☐
6	B-022-047	E	☐	☒	☐
7	B-022-050	F	☐	☒	☐
8	D-101-017	G	☐	☒	☐
9	D-101-018	F	☐	☒	☐
10	D-102-011	E	☐	☒	☐
11	D-304-018	K	☐	☒	☐
12	D-409-011	J	☐	☒	☐
13	D-409-015	N	☐	☒	☐
14	D-409-029	P	☐	☒	☐
15	D-409-033	J	☐	☒	☐
16	D-409-037	J	☐	☒	☐
17	D-409-051	L	☐	☒	☐
18	D-409-053	L	☐	☒	☐
19	D-409-059	E	☐	☒	☐
20	D-409-062	J	☐	☒	☐
21	D-409-064	J	☐	☒	☐
22	D-409-070	C	☐	☒	☐
23	D-409-073	D	☐	☒	☐
24	D-409-076	E	☐	☒	☐
25	D-409-079	F	☐	☒	☐
26	D-409-083	J	☐	☒	☐
27	D-409-086	H	☐	☒	☐
28	D-409-089	L	☐	☒	☐
29	D-409-092	K	☐	☒	☐
30	D-409-095	K	☐	☒	☐

31	D-409-098	K	☐	☒	☐
32	D-502-130	D	☐	☒	☐
33	D-502-131	E	☐	☒	☐
34	D-502-132	E	☐	☒	☐
35	D-502-133	F	☐	☒	☐
36	D-502-134	D	☐	☒	☐
37	D-502-135	C	☐	☒	☐
38	D-502-136	F	☐	☒	☐
39	D-502-137	G	☐	☒	☐
40	D-502-139	D	☐	☒	☐
41	D-502-143	C	☐	☒	☐
42	D-502-152	-	☐	☒	☐
43	D-502-160	C	☐	☒	☐
44	D-502-161	D	☐	☒	☐
45	D-502-162	B	☐	☒	☐
46	D-912-625	L	☐	☒	☐
47	D-922-783	C	☐	☒	☐
48	D-922-784	C	☐	☒	☐
49	D-938-783	B	☐	☒	☐
50	D-938-784	B	☐	☒	☐
51	E-022-062	K	☐	☒	☐
52	PNPP Calculation 3.2.15.4	1	☐	☒	☐
53	Moody, Frederick J., “Introduction to Unsteady Thermofluid Mechanics”, John Wiley & Sons	1990	☐	☒	☐
54	GE Nuclear Energy Division, “System Criteria and Applications for Protection against the Dynamic Effects of Pipe Break”, Document No. 22A2625	2	☒	☐	☐

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TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks	

Analysis Methodology

This calculation evaluates the Turbine Building temperature response for four different Main Steam Line (MSL) leak rates (2.9468[1] Lb_m/sec, 10.99 Lb_m/sec, 19.68 Lb_m/sec, and 45.11 Lb_m/sec) using the GOTHIC computer code. The leakage flow rates used in this calculation were chosen to provide a broad range of flows based on parameters of significance to the problem. The flow rates were established based on the following rationale:

- 2.9468 Lb_m/sec

This leakage rate is equivalent to the current 25 gpm feedwater line leak that temperature switches 1E31N0361A/B/C/D are intended to detect.

$$25\frac{gal}{min}\times 0.13368\frac{ft^3}{gal}\times 52.905\frac{Lb_m}{ft^3}\div 60\frac{sec}{min}=2.9468\frac{Lb_m}{sec}$$

Note that the density is that of the feedwater at 425°F (DIN 3).

- 10.99 Lb_m/sec (Actual value calculated 10.9847 Lb_m/sec)

This leakage flow corresponds to the leakage from an equivalent 1 inch schedule 80 pipe break. (0.719 square inch opening multiplied by G = 2200 Lbm/sec-ft2 for steam at 1100 psia and 1190.4 Btu/lb_m). Steam conditions[2] are from Figure 3 of DIN 3. The conservative[3] value for G is obtained from the Moody diagram for maximum flow rate (DIN 53). A copy of the Moody Diagram is included as Attachment G. This leak is equivalent to a 93 gpm feedwater line leak.

- 19.68 Lb_m/sec (Actual value calculated 19.6788 Lb_m/sec)

This leakage flow corresponds to the integrated break flow released from a main steam line break (141, 687 Lb_m) (DIN 52) divided by 7200 seconds (two hours). Two hours is the basis for the 10CFR100 dose calculations. This leak is equivalent to a 167 gpm feedwater line leak.

- 45.11 Lb_m/sec (Actual value calculated 45.1153 Lb_m/sec)

This leakage flow corresponds to the leakage from an equivalent 2 inch schedule 80 pipe break (2.953 square inch opening times 2200 Lb_m/sec-ft2 for 1100 psia[2] steam). GE states that this opening size represents the maximum opening size for which the makeup systems can keep up. Thus, this opening size is defined by GE as not a LOCA (DIN 54). This leak is equivalent to a 383 gpm feedwater line leak.

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[1] This mass flow value contains a greater number of significant digits as compared to the accompanying flow rate values, because of multiple references to this specific number in other PNPP documents.

[2] Enercon is aware that the GE Thermal Kit identified in DIN 3 has been updated to contain the partial arc turbine modification. The latest Kit, 1LA0279, is contained in DI-237 Rev. 2. and gives a pressure of 980.7 psia. For a lower pressure to obtain the same flow rate would require a larger leakage area. This has no effect on the results of this calculation as the assumed leak rates were chosen somewhat arbitrarily in order to represent a range of flows.

[3] The Moody Diagram represents homogenous, equilibrium steam-water and, thus, presents lower G values than other publications for 1100 psia steam. The lower G value results in a smaller leak rate, which takes more time to elevate the room temperature.

The time at each leak rate that would result in a mass release equivalent to the main steam line break is calculated by dividing the mass equivalent of a main steam line break by the particular leak flow rate.

$$t = \frac{M}{Q}$$

where, t = time required for leak to result in mass release equivalent to the MSLB [seconds]
M = MSLB mass release equivalent of 141, 687 Lb_m
Q = leak rate [gpm]

This results in the following maximum allowable times for each leak rate:

2.9468 Lb_m/sec limit at 48,082 seconds, or 13 hrs 21 minutes 22 seconds

10.99 Lb_m/sec limit at 12,893 seconds, or 3 hrs 34 minutes 53 seconds

19.68 Lb_m/sec limit at 7200 seconds, or 2 hrs

45.11 Lb_m/sec limit at 3141 seconds, or 52 minutes 21 seconds[4]

Each evaluation will determine the time required to reach 145°F and 160°F at the location of temperature sensors 1E31N0361A/B/C/D. The E31 leak detection thermocouples are located on the East wall at column TB14, approximate elevation 632-feet (GOTHIC sub-volume V7s15). The calculation will contain thirty-six different case runs defined as follows. An individual case run will evaluate the temperature response due to each steam line leak rate occurring at each of the three defined leak locations for three external environmental conditions.

The GOTHIC computer code (Version 7.0) is used to model the Turbine Building. Local effects in the Turbine Building will be addressed by subdividing the volumes into smaller sub-volumes, then assigning the leak location to different sub-volumes. The local temperature in the vicinity of the leak detection thermocouples will then be calculated. The primary zones of interest are Environmental Zone TB-1 (DIN 51) and the underlying floors at the East end of the building. Flow paths with loss coefficients are used to connect various volumes, and the model initialization temperatures reflect steady-state conditions. Attachment A is provided for information to graphically identify the column-lines and elevations in the Turbine Building. A code-generated diagram in Attachment B indicates the basic layout of the Turbine Building GOTHIC model, showing the control volumes, the boundary conditions, and the interconnecting flow paths. The GOTHIC model will also take into account ventilation in the TB-1 Zone, the effect of steel heat sinks on the rate of temperature rise, and the effects of outdoor temperature.

Control Volumes

[4] It is understood that this leak rate will result in a mass effluent greater than a MSLB in less than two hours. The purpose of this leak rate is to provide additional information.

Control volumes are the basic building blocks of GOTHIC and are generally used to model individual rooms in a building. Control volumes may be subdivided in situations where buoyancy-induced flow is the primary means of mass transport or, as in this case, a steam line leak is small and there exists the possibility of only localized temperature increases.

The volume of equipment, piping, HVAC ducts, and other components within rooms is not subtracted from the total room volume[5]. The reference elevation is the floor of the control volume. The height is the distance from the floor to the ceiling of the control volume. The hydraulic diameter input for control volumes is defined as follows:

$D_H = \frac{4A}{P_w}$, where A is the cross-sectional area and P_w is the wetted perimeter (2*(L+W)).

There are seven subdivided control volumes for the Turbine Building model. The hydraulic diameter is calculated in the horizontal plane. All dimensions are taken from the concrete outline drawings (DIN 12 – 31). Refer to the accompanying isometric sketch (Attachment A) for the control volume layout, subdivision and dimensions.

<u>Control Volume 1 (CV1)</u>

CV1 is the operating floor at elevation 647.5'. This volume stretches the entire length of the turbine building from column TB1 to column TB17.

$V = 445.4*115.33*67.2 = 3{,}452{,}000\ ft^3$
$D_H = 4(115.33)(445.4)/2(115.33+445.4) = 183.2\ ft$[6]

This volume is subdivided into 24 sub-volumes as indicated on the turbine building isometric sketch (Attachment A). The vertical subdivisions are dimensioned to match several of the control volumes identified below. The horizontal subdivision at elevation 674.5' matches the elevation of the internal walls at columns TB9 and TB13.

<u>Control Volume 2 (CV2)</u>

CV2 extends from column TB1 to TB4. It is physically connected to the building operating deck at elevation 647.5’, but it extends down to elevation 620.5' on the West side of the Turbine Building. This volume was subdivided into six sub-volumes.

Preliminary runs of the model indicated that the inclusion of this volume had a negligible effect on the results. Therefore, it was disconnected and subdivisions were removed in order to improve the run

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[5] The exact volume is not critical to this analysis since air has little heat capacity and pressurization is not an issue. Additionally, a sensitivity case was run to determine the effect of reducing the Control Volume 7 by 10%, in order to account for piping, equipment, etc. The results were identical to the original run.
[6] The hydraulic diameter of the sub-volume channels for all of the Control Volumes is set to 1.0E+06 feet as recommended by the GOTHIC Users Manual (DIN 4).

times. Note that this volume remains in the model but that all physical data associated with it was not design verified.

Control Volumes 3-7 (CV3 – CV7)

These control volumes compose the area in the Turbine Building under the operating floor between column lines TB9 and TB14. Each control volume selected is an area between two column lines. These volumes extend from the floor elevation at 577.5' to three feet below the operating floor at 647.5'.

CV3 (TB9-TB10)
$V = 34.17*115.33*67 = 264,000\ ft^3$
$D_H = 4(115.33)(34.17)/2(115.33+34.17) = 52.7\ ft$

CV4 (TB10-TB11)
$V = 36.75*115.33*67 = 284,000\ ft^3$
$D_H = 4(115.33)(36.75)/2(115.33+36.75) = 55.7\ ft$

CV5 (TB11-TB12)
$V = 36.17*115.33*67 = 279,500\ ft^3$
$D_H = 4(115.33)(36.17)/2(115.33+36.17) = 55.1\ ft$

CV6 (TB12-TB13)
$V = 35.0*115.33*67 = 270,500\ ft^3$
$D_H = 4(115.33)(35.0)/2(115.33+35.0) = 53.7\ ft$

CV7 (TB13-TB14)
$V = 36.75*115.33*67 = 284,000\ ft^3$
$D_H = 4(115.33)(36.75)/2(115.33+36.75) = 55.7\ ft$

Each of these volumes is subdivided into 18 sub-volumes. The first horizontal subdivision at elevation 589.5' corresponds to the height of the cubicle walls at the bottom of the Turbine Building. The second elevation subdivision at 620.0' is the grade elevation, which also roughly corresponds to the bottom elevation of some of the internal junctions. The internal junctions allow air to flow from one area to another (Floors are at 620' and 624'). See Attachment A.

The critical sub-volume of concern is V7s15, which contains the temperature detectors.

Thermal Conductors

Above grade at elevation 620 ft (DIN 10), the Turbine Building is treated as though it is conducting with the outside environment. The outdoor temperature used depends on the case being evaluated. Refer to Section "Initial Conditions". The heat transfer coefficient of the outside surface vertical walls above grade is set to 1.46 Btu/hr-ft^2-°F (DIN 1, still air on a vertical non-reflective surface). The heat transfer coefficient of the roof on CV1 is set to 1.63 Btu/hr-ft^2-°F (DIN 1, still air on horizontal non-reflective surface with heat flowing upwards). The inside surface allows natural convection depending on the slab orientation (vertical, face up, face down). Below grade, the Turbine Building surface walls conduct directly with the ground. Ground temperature is set constant at 53°F (see Assumption 6). According to the D-409 series drawings (DIN 12 – 31), the concrete walls, as well as the floor of CV1, are three feet thick and extend from the bottom elevation of the Turbine Building to above grade at Elevation 647.5'. This encompasses all of Control Volumes 3 – 7. Control Volume 1, which starts at Elevation 647.5', has steel walls and a steel ceiling. However, for CV1 between Elevations 647.5' and 674.5', there are concrete walls just inside the outside steel walls. Since the concrete is significantly thicker than the steel, these walls are treated solely as concrete. Rigorous accounting of the steel in CV1 is not required. Control Volume 1 lies above Control Volume 7 where the temperature sensors reside. Any minor changes to the temperature profile above CV7 will not affect the steady state temperature at the thermocouples, because air is being moved up from below the operating floor through forced convection. The areas of the walls and ceiling/roof of CV1 were determined by drawings D-101-017 (DIN 8) and D-101-018 (DIN 9). The areas of the walls and ceiling/floors of CV3 – CV7 were determined by drawings D-409-011 (DIN 12) and D-409-015 (DIN 13). The GOTHIC preprocessor is used to suitably node the concrete and steel slabs. The slabs are sized to match the dimensions shown on the Turbine Building isometric sketch (Attachment A). All wall, floor, and ceiling slabs are spanned across the volume subdivisions, which border the appropriate surface. All conductors are initialized at the same initial temperature of the volume in which they reside.

This model incorporates steel heat sinks as indicated by the D-502 series drawings (DIN 32 – 41, 43 – 46) for the Turbine Building. The total volume and surface area of steel is calculated for each of the control volumes below the operating floor (Control Volumes 3 – 7) in Attachment C. This includes platforms, steel framing, posts, and hangers. A set of spreadsheets displaying the cell formulas are provided in Attachment D.

The steel member type and length for each I-beam, post, and hanger in Control Volumes 3 - 7 was gathered from the D-502 series drawings listed above. Using steel member dimensions determined from the Steel Construction Manual (DIN 2), surface areas and volumes were calculated.

$$\text{Surface Area [sq.in.]} = (4 \times b_f + 2 \times d - 2 \times t_w) \times L \times 12$$
$$\text{Volume [cu.in.]} = [2 \times t_f \times b_f + (d - 2 \times t_f) \times t_w] \times L \times 12$$

where, b_f, d, t_f, and t_w are steel member dimensions [in.]
L = length of the steel member [ft]

The platforms are made up of grating that is constructed of 1-¼ inches by 3/16 inch bearing bars that are spaced 1-3/16 inches center-to-center (DIN 42). To determine the surface area and volume of the platforms, first the area footprint is determined from the D-502 series drawings for Control Volumes 3 – 7. Then, assuming the grating consists of only the bearing bars in one direction[7], the volume and surface area per square foot of grating is calculated using the following method:

$$N = \frac{L}{w \times d}$$

[7] The steel guide rods are not factored in for conservatism.

where, N = average number of bars per square foot of grating
L = length of bars [inches]
w = width of bars [inches]
d = distance between bars [inches]

There are on an average of 8.7 twelve-inch bars per square foot of grating. This gives a total of 104.4 inches of bar per square foot of grating.

$$V = L_A \times w \times t$$

where, V = volume per square foot of grating [cubic inches]
L_A = length of bar per square foot of grating [inches]
w = width of bars [inches]
t = thickness of bearing bars [inches]

Volume equals 24.5 cubic inches per square foot of grating.

VOLUME FACTOR : 24.5 in.^{3} / 1728 = .0142 feet cubed per square foot of foot print

$$SA = L_A \times t \times 2 + L_A \times w \times 2$$

where, SA = surface area per square foot of grating [square inches]
L_A = length of bar per square foot of grating [inches]
t = thickness of bearing bars [inches]
w = width of bars [inches]

Surface area equal 300 square inches per square foot of grating. The surface area created by the height x width dimensions are considered negligible for this calculation.

SURFACE AREA FACTOR : 300 in.^{2} / 144 = 2.083 square feet of surface area per square foot of foot print

Based on the total calculated volume and surface area, a steel conductor of appropriate thickness is spanned across each of the control volumes, maintaining a regular distribution across each sub-volume.

<u>Flow Paths (Junctions) and Leak Locations</u>

Flow paths are used to connect one volume to another, or to connect a boundary condition with a volume. There are large vertical openings between the lower volumes and large horizontal openings between the lower volumes and the operating deck. The flow areas, which expose multiple sub-volumes of different control volumes, must be broken into multiple flow paths.

The inertia length of a GOTHIC flow path is the center-to-center distance between the connected volumes. For this application, since the flow velocities are relatively small for volume-to-volume flow, the flow path inertia length is approximated at 30 feet for all volume-to-volume connections. The flow path friction length is also non-critical for this application and is set to 1 foot for all flow paths. The flow path friction length only becomes important when the model is concerned with buoyancy and thermally-induced flow. In this case, air movement is driven by forced convection (i.e. the ventilation system). The forward and reverse loss coefficient for all flow paths is set to 2.78 as recommended by the GOTHIC Users Manual (DIN 4).

Flow Paths 1-6 represent the three large openings in the wall at column-line TB13, which connect Control Volumes 6 and 7. Two junctions are used for each opening because the flow area of each spans two sub-volumes. Preliminary runs indicated that several inches of water would accumulate on the floor of CV7, so Flow Paths 24 and 25 were added to simulate the cubicle wall opening which connects Control Volumes 6 and 7. The dimensions for these flow paths were taken from drawing D-409-086 (DIN 27).

Flow Paths 7-14 represent the large wall openings at the column lines in the Turbine Building below the operating deck. The dimensions for these flow paths are taken from drawings D-409-089 (DIN 28), D-409-092 (DIN 29), and D-409-095 (DIN 30). In some cases, the dimensions of these flow paths have been approximated, and multiple flow paths have been combined into single flow paths. This approach is judged acceptable, since scoping runs indicated that the flow between these volumes would have little effect on the results.

Flow Paths 15 – 20, 26, and 27 are the horizontal openings on the operating deck (EL. 647'-5"). The area of these openings was derived from drawings D-409-029 (DIN 14) and D-409-033 (DIN 15).

Flow Path 21, at the top of the Turbine Building, is the ventilation air exit for the entire building. For modeling purposes, the area of the opening needs to be set large enough to allow the air to be driven to the outside atmosphere via means of BC 1P (see Boundary Conditions below).

Flow Path 22 is the opening in the main steam piping from which the steam leaks into the Turbine Building. The dimensions for this flow path are approximated. The approximation is irrelevant, because the flow, in this case, is driven by the boundary conditions.

Flow Path 23 is the opening of the Auxiliary Building steam tunnel to the Turbine Building. The dimensions for this flow path are taken from drawing D-409-062 (DIN 20).

Flow Paths 28 – 37 represent ventilation openings from the HVAC ducts to Control Volumes 3 – 7. Each CV has two flow paths. This represents the two main duct lines supplying each control volume. The discharge locations are combined into a single flow path per sub-volume for the GOTHIC model. The heights of the discharge locations are averaged for each sub-volume (DIN 47, 48). This is acceptable, because all air is considered homogeneous inside each sub-volume.

The purpose for the leak detection system is to provide a redundant means of detecting and isolating leaks in the primary coolant system (RCS) for BWRs. The system was intended by GE to prevent the escalation of a leak into the design basis accident. For this system, the design basis accident is the full main steam line break (i.e. 28 inch piping break). Therefore, the leak locations correspond to those locations where the full size main steam line piping is located.

Drawing D-304-018 (DIN 11) illustrates the main steam piping upstream of the Turbine Stop Valves (TSVs). The steam lines enter the TB from the Steam Tunnel at an approximate elevation of 630', then elbow downward to an approximate elevation of 592'. Sloping downward, these 28-inch lines traverse northward to column TB-E, where condensate traps are located. The large pipes elbow again, rising vertically (within about 5-feet of the east wall) to Elevation 635'-6". Here they elbow again and enter the TSVs. A Main Steam Line Break (MSLB) could occur in this piping at the lower elevations in the non-zoned region below TB-1.

Based on this, leaks are assumed at three locations:

1) MSLB at 624' near TB14 (east wall) and TBE (Turbine Building centerline between north and south wall)

2) MSLB at 592' near TB14 and TBI (southeast corner)

3) MSLB at 592' near TB13 and TBI (southwest corner)

Location 1 is chosen to determine the effects of ventilation on the thermocouples. Locations 2 and 3 are chosen since they are the farthest from the leak detection thermocouples and therefore represent the worst case from a detection standpoint.

Leaks in piping that are physically closer to the thermocouples are concluded by inspection to be bounded by leaks in these locations. Also, leaks in main steam branch lines are ignored since these leaks could not propagate into the large main steam line break that is the primary focus of this leak detection system.

To further verify that the chosen leak locations are bounding, two additional possible limiting cases were run. Both cases are under Winter (cold) conditions with a 2.9468 Lb_m/sec leak rate. These conditions exhibit the most conservative scenario, in which the most amount of steam would need to leak out before raising the room temperature to a specified point. Leak 4 was chosen as the point where the main steam line first enters the Turbine Building from the Steam Tunnel (GOTHIC sub-volume 7Vs18, EL. 630 ft). This location is farthest from the thermocouples at a higher elevation. Leak 5 was chosen to be located where the Main Steam line elbows up near TBE, directly below the thermocouples (GOTHIC sub-volume 7Vs9, EL. 601.5 ft). This leak would lie directly between the two vents inside their air paths. Since their respective maximum temperatures of 124.2°F and 129.4°F are greater than the maximum temperatures resulting from Leak Locations 1 and 3 under identical conditions, our current leak locations remain the most conservative. Thus, they are bounding.

To aid in maintaining conservatism, all steam leak flow paths were oriented to point in the West direction, away from the thermocouples on the East wall. A directional sensitivity case was run with a mass flow rate of 45.11 Lb_m/sec during summer conditions in leak location 3. The sensitivity run indicated that while a break oriented in the East and North directions both resulted in steady state temperatures of approximately 200°F, a break oriented in the West direction reached a steady state temperature of only 195°F.

<u>Boundary Conditions</u>

Boundary conditions provide a means of communication between the model and known conditions at the boundaries of the model. Thirteen boundary conditions are used for this model.

A pressure boundary condition 1P is connected to the top of the Turbine Building to prevent an unrealistic pressure increase inside the Turbine Building (i.e., simulate leakage to atmosphere). The pressure of this boundary is set slightly lower than atmospheric to allow the Turbine Building lower elevations to remain at atmospheric (considering the static head of air).

A flow boundary condition 2F is used to simulate the main steam line break (MSLB). The flow rate is multiplied by a forcing function to ramp the flow from zero to unity in the first second of the transient in order to prevent numerical problems which could occur if full flow were used at time zero. The following boundary condition values are for 25 gpm flow and were derived from Figure 3 of DIN 3, “Original VWO Flow”:

<u>MSLB</u>

flow	=	2.9468 lb_m/s, 10.99 lb_m/s, 19.68 lb_m/s, or 45.11 lb_m/s
enthalpy[8]	=	1190.4 Btu/lb_m
LVF[9]	=	0
SPR[10]	=	1

Another flow boundary condition 3F is used to inject inlet air from the steam tunnel. Based on drawing B-022-006 (DIN 5), the average air temperature is 121°F (see Assumption 2). The air-flow is 2500 scfm (DIN 46), which converts to 41.67 ft^3/s for input to the GOTHIC code.

Fluid boundary conditions 4F – 13F supply ventilation air to Control Volumes 3 – 7, according to the flow rates indicated on drawings D-922-783 (DIN 47) and D-922-784 (DIN 48). Their flow rates are summed together. This is acceptable, because all air is considered homogeneous inside each sub-volume. The ventilation air temperature is considered to be 63°F throughout the year (see Assumption 1).

The fluid pressure in both of these cases is not critical since it is used only to determine fluid density and thus the fluid momentum[11].

<u>Initial Conditions</u>

All volumes are initialized at atmospheric pressure. The initial temperature and humidity for both the Turbine Building control volumes and the outside environment are based on Drawings B-022-047 (DIN 6) and B-022-050 (DIN 7), respectively (see Table 1 below). All heat sinks are initialized at the same temperature as the Turbine Building control volumes.

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[8] Enercon is aware that the GE Thermal Kit identified in DIN 3 has been updated to contain the partial arc turbine modification. The latest Kit, 1LA0279, is contained in DI-237 Rev. 2. and gives an enthalpy of 1190.8 Btu/Lb_m. This GE value is only slightly greater than the value used in the GOTHIC analysis, thus it will have a minimal impact on the results of this calculation.

[9] Liquid Volume Fraction

[10] Steam Pressure Ratio

[11] Due to the low flow rate, the flow momentum is not important to this analysis.

Turbine Building Thermal Characteristics

Outdoor and initial Turbine Building temperature data (DIN 6, 7) is used to determine the Turbine Building thermal characteristics, thus providing a model which will give an adequate indication of temperature rise during the steam line leak.

Heat loads within each of the Turbine Building control volumes are approximated with artificial thermal conductors that contribute a specified heat flux to the Turbine Building. This feature of GOTHIC is used instead of heating components, because the conductors can be spanned over the entire subdivided volume, whereas heating components cannot be spanned. This method of approximating the heat load in the Turbine Building assumes that the heat load is distributed evenly. The correct heat load was determined through a trial-and-error method of simply setting all boundary conditions to those indicated in Table 1 below, and then modifying the heat flux of the conductors until the correct Turbine Building temperature was achieved. Based on this methodology, a 10,000 ft^2 steel conductor with the heat flux indicated in Table 1 was placed into each of the Turbine Building Control Volumes 3-7. Based on this benchmark model, the boundary conditions will be adjusted and the MSL leak added to determine the thermocouple sub-volume temperature.

Table 1
Environmental Conditions and Corresponding Heat Flux

Zone	OU-T		TB-1		Heat Flux
	Temp [°F]	RH	Temp [°F]	RH	[BTU/sq.ft]
High	104	100%	130	90%	155
Low	-10	20%	113	20%	144
Average	58	100%	122	50%	148

The use of these heat loads does not totally preclude a small temperature transient. Therefore, the steam line leak is delayed to t = 1 hour in order to allow the transient to steady. In addition to this, the heat load is introduced gradually to the Turbine Building, increasing from 0.7 of total at t = 0 seconds to unity at t = 1000 seconds (see forcing function #2 in Attachment E). This gradual introduction of the heat load decreases the time it takes for steady state to be achieved in the GOTHIC model.

Assumptions

1. Based on conversations with PNPP personnel, ventilation air remains at approximately 63°F for all outside air temperatures. Therefore, the ventilation air temperature is assumed to be 63°F.

2. For this analysis, the Steam Tunnel (Zone AB-7E) average temperature of 121°F (DIN 5) will be used for all cases. This is reasonable since the air flow between the Auxiliary Building steam tunnel and the Turbine Building is relatively small compared to the area ventilation flow rate.

3. Minor contributors to the total steel volume, such as stairs and handrails, are ignored. HVAC ducts are not included because they were determined to be insulated per drawings D-938-783 (DIN 49) and D-938-784 (DIN 50).

4. Leaks are assumed at three locations:

   a) MSLB at 624' near TB14 (east wall) and TBE (Turbine Building centerline between north and south wall, sub-volume 7s15)
   b) MSLB at 592' near TB14 and TBI (southeast corner, sub-volume 7s11)
   c) MSLB at 592' near TB13 and TBI (southwest corner, sub-volume 7s12)

   Adequate justification will be provided in the "Flow Paths and Leak Locations" section of this calculation to confirm that the three current leak locations represent limiting locations for the assumed steam leak in relation to the position of the temperature sensors.

5. An enthalpy of 1190.4 Btu/lb_m (DIN 3) for the main steam line leak is based on thermodynamic conditions at the current 100% power level[12]. It is assumed constant for all MSL leak rates.

[12] Refer to footnote 8 on page 9.

6. A ground temperature of 53°F is assumed. The average between the hot (86°F) and cold (28°F) mean dry bulb temperatures (1% percentile) listed for Cleveland, Ohio in ASHRAE (DIN 1) is 57°F. Thus, this is judged to be a conservative assumption.

7. All steam leaks (Flow Path 22) are set to point towards the west direction. Setting the steam leaks to point away from the thermocouples on the east wall maximizes conservatism.

8. All other assumptions are stated within the calculation.

Acceptance Criteria

The temperature in the Turbine Building due to the 2.9468 lb_m/sec steam leak must reach the particular analytical limit (145°F or 160°F) in less than 13 hours 21 minutes 22 seconds.

The temperature in the Turbine Building due to the 10.99 lb_m/sec steam leak must reach the particular analytical limit (145°F or 160°F) in less than 3 hours 34 minutes 53 seconds.

The temperature in the Turbine Building due to the 19.68 lb_m/sec steam leak must reach the particular analytical limit (145°F or 160°F) in less than 2 hours.

The temperature in the Turbine Building due to the 45.11 lb_m/sec steam leak must reach the particular analytical limit (145°F or 160°F) in less than 52 minutes 21 seconds.

Basis: The total mass effluent from the steam line leak shall not exceed the total mass release from the main steam line break (141,687 lbm) within two hours. A leak rate that satisfies this criterion would ensure that the 10CFR100 site boundary dose limit is not exceeded.

Computation

The thermal response over a 24-hour period at the location of the temperature sensors and at the steam leak is calculated by the GOTHIC computer program. For further information on how GOTHIC performs its analysis, refer to the GOTHIC Users Manual (DIN 4).

Results

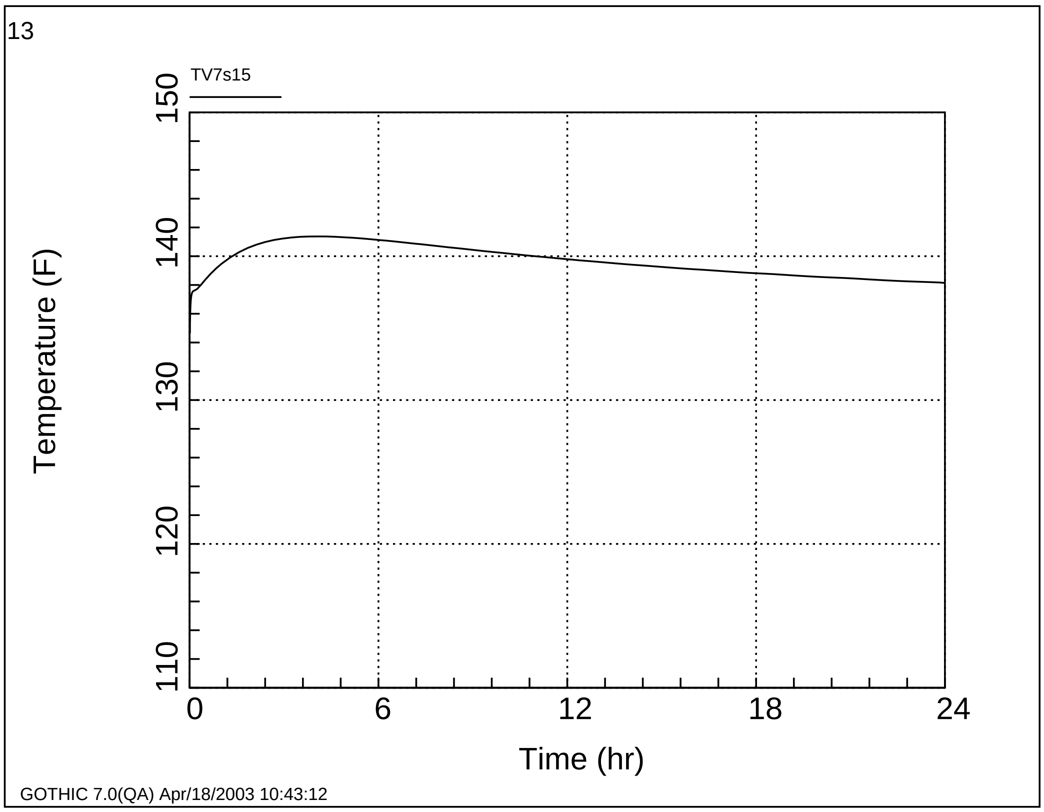
The resultant temperature graphs indicate the temperature of the sub-volume that contains the E31 leak detection thermocouples (located on the east wall at TB14, approximate elevation 632-feet, GOTHIC sub-volume V7s15). Also shown is the sub-volume temperature at the leak location (if different from the thermocouple sub-volume). The results over a 24-hour period for all 36 cases are displayed below. The following three summary items are listed below each graph.

- The maximum temperature realized at the location of the thermocouples, along with the time required to reach the maximum temperature.
- The time required to reach 145°F at the thermocouples[13].
- The time required to reach 160°F at the thermocouples[13].

A summary of the times required to reach 145°F and 160°F can be found in Tables 2 and 3, respectively, at the end of this section.

[13] Data points created by the GOTHIC analysis typically did not occur exactly at 145°F or 160°F. Because of this, the data point was chosen that occurred at a time with a realized temperature closest to, but not less than, the target temperature (usually within a few tenths of a degree).

Leak Location 1 – Summer
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 141.4°F after 4 hrs 3 min 50 sec

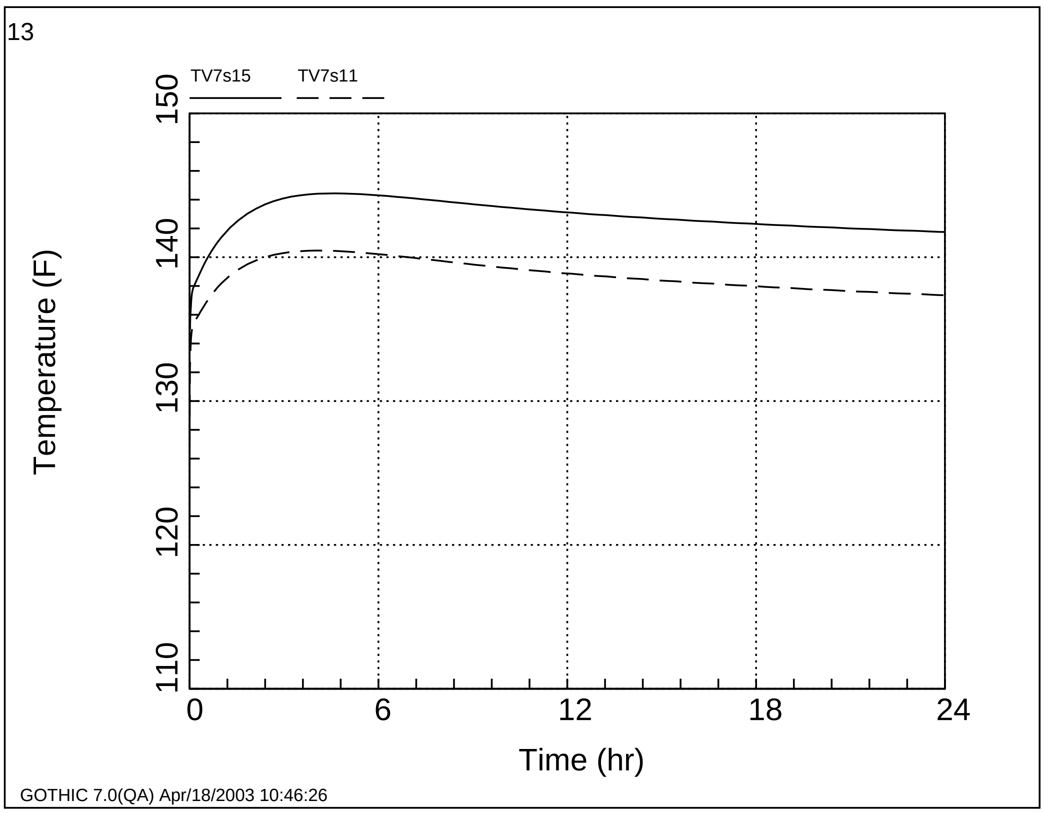
Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Summer
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 144.4°F after 4 hrs 37 min 10 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

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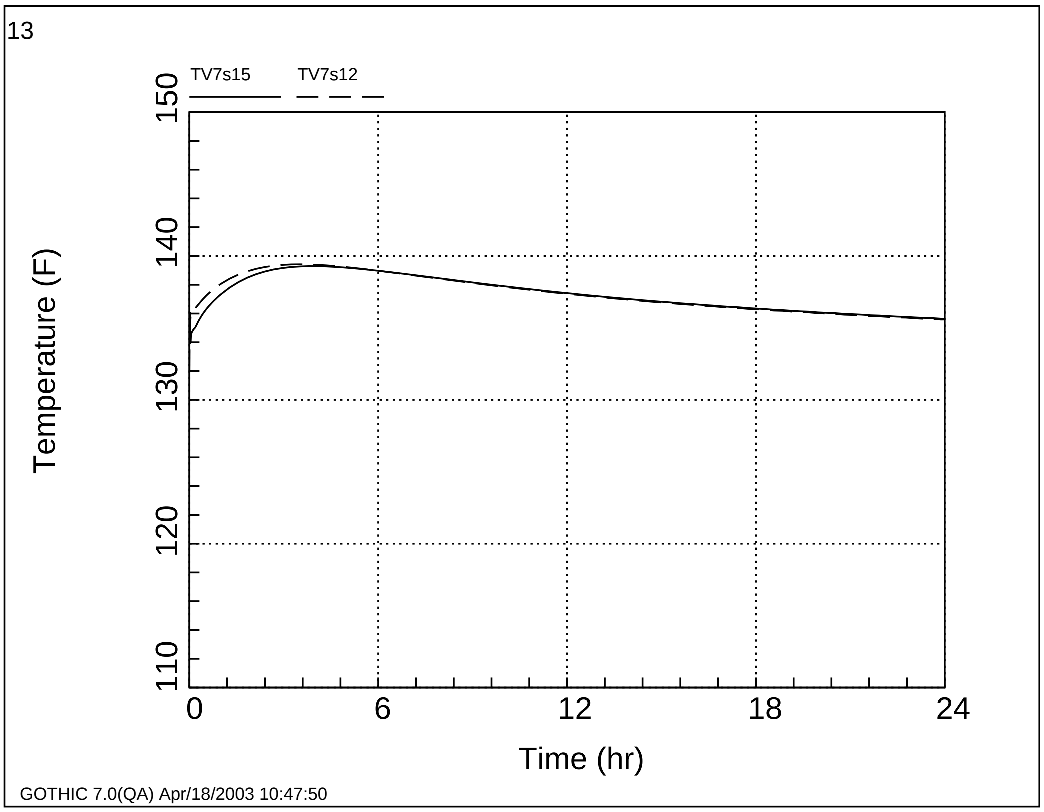
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Summer
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 139.3°F after 3 hrs 47 min 20 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

CALCULATION COMPUTATION

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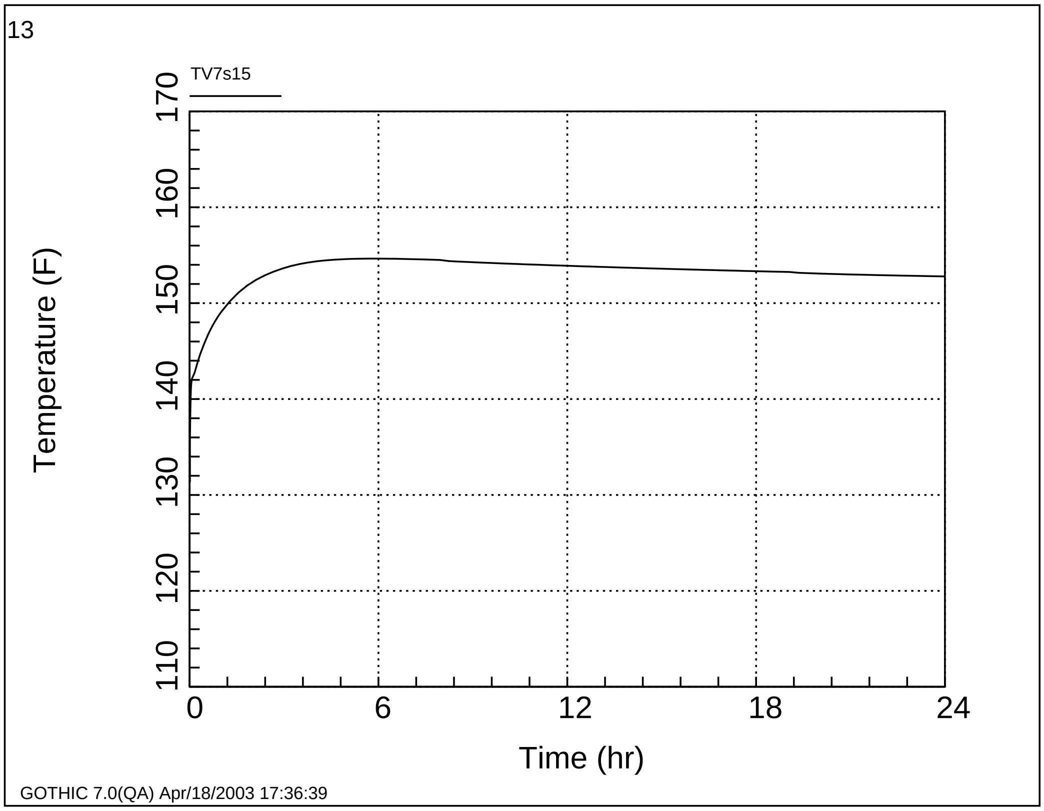
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 1 – Summer
10.99 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 154.6°F after 6 hrs 0 min 10 sec

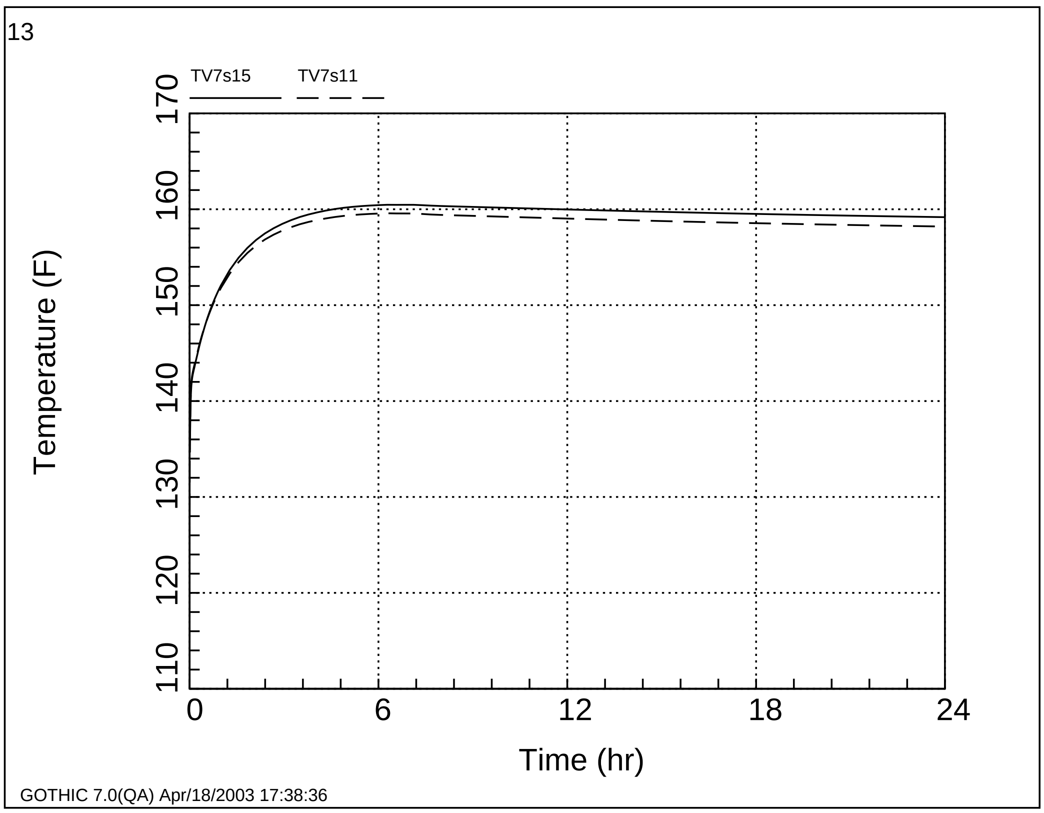
Time required to reach 145°F – 22 min 30 sec

Time required to reach 160°F – N/A

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Summer
10.99 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 160.5°F after 6 hrs 17 min 0 sec

Time required to reach 145°F – 15 min 24 sec

Time required to reach 160°F – 4 hrs 36 min 49 sec

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CALCULATION COMPUTATION

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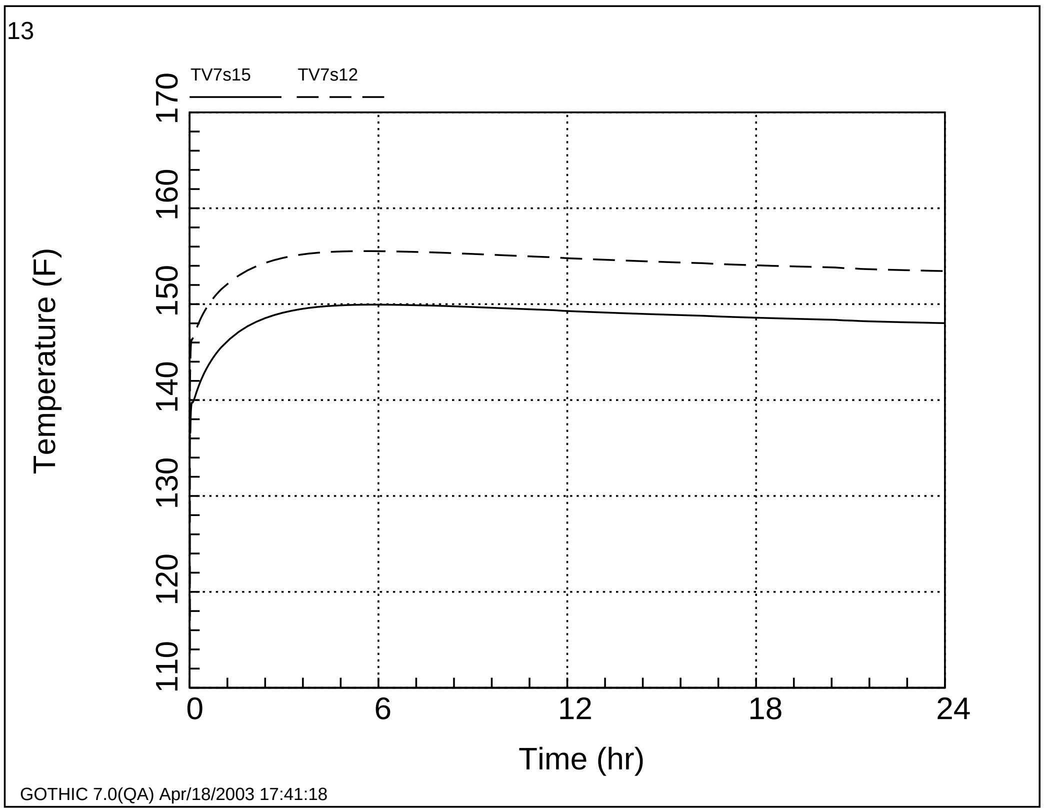
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Summer
10.99 Lb_m/sec leak rate



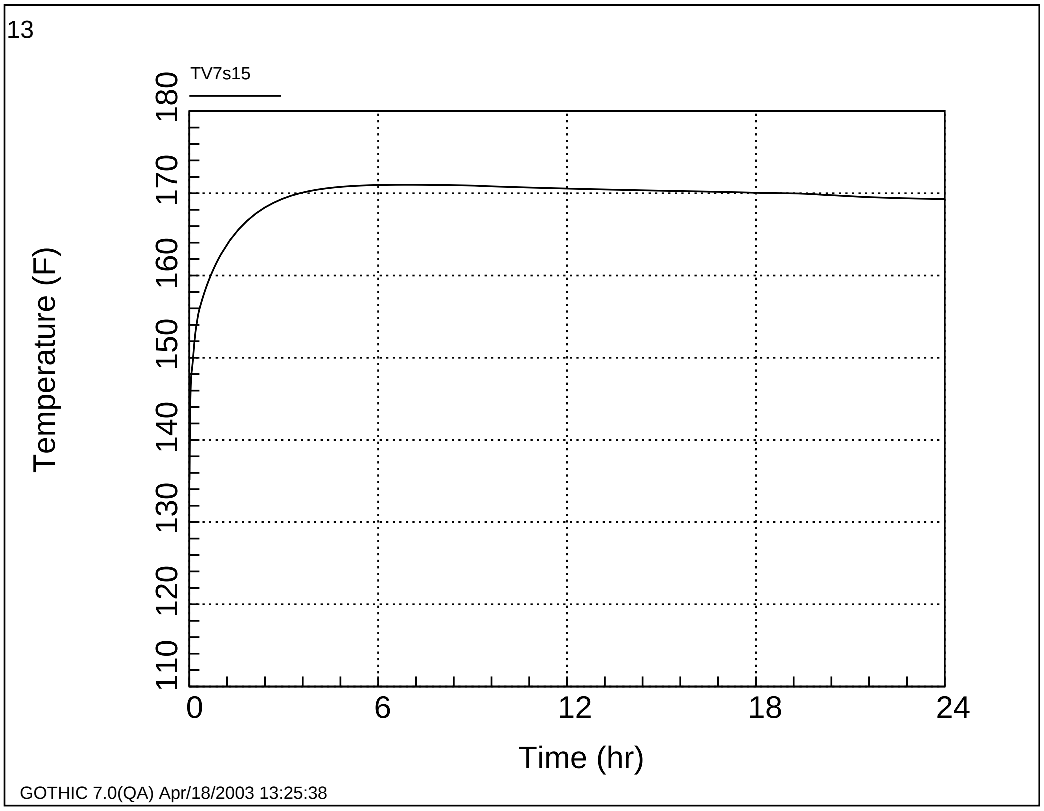
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 149.9°F after 5 hrs 44 min 20 sec

Time required to reach 145°F – 52 min 51 sec

Time required to reach 160°F – N/A

Leak Location 1 – Summer
19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 171°F after 6 hrs 50 min 30 sec

Time required to reach 145°F – 1 min 59 sec

Time required to reach 160°F – 40 min 52 sec

CALCULATION COMPUTATION

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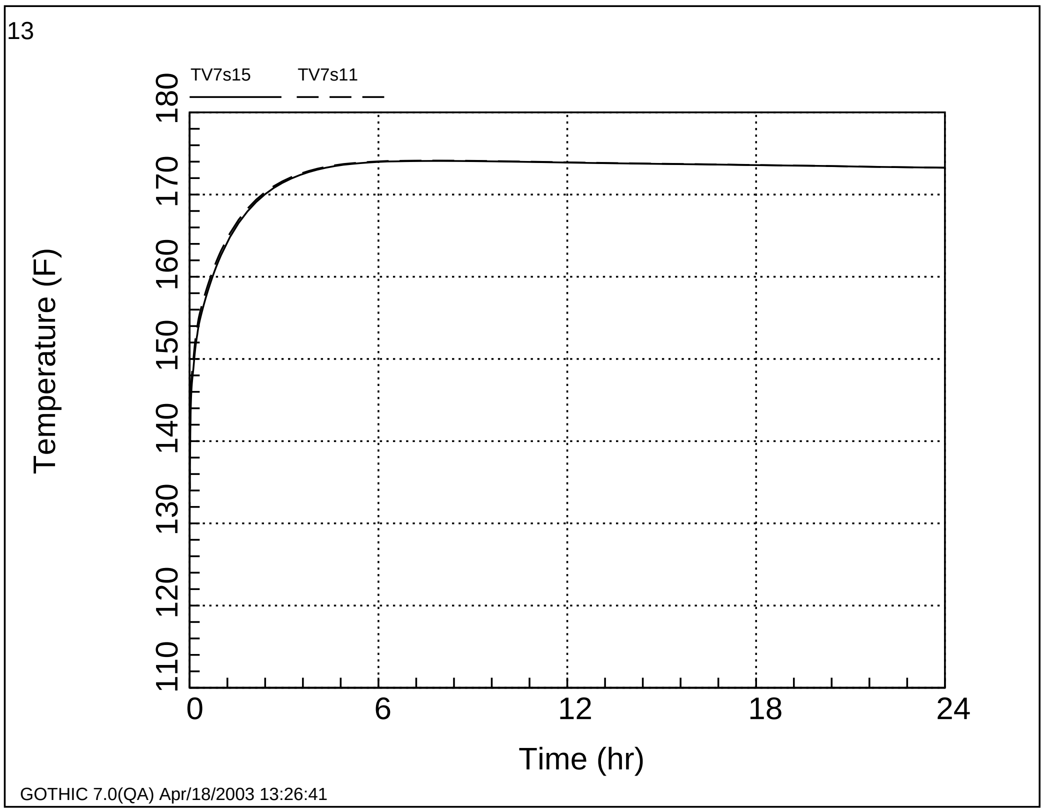
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Summer
19.68 Lb_m/sec leak rate



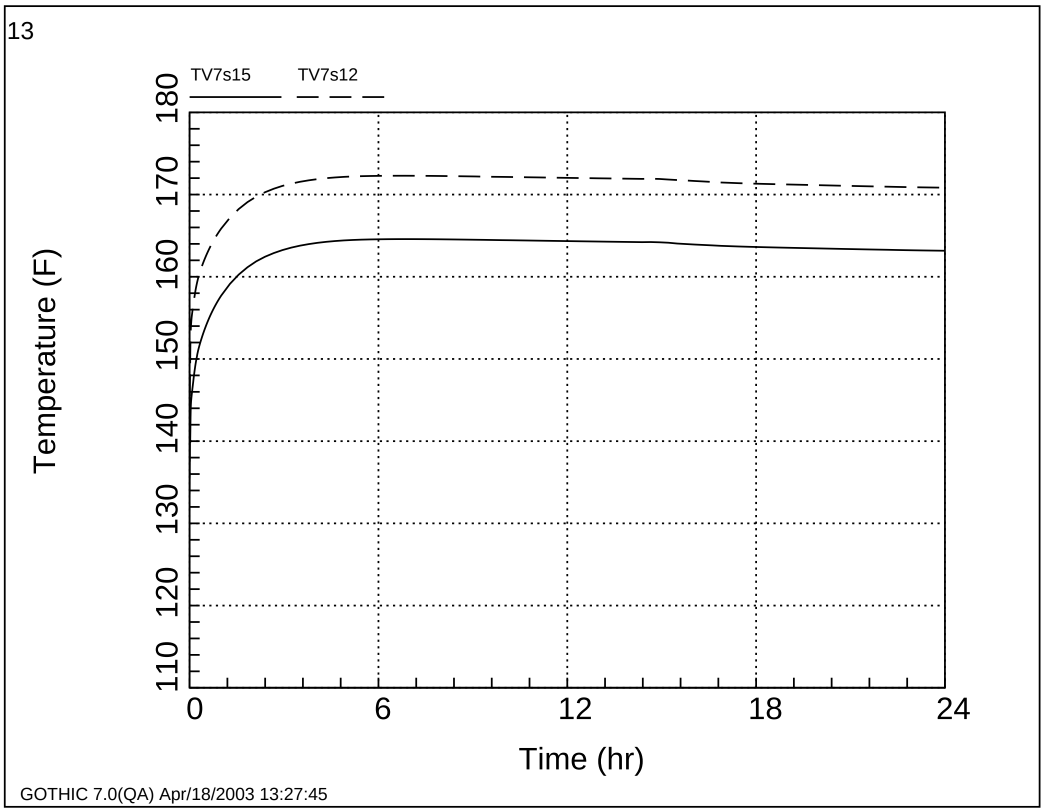
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 174.1°F after 7 hrs 57 min 0 sec

Time required to reach 145°F – 2 min 41 sec

Time required to reach 160°F – 43 min 52 sec

Leak Location 3 – Summer
19.68 Lb_m/sec leak rate



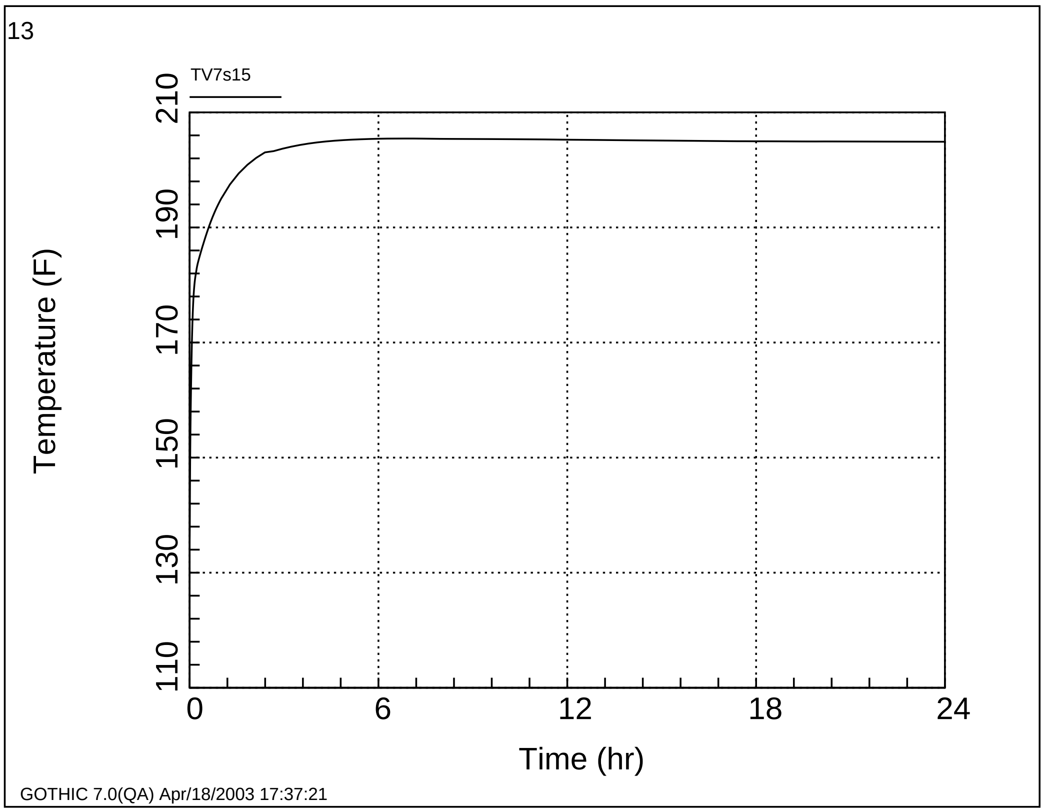
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 164.6°F after 6 hrs 51 min 0 sec

Time required to reach 145°F – 3 min 8 sec

Time required to reach 160°F – 1 hr 33 min 37 sec

Leak Location 1 – Summer
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 205.5°F after 6 hrs 50 min 20 sec

Time required to reach 145°F – 58 sec

Time required to reach 160°F – 2 min 39 sec

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CALCULATION COMPUTATION

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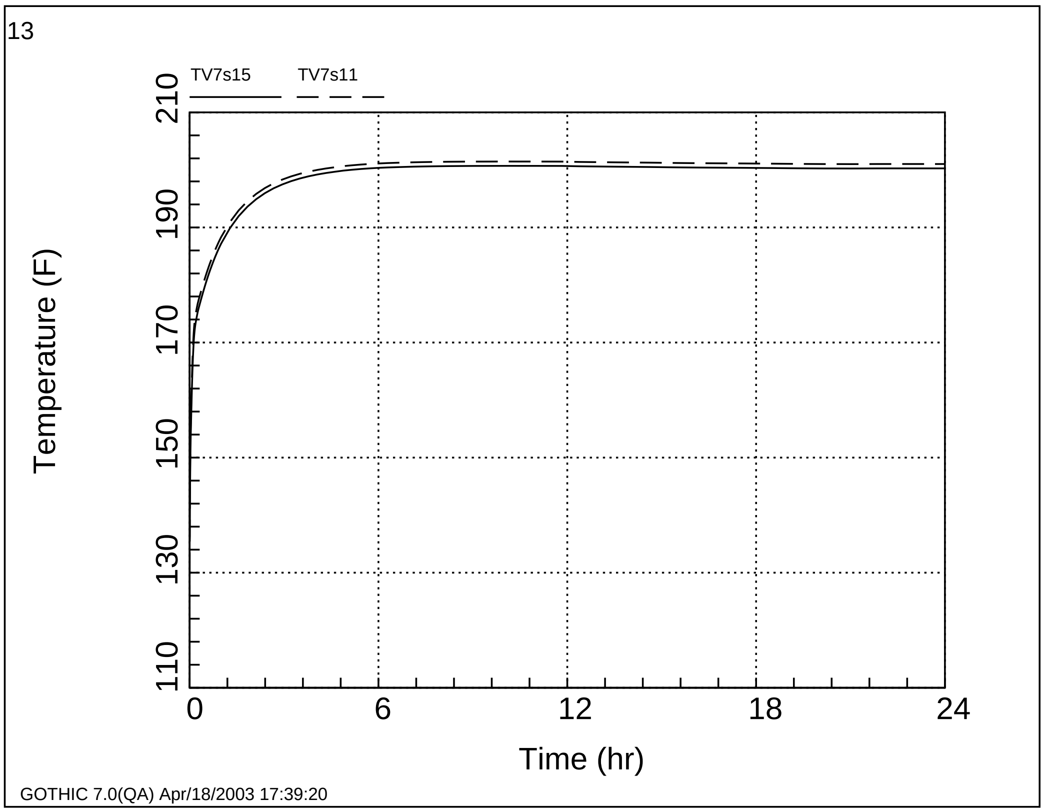
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Summer
45.11 Lb_m/sec Leak Rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 200.7°F after 10 hrs 10 min 20 sec

Time required to reach 145°F – 58 sec

Time required to reach 160°F – 3 min 59 sec

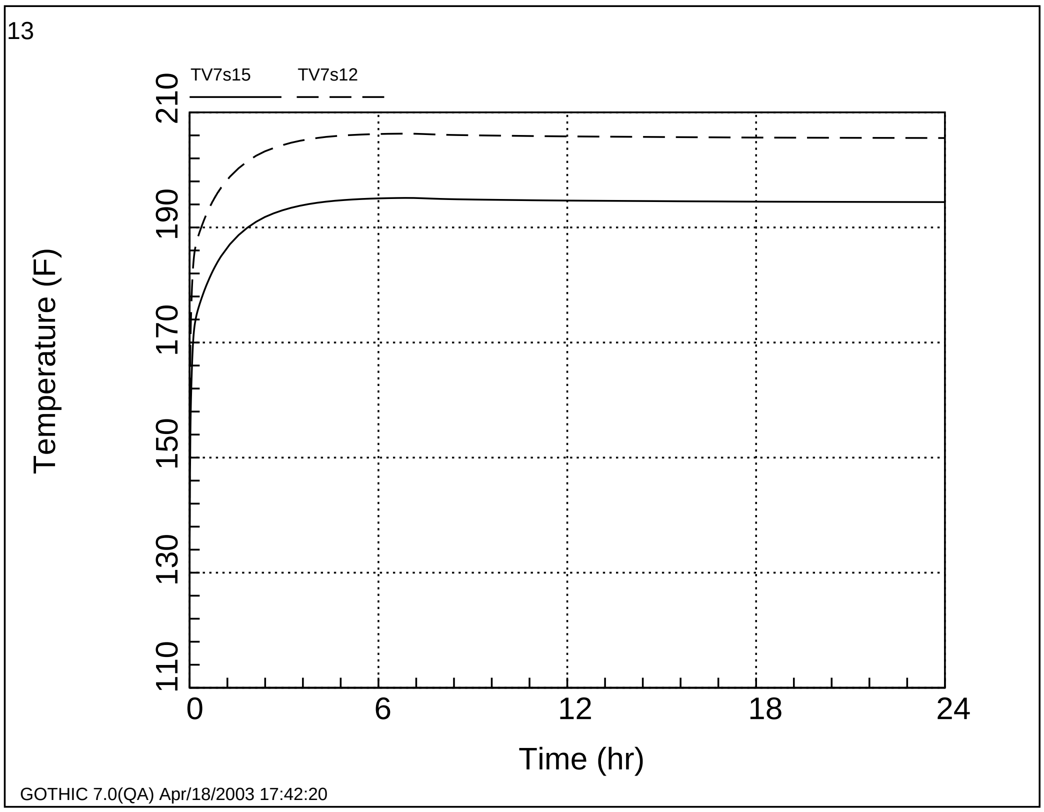
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Summer
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 195.1°F after 6 hrs 50 min 50 sec

Time required to reach 145°F – 40 sec

Time required to reach 160°F – 2 min 54 sec

FirstEnergy

CALCULATION COMPUTATION

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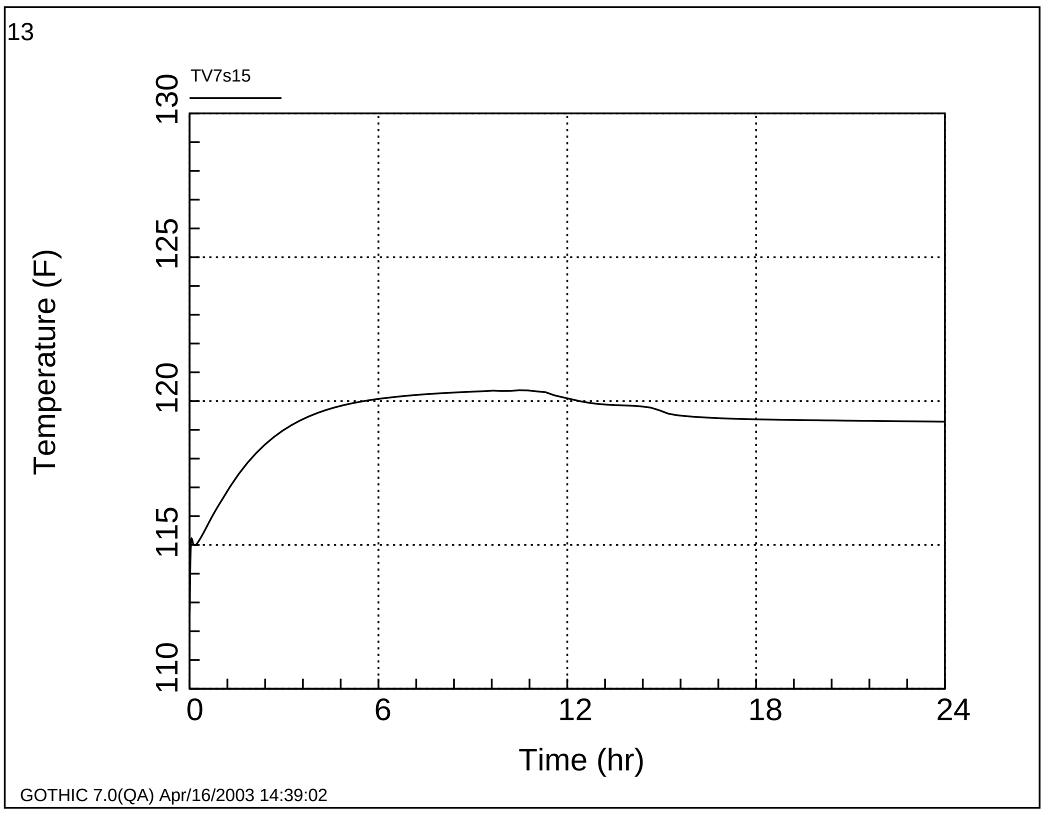
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 1 – Winter
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 120.4°F after 10 hrs 28 min 20 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

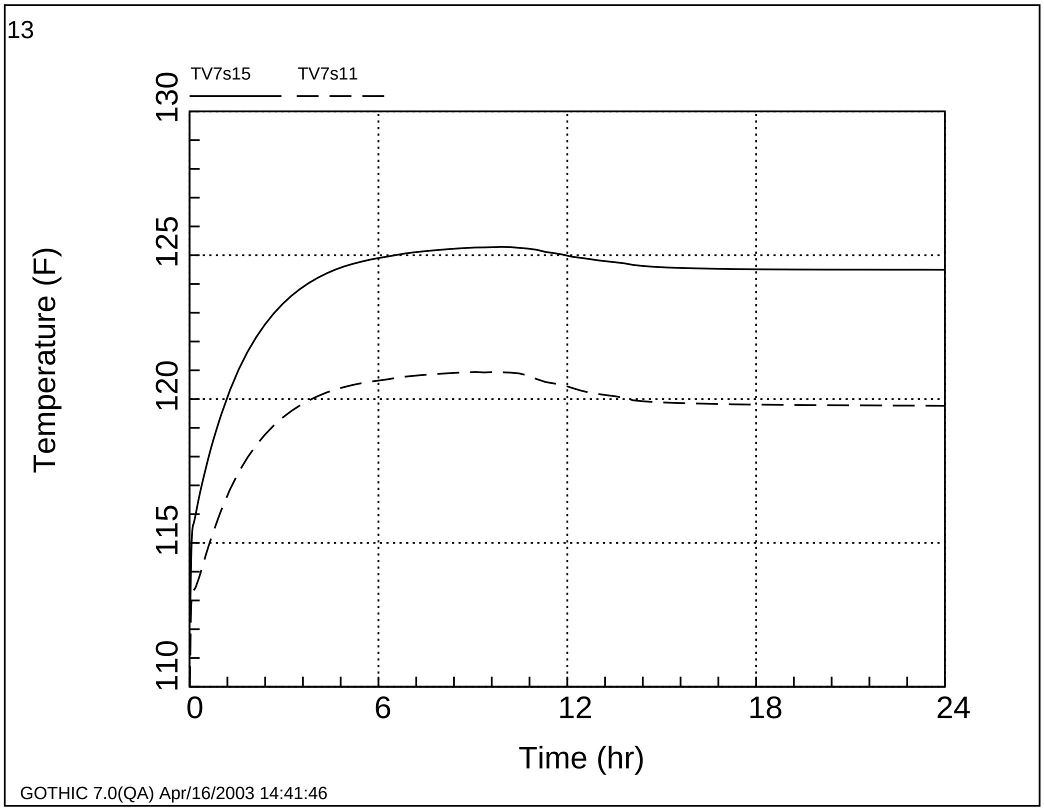
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Winter
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 125.3°F after 9 hrs 55 min 0 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

FirstEnergy

CALCULATION COMPUTATION

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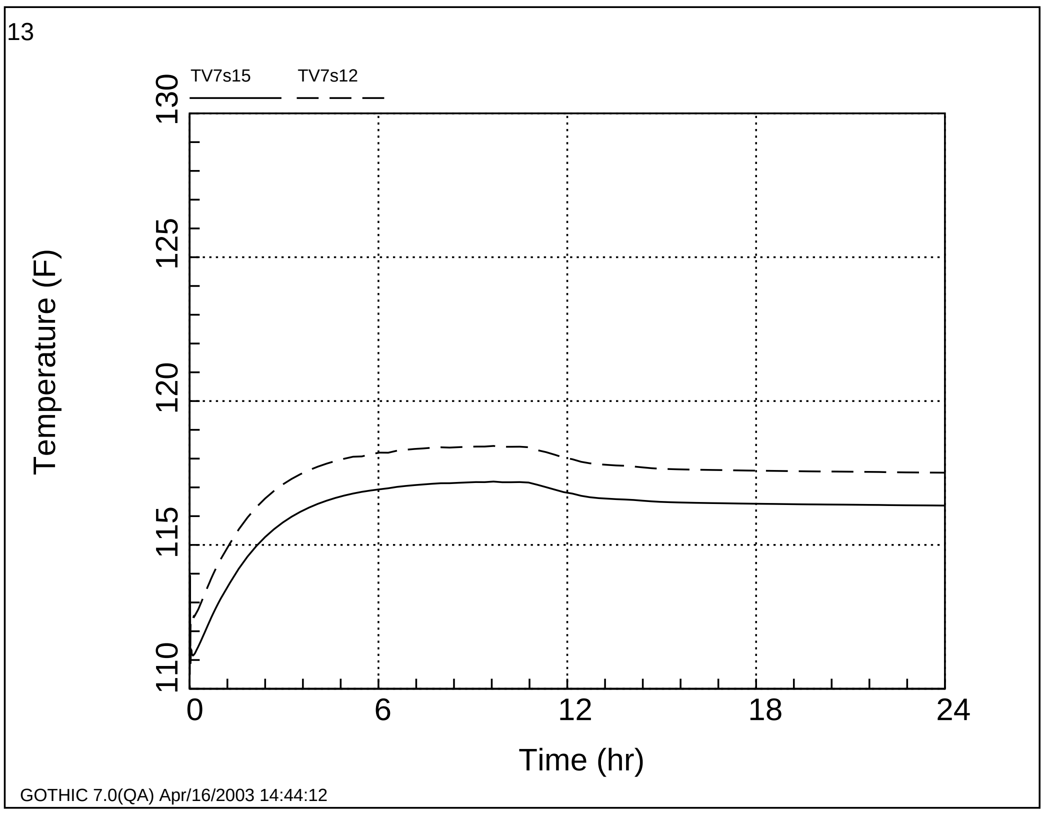
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Winter
2.9468 Lb_m/sec leak rate



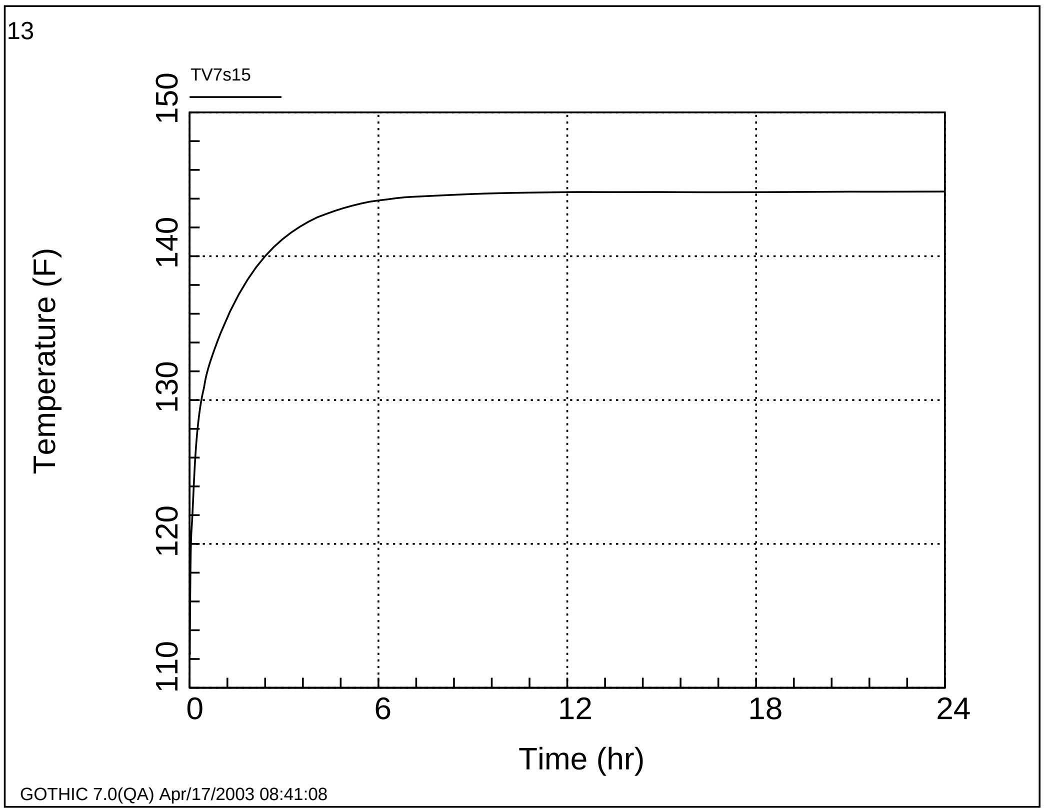
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 117.2°F after 9 hrs 39 min 10 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

Leak Location 1 – Winter
10.99 Lb_m/sec leak rate



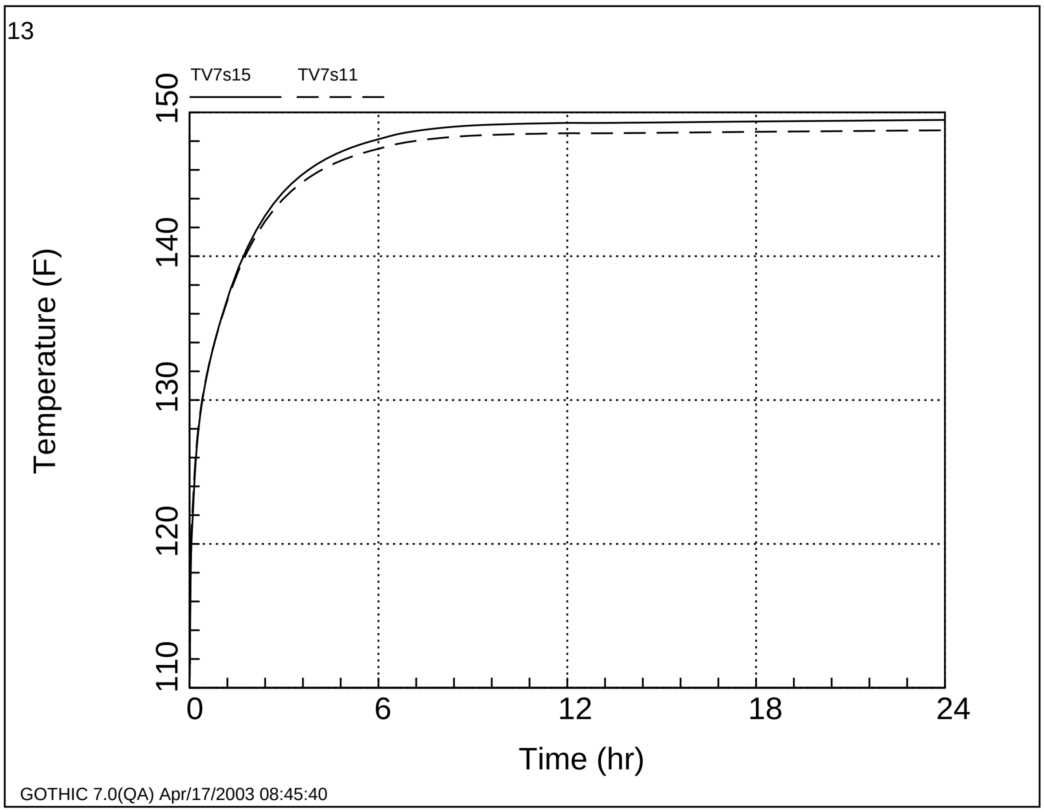
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 144.5°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

Leak Location 2 – Winter
10.99 Lb_m/sec leak rate



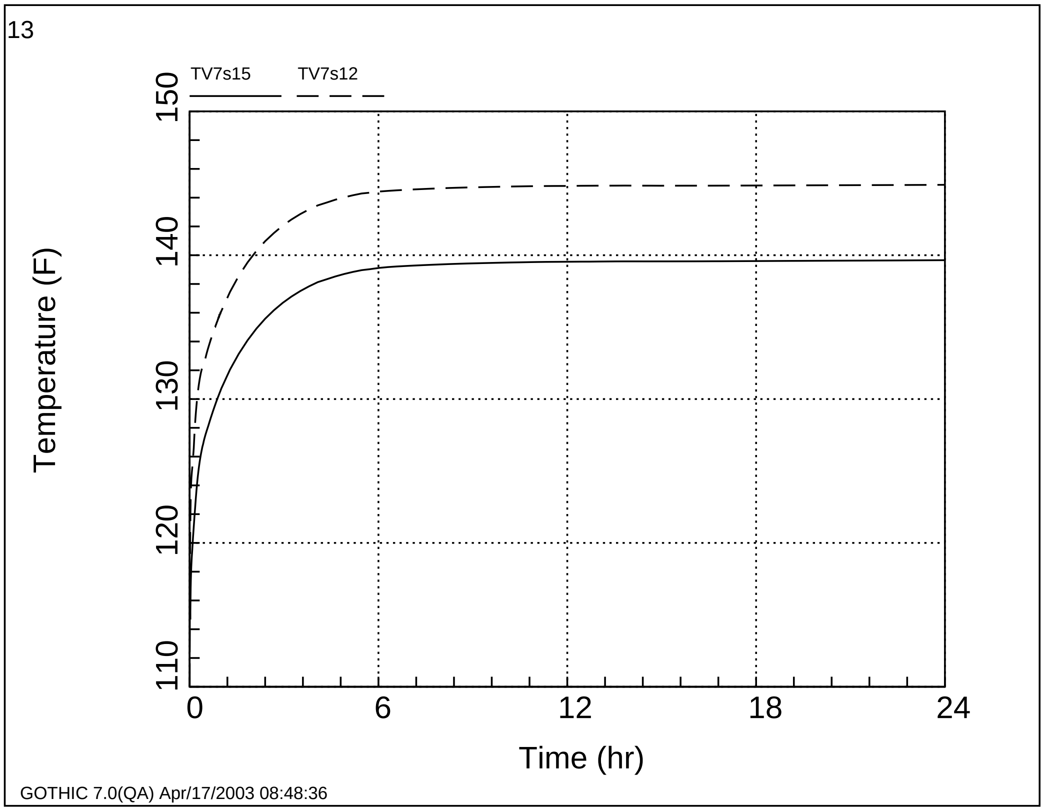
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 149.5°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 3 hrs 13 min 44 sec

Time required to reach 160°F – N/A

Leak Location 3 – Winter
10.99 Lb_m/sec leak rate



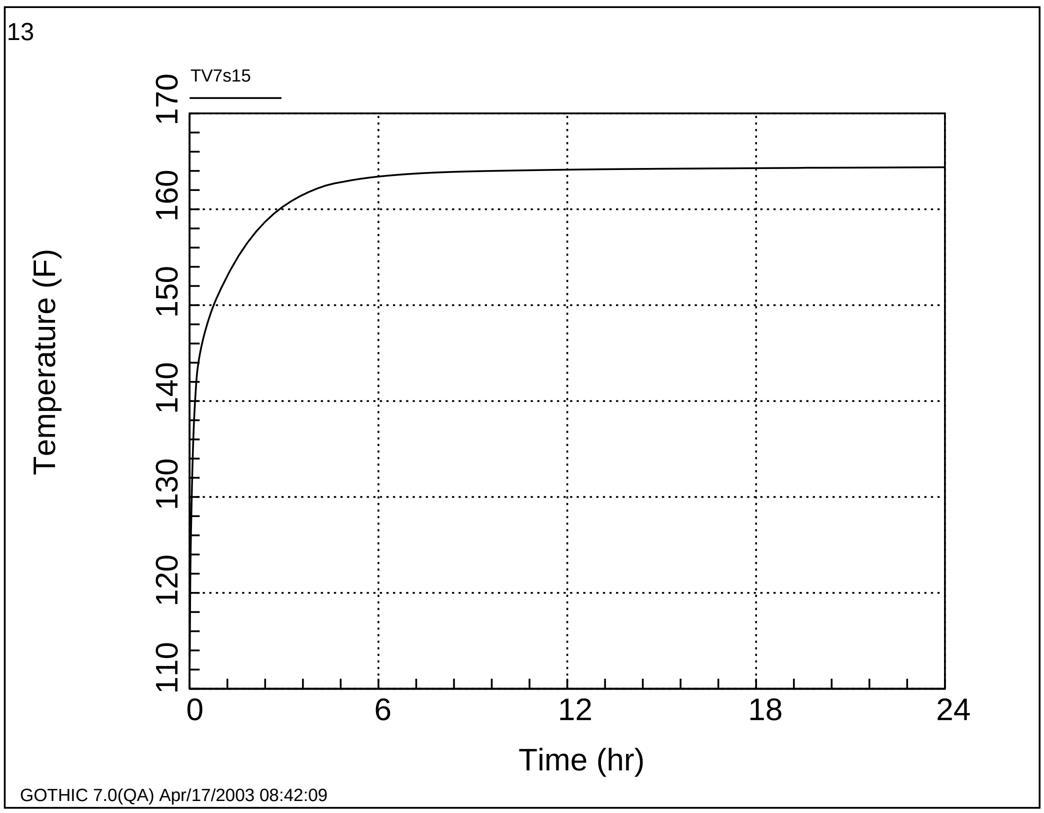
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 139.7°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

Leak Location 1 – Winter
19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 164.4°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 20 min 2 sec

Time required to reach 160°F – 2 hrs 56 min 47 sec

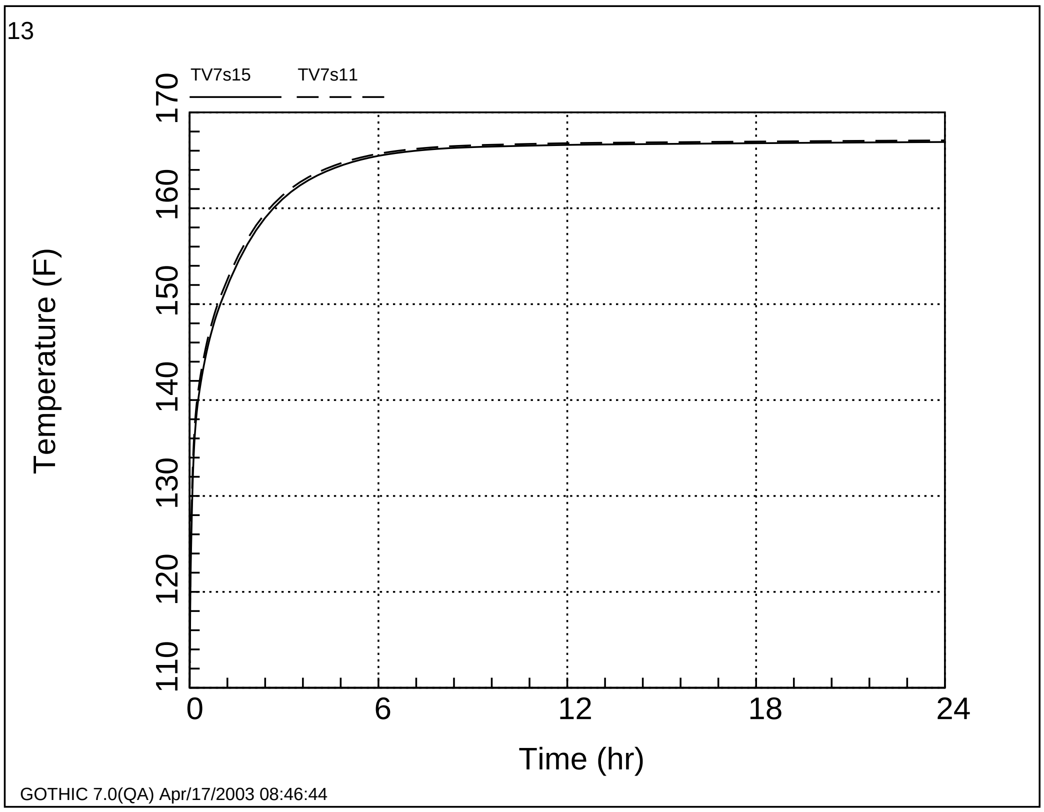
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Winter
19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 166.9°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 32 min 26 sec

Time required to reach 160°F – 2 hrs 40 min 11 sec

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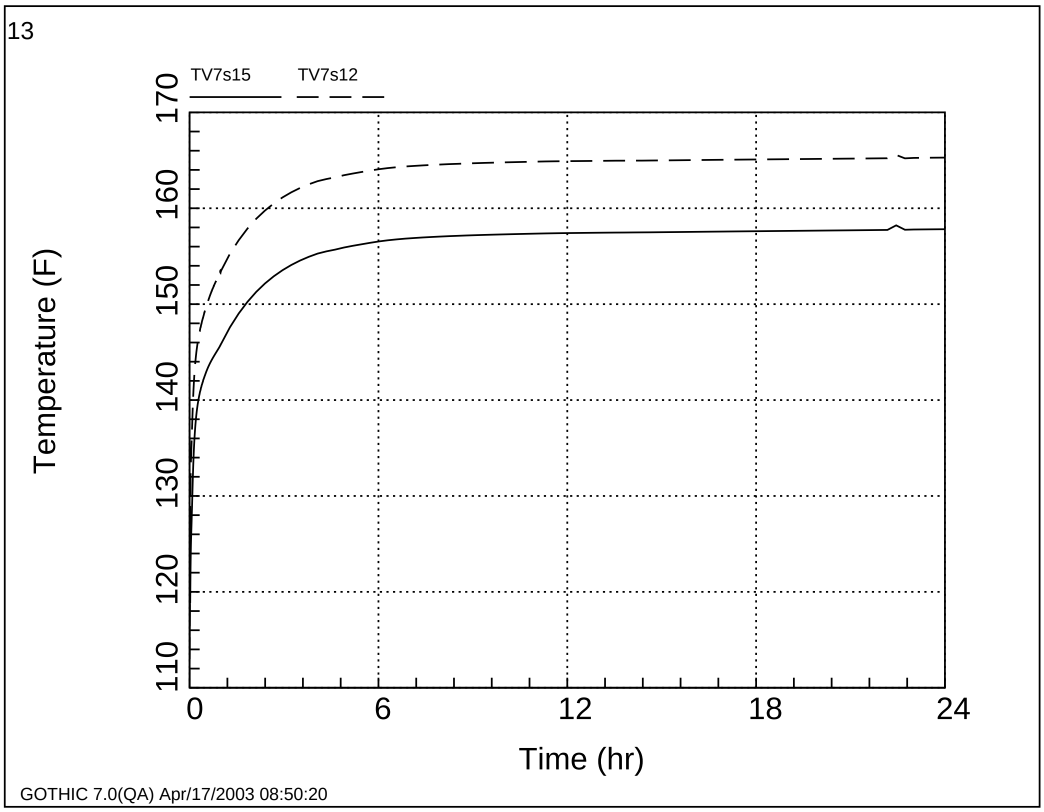
TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks	

Leak Location 3 – Winter
19.68 Lb_m/sec leak rate



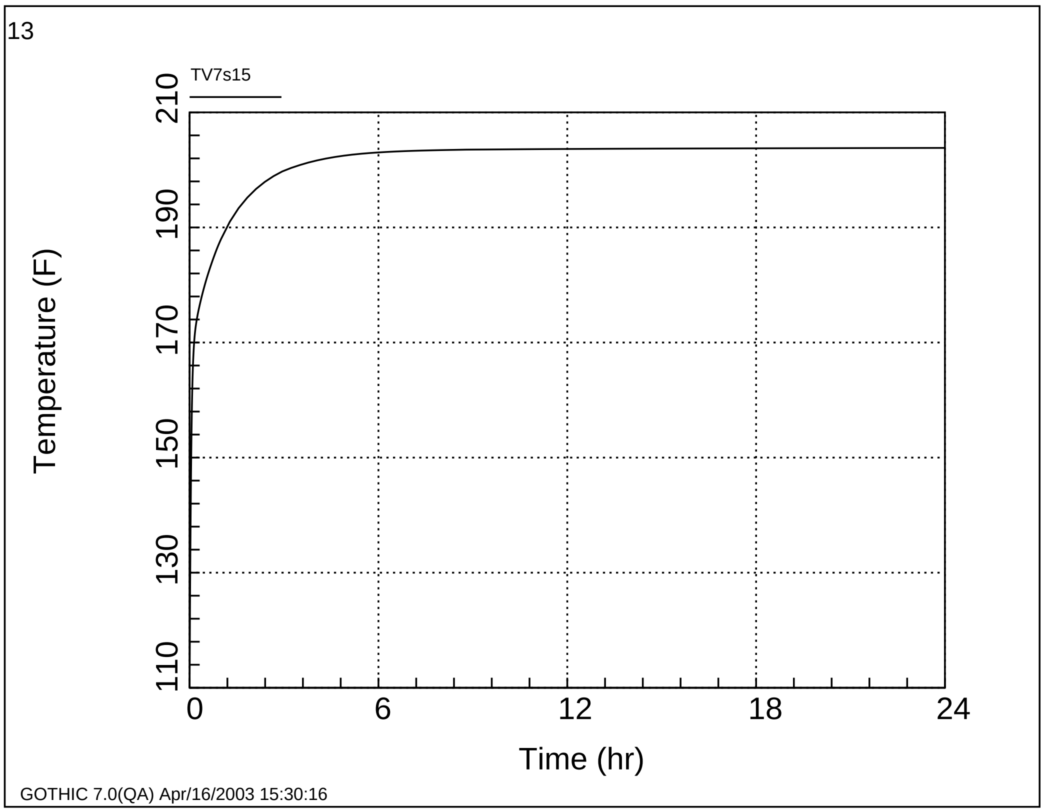
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 158.2°F after 22 hrs 27 min 0 sec

Time required to reach 145°F – 51 min 10 sec

Time required to reach 160°F – N/A

Leak Location 1 – Winter
45.11 Lb_m/sec leak rate



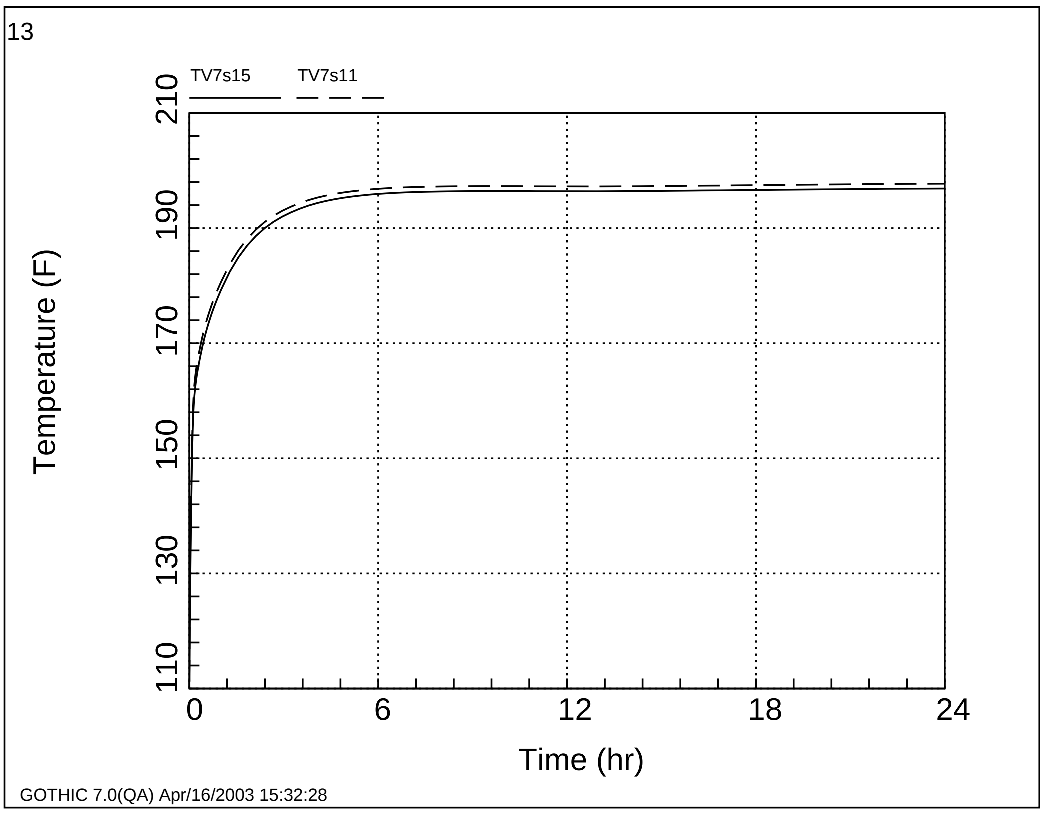
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 203.8°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 2 min 41 sec

Time required to reach 160°F – 4 min 42 sec

Leak Location 2 – Winter
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 196.9°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 4 min 4 sec

Time required to reach 160°F – 9 min 5 sec

FirstEnergy

CALCULATION COMPUTATION

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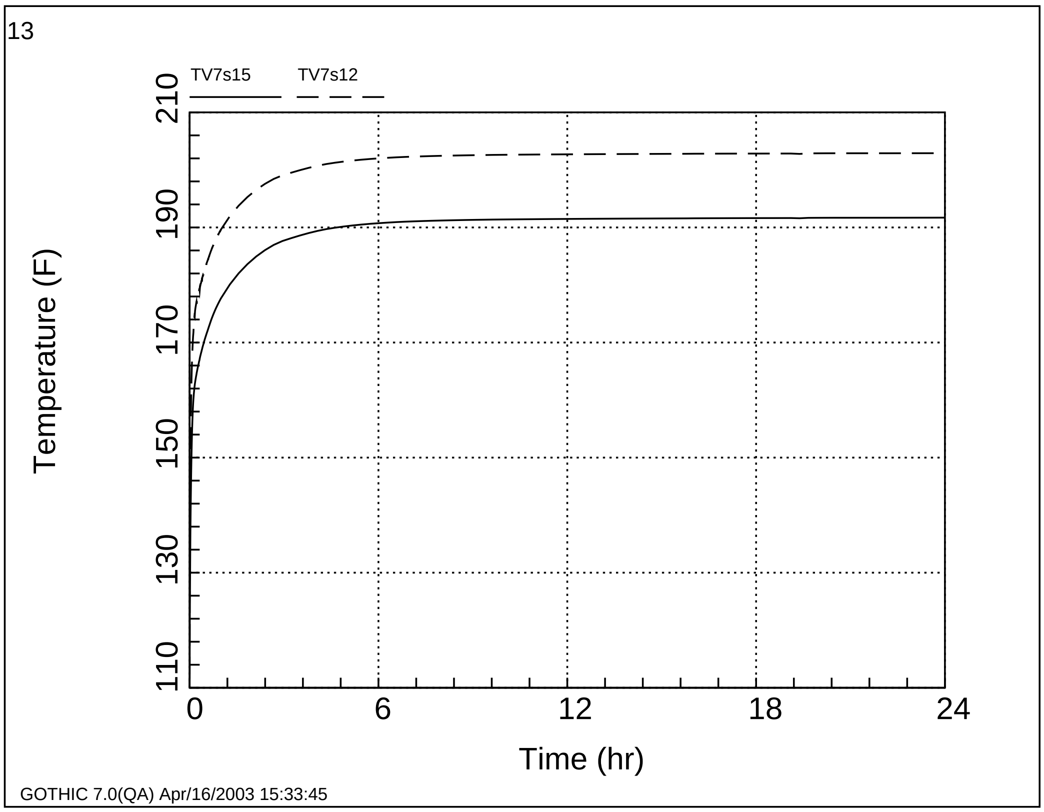
CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Winter
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 191.7°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 2 min 34 sec

Time required to reach 160°F – 7 min 13 sec

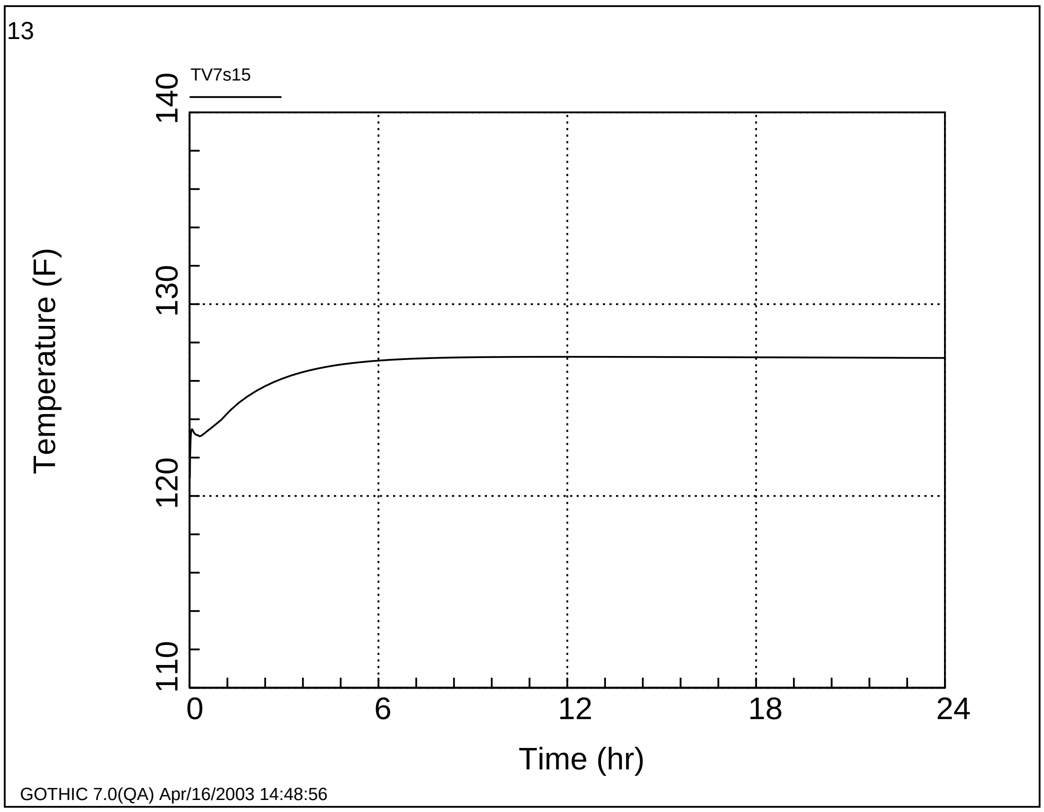
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 1 – Average
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 127.3°F after 11 hrs 52 min 20 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

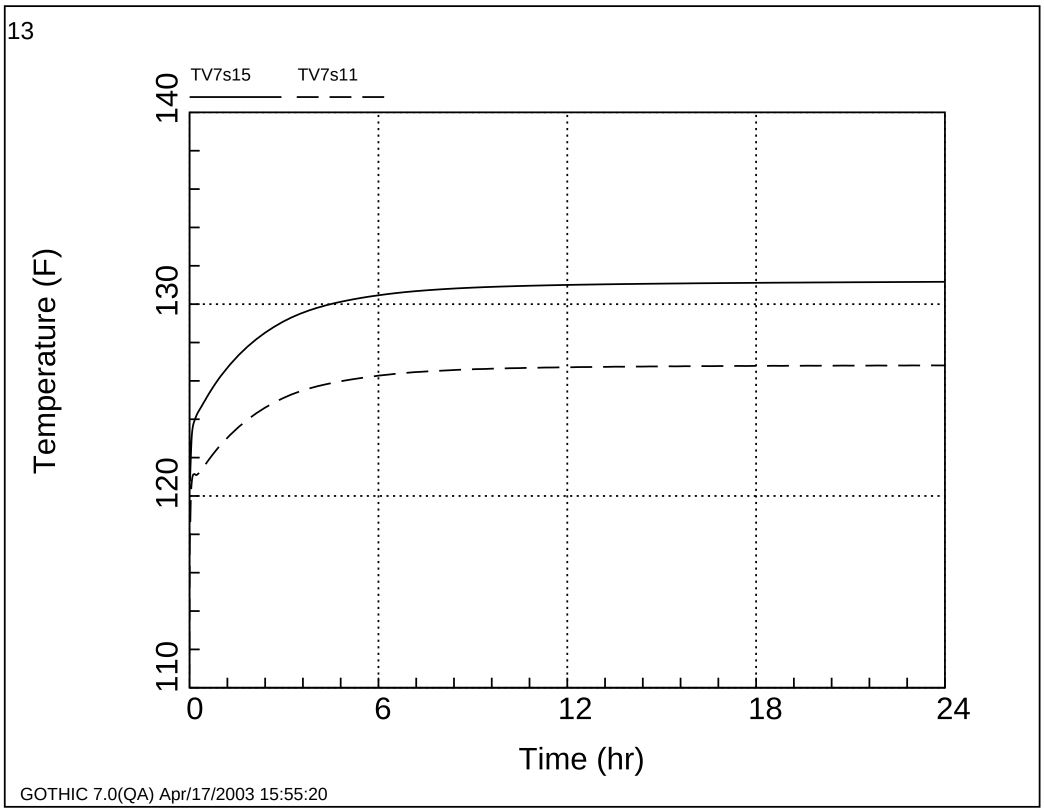
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Average
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 131.2°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

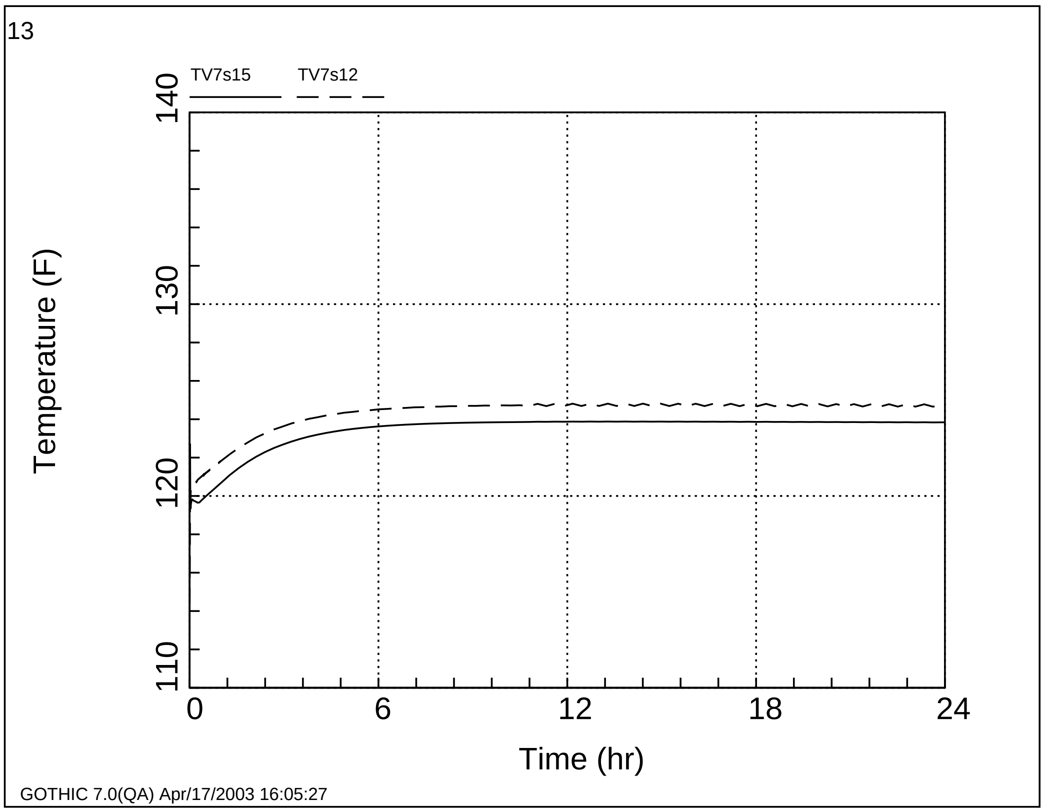
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Average
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 123.8°F after 23 hrs 53 min 58 sec

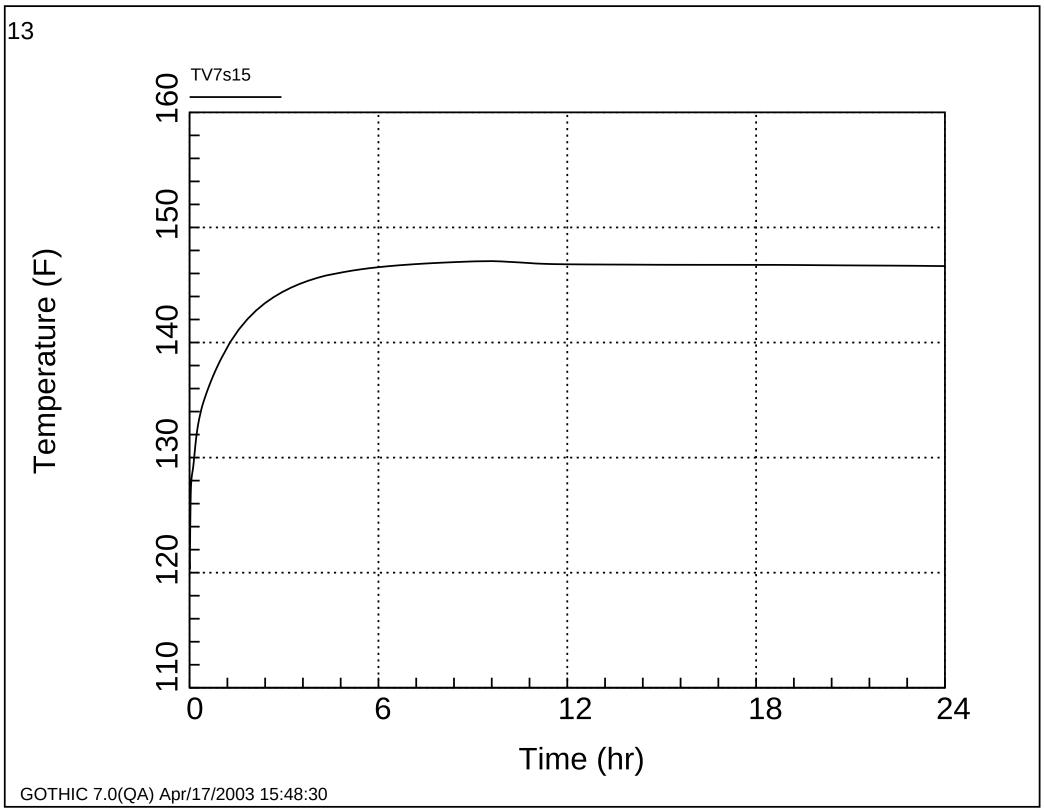
Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 1 – Average
10.99 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 147.1°F after 9 hrs 37 min 10 sec

Time required to reach 145°F – 3 hrs 30 min 16 sec

Time required to reach 160°F – N/A

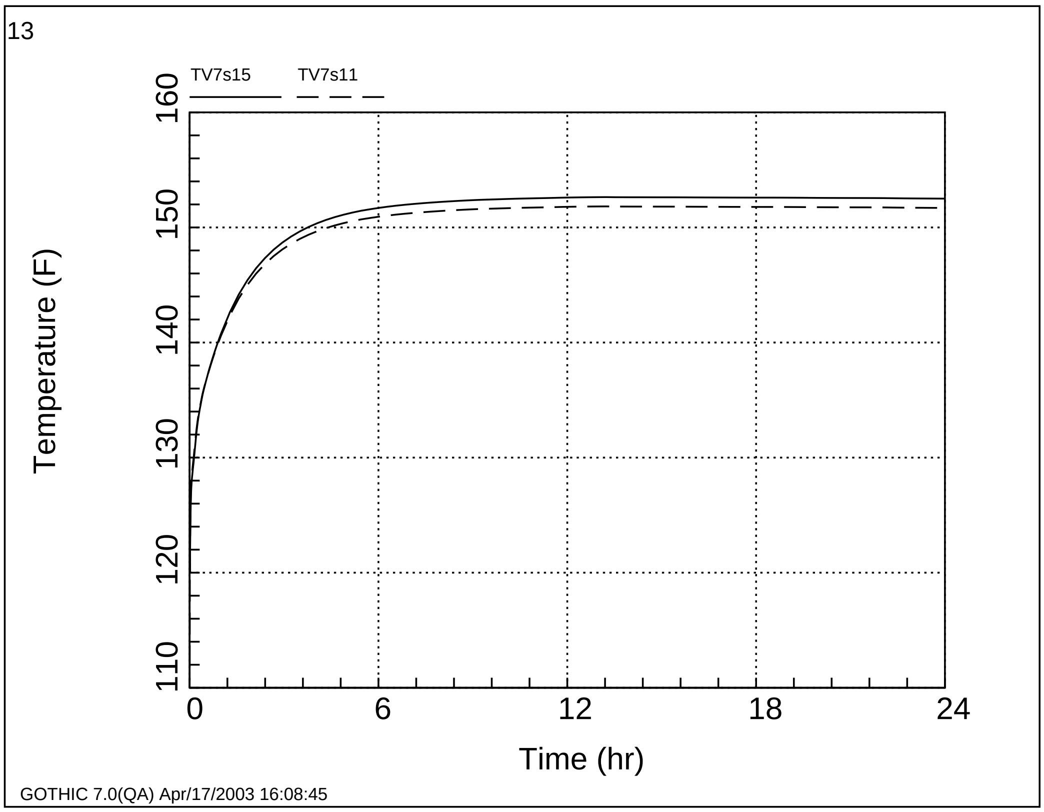
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Average
10.99 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 152.6°F after 13 hrs 14 min 0 sec

Time required to reach 145°F – 1 hr 50 min 9 sec

Time required to reach 160°F – N/A

FirstEnergy

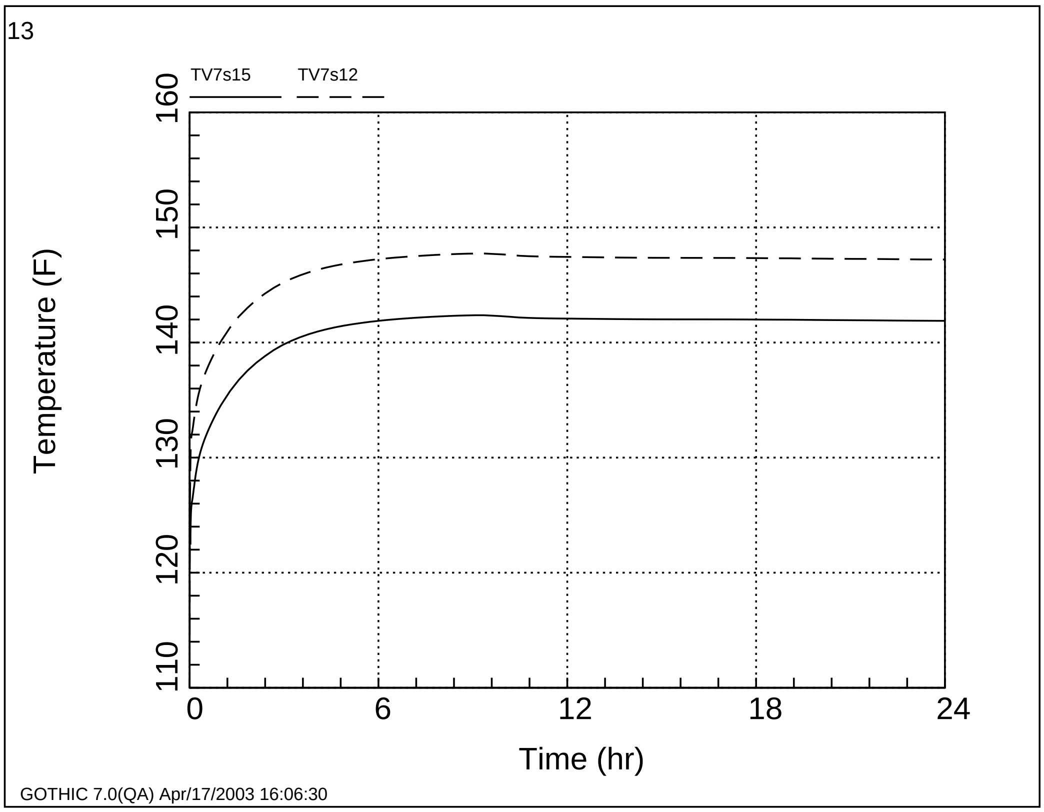
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Average
10.99 Lb_m/sec leak rate



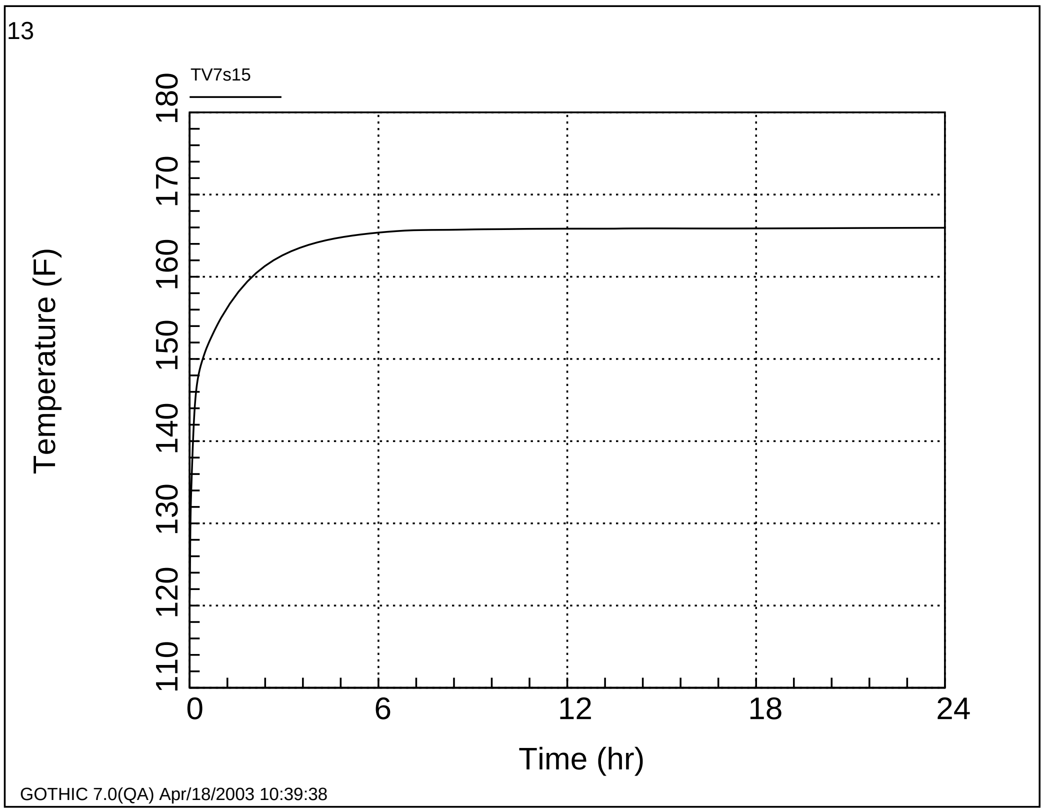
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 142.4°F after 9 hrs 5 min 0 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

Leak Location 1 – Average
19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 166°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 10 min 58 sec

Time required to reach 160°F – 2 hrs 6 min 46 sec

CALCULATION COMPUTATION

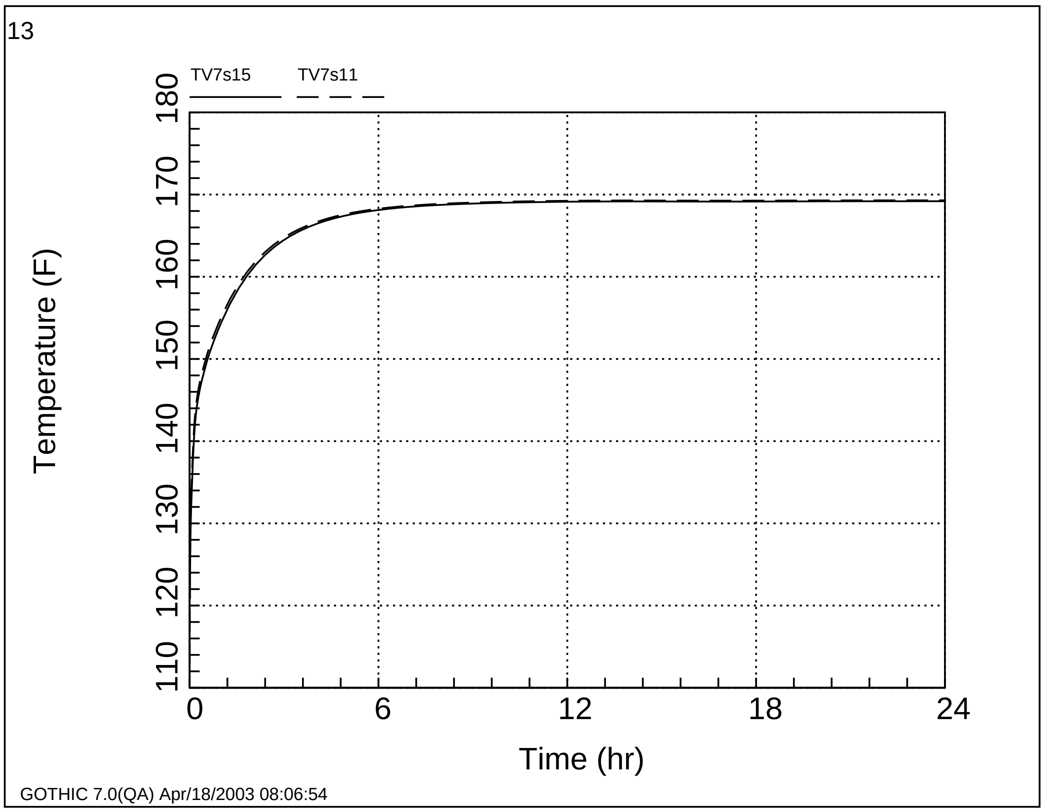
NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Average

19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 169.2°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 15 min 58 sec

Time required to reach 160°F – 1 hr 50 min 17 sec

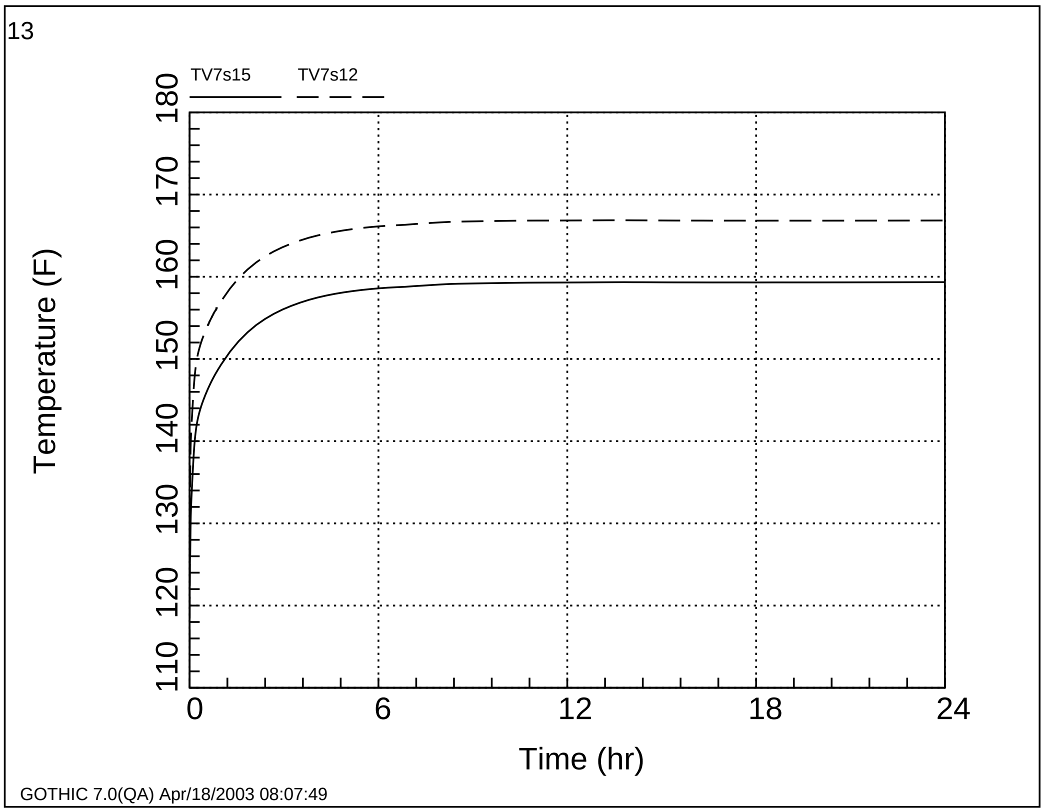
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Average
19.68 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 159.3°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 26 min 21 sec

Time required to reach 160°F – N/A

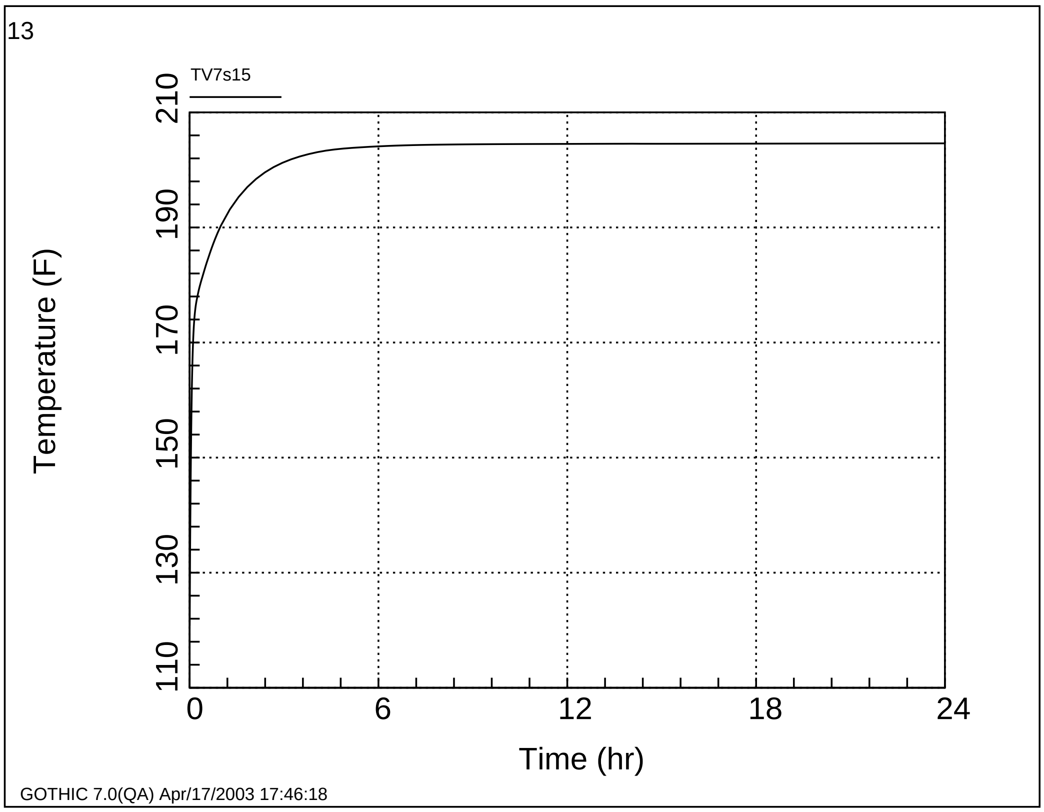
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 1 – Average
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 204.6°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 2 min 7 sec

Time required to reach 160°F – 4 min 8 sec

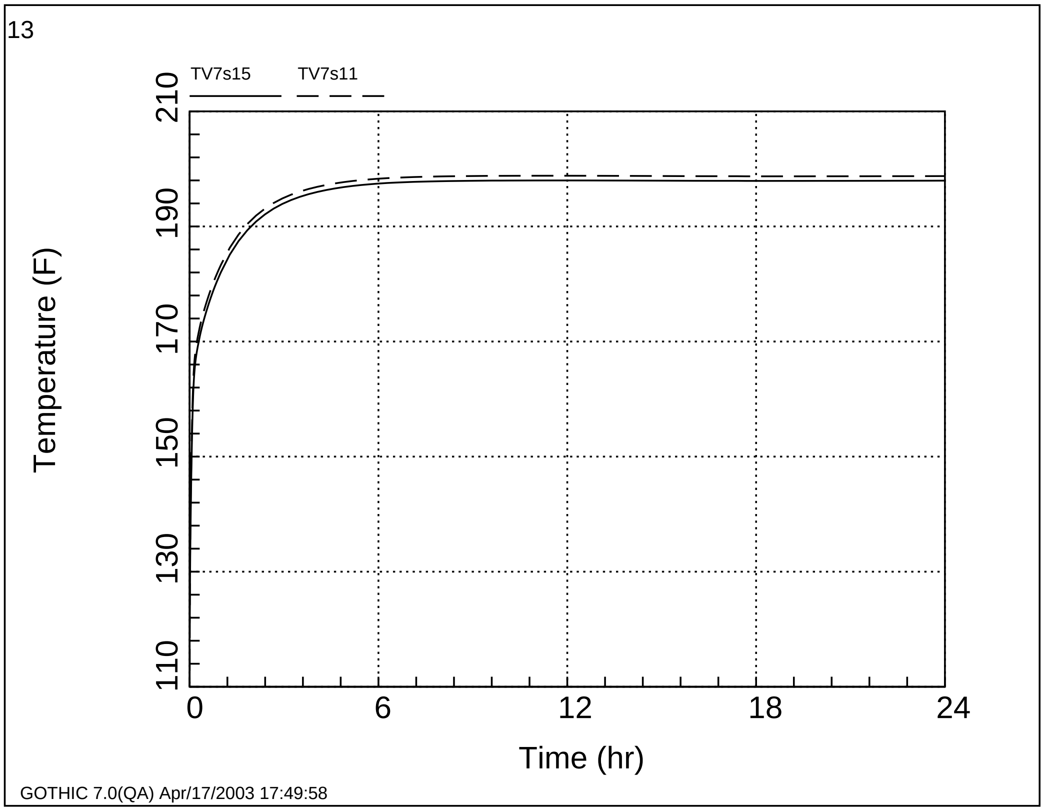
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 2 – Average
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 198°F after 11 hrs 50 min 10 sec

Time required to reach 145°F – 3 min 8 sec

Time required to reach 160°F – 6 min 30 sec

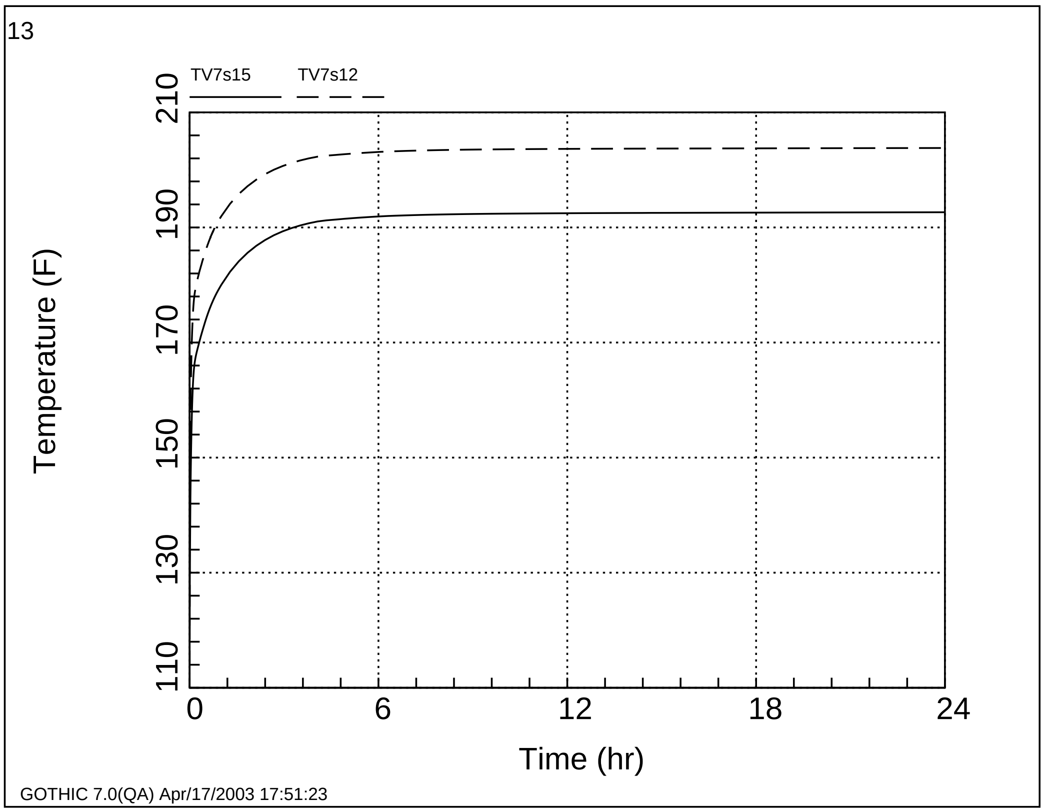
CALCULATION COMPUTATION

NOP-CC-3002-01 Rev. 00

CALCULATION NO.: 2.4.6.14 Rev. 0

TITLE / SUBJECT: Turbine Building Temperature Response to Steam Leaks

Leak Location 3 – Average
45.11 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 192.6°F after 24 hrs 0 min 0 sec

Time required to reach 145°F – 1 min 53 sec

Time required to reach 160°F – 5 min 12 sec

Table 2 – Time Required to Reach 145°F at the Thermocouples

	Summer	Winter	Average
2.9468 Lb_m/sec	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A
10.99 Lb_m/sec	Leak 1 - 22 min 30 sec Leak 2 - 15 min 24 sec Leak 3 - 52 min 51 sec	Leak 1 - N/A Leak 2 - 3 hrs 13 min 44 sec Leak 3 - N/A	Leak 1 - 3 hrs 30 min 16 sec Leak 2 - 1 hr 50 min 9 sec Leak 3 - N/A
19.68 Lb_m/sec	Leak 1 - 1 min 59 sec Leak 2 - 2 min 41 sec Leak 3 - 3 min 8 sec	Leak 1 - 20 min 2 sec Leak 2 - 32 min 26 sec Leak 3 - 51 min 10 sec	Leak 1 - 10 min 58 sec Leak 2 - 15 min 58 sec Leak 3 - 26 min 21 sec
45.11 Lb_m/sec	Leak 1 - 58 sec Leak 2 - 58 sec Leak 3 - 40 sec	Leak 1 - 2 min 41 sec Leak 2 - 4 min 4 sec Leak 3 - 2 min 34 sec	Leak 1 - 2 min 7 sec Leak 2 - 3 min 8 sec Leak 3 - 1 min 53 sec

Table 3 – Time Required to Reach 160°F at the Thermocouples

	Summer	Winter	Average
2.9468 Lb_m/sec	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A
10.99 Lb_m/sec	Leak 1 - N/A Leak 2 - 4 hrs 36 min 49 sec Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A	Leak 1 - N/A Leak 2 - N/A Leak 3 - N/A
19.68 Lb_m/sec	Leak 1 - 40 min 52 sec Leak 2 - 43 min 52 sec Leak 3 - 1 hr 33 min 37 sec	Leak 1 - 2 hrs 56 min 47 sec Leak 2 - 2 hrs 40 min 11 sec Leak 3 - N/A	Leak 1 - 2 hrs 6 min 46 sec Leak 2 - 1 hr 50 min 17 sec Leak 3 - N/A
45.11 Lb_m/sec	Leak 1 - 2 min 39 sec Leak 2 - 3 min 59 sec Leak 3 - 2 min 54 sec	Leak 1 - 4 min 42 sec Leak 2 - 9 min 5 sec Leak 3 - 7 min 13 sec	Leak 1 - 4 min 8 sec Leak 2 - 6 min 30 sec Leak 3 - 5 min 12 sec

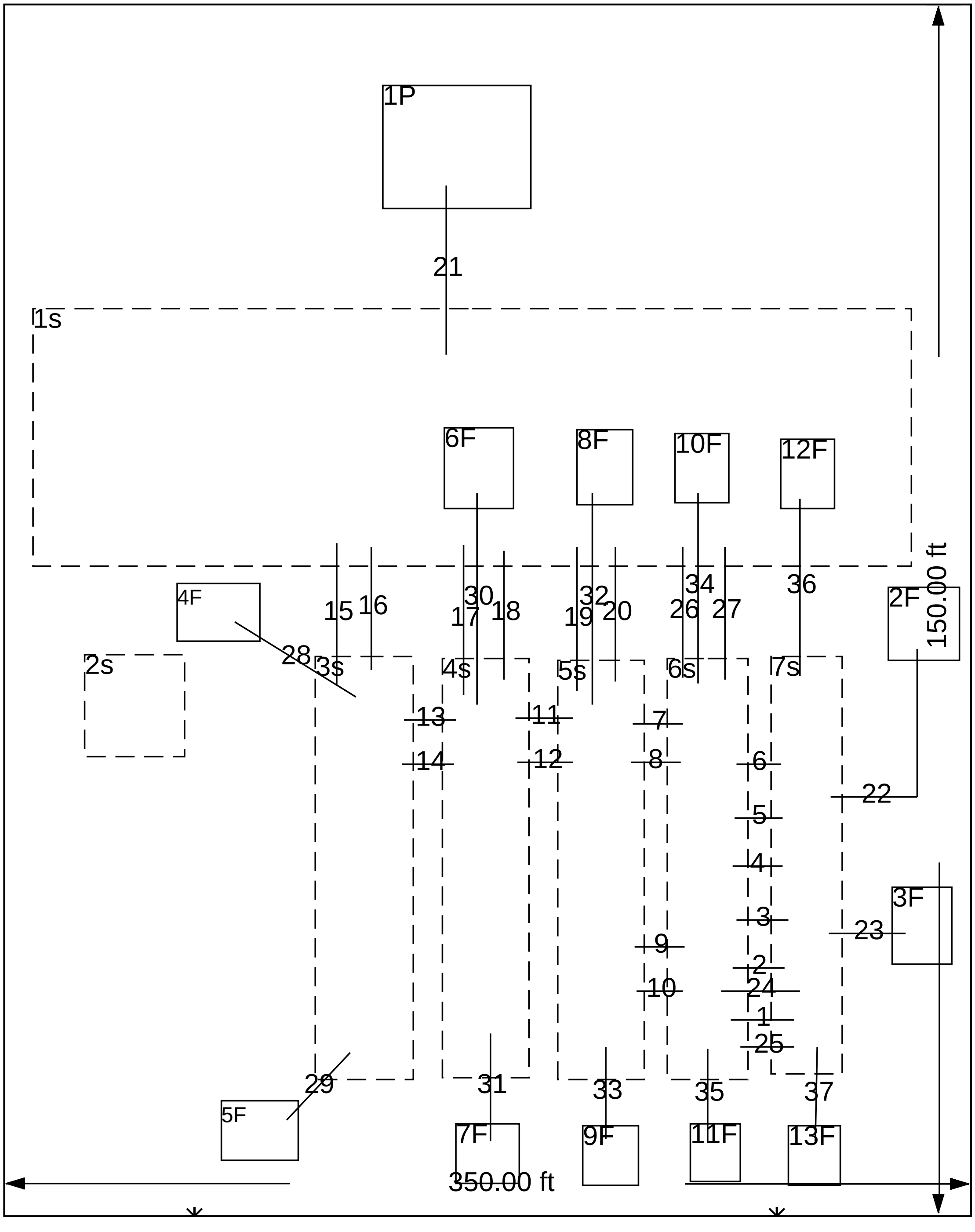
Conclusions

The analysis results indicate that neither a 2.9468 Lb_m/sec leak, nor a 10.99 Lb_m/sec leak, will result in an elevated temperature of 145°F near the E31 temperature detectors for any analyzed condition. A 19.68 Lb_m/sec leak will result in an elevated temperature of 145°F under the required 2 hrs, but not 160°F, for all analyzed conditions. Of the four leak rates, only a 45.11 Lb_m/sec leak will result in an elevated temperature of 160°F near the E31 temperature detectors for the analyzed conditions. It does so in less time than the required limit of 52 minutes 21 seconds.

Attachments

Attachment A: Control Volumes Isometric Sketch	1 page
Attachment B: GOTHIC-generated model layout	1 page
Attachment C: Steel Heat Sink EXCEL spreadsheet	7 pages
Attachment D: Steel Heat Sink EXCEL spreadsheet formulas	9 pages
Attachment E: Gothic Input Deck	25 pages
Attachment F: Leak Location Bounding Sensitivity Graphs	2 Pages
Attachment G: Moody Diagram	2 Pages

Replace this page with Isometric Sketch


1P
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Steel Heat Sink Totals

*Actual values used in GOTHIC Model

	S.A. [sq.ft]	Vol. [cu.ft]	Thickness [in.]	S.A. [sq.ft]	Thickness [in.]	
Zone 3	13,047	230	0.21	14,770	0.17	**See Note Below**
Zone 4	12,569	200	0.19	16,256	0.17	
Zone 5	12,385	203	0.20	16,121	0.17	
Zone 6	21,961	335	0.18	29,621	0.15	
Zone 7	27,590	460	0.20	37,221	0.16	

Platform Support Data (Hangers and Posts)

	S.A. [sq.in.]	Vol. [cu.in.]	S.A. [sq.ft]	Vol. [cu.ft]	D-502 Series Drawing References
Zone 3	1,047,810	244,326	7,276	141	130, 132, 134, 135
Zone 4	777,385	159,985	5,399	93	130, 132, 134, 135, 139
Zone 5	682,105	142,696	4,737	83	130, 132, 134, 135
Zone 6	909,192	211,553	6,314	122	131, 133, 136, 137
Zone 7	1,984,834	568,850	13,784	329	131, 133, 136, 137, 139

Steel Framing

Posts:

	S.A. [sq.in.]	Vol. [cu.in.]	S.A. [sq.ft]	Vol. [cu.ft]	D-502 Series Drawing References
Zone 6	221,925	58,473	1,541	34	143
Zone 7	275,363	86,569	1,912	50	143

I-Beams:

	S.A. [sq.in.]	Vol. [cu.in.]	S.A. [sq.ft]	Vol. [cu.ft]	D-502 Series Drawing References
Zone 3	325,220	112,269	2,258	65	160, 161
Zone 4	382,218	132,585	2,654	77	160, 161
Zone 5	451,326	154,522	3,134	89	160, 161
Zone 6	548,861	188,062	3,812	109	162
Zone 7	0	0	0	0	(Included in Platform Support Total)

Platforms (Grating)

	Area Footprint [sq.ft]	Volume Factor [ft]	S.A. Factor	Volume [cu.ft]	S.A. [sq.ft]	D-502 Series Drawing References
Zone 3	1,686	0.0142	2.0830	23.9	3,511.9	130, 132, 134, 135
Zone 4	2,168	0.0142	2.0830	30.8	4,515.9	130, 132, 134, 135, 139
Zone 5	2,167	0.0142	2.0830	30.8	4,513.9	130, 132, 134, 135
Zone 6	4,942	0.0142	2.0830	70.2	10,294.2	131, 133, 136, 137
Zone 7	5,710	0.0142	2.0830	81.1	11,893.9	131, 133, 136, 137, 139

Note: Errors were discovered in the calculation of the surface areas and volumes used for the steel conductors in the GOTHIC model. To determine the potential impact of these changes, test runs were performed for multiple cases. It was subsequently determined that the minor changes in steel conductor S.A. and thickness had no discernible impact on the final results. It is important to note also that the steel heat sink totals are not more than a best estimate of all the exposed steel that exists in the Turbine Building zones of interest.

Platform Supports

Zone 3

Size	Total of Lengths [ft]	d	bf	tf	tw	S.A. [sq.in.]	Volume [cu.in.]
C10x15	517	10	2.6	0.436	0.24	185,624	27,657
C10x30		10	3.033	0.436	0.673	0	0
C12-25		12	3.047	0.501	0.387	0	0
C12x20		12	2.94	0.5	0.282	0	0
C8x11.5	277	8	2.26	0.39	0.22	81,770	11,139
C9x15		9	2.485	0.413	0.285	0	0
L2.5x2.5x.25		2.5	2.5	0.25		0	0
L3.5x3.5x(3/8)	381	3.5	3.5	0.375		64,008	11,359
L3x3x(1/4)	316	3	3	0.25		45,504	5,451
L3x3x(5/16)	44	3	3	0.3125		6,336	938
L4x4x(.25)	47	4	4	0.25		9,024	1,093
L4x4x(3/8)	169	4	4	0.38		32,448	5,799
L6x6x.5		6	6	0.5		0	0
W10x17	92	10.11	4.01	0.33	0.24	39,501	5,426
W10x21	85	10.17	5.75	0.35	0.24	43,717	6,424
W10x45		10.1	8.02	0.62	0.35	0	0
W10x54		10.09	10.03	0.615	0.37	0	0
W12x40	295	11.94	8.005	0.515	0.295	195,797	40,581
W12x50		12.19	8.08	0.64	0.37	0	0
W12x85		12.5	12.12	0.8	0.51	0	0
W14x48		13.79	8.03	0.595	0.34	0	0
W18x114	96	18.85	11.23	0.975	0.63	93,727	37,492
W18x70	160	18.47	7.635	0.81	0.495	127,661	39,762
W24x110		24.16	12.78	0.8	0.525	0	0
W24x76		23.92	8.99	0.68	0.44	0	0
W8x17	37	8.13	5.2	0.32	0.22	16,259	2,209
W12x161	64	13.85	12.52	1.51	0.91	58,337	36,607
L3x3x(.75)	74	3	3	0.75		10,656	3,497
L5x5x(.5)	156	5	5	0.5		37,440	8,892
Total						**1,047,810**	**244,326**

Zone 4

Size	Total of Lengths [ft]	d	bf	tf	tw	S.A. [sq.in.]	Volume [cu.in.]
C10x15	248	10	2.6	0.436	0.24	89,042	13,267
C10x30		10	3.033	0.436	0.673	0	0
C12-25	80	12	3.047	0.501	0.387	33,997	7,017
C12x20	43	12	2.94	0.5	0.282	18,161	3,118
C8x11.5	600	8	2.26	0.39	0.22	177,120	24,129
C9x15		9	2.485	0.413	0.285	0	0
L2.5x2.5x.25	16	2.5	2.5	0.25		1,920	228
L3.5x3.5x(3/8)	132	3.5	3.5	0.375		22,176	3,935
L3x3x(1/4)	200	3	3	0.25		28,800	3,450
L3x3x(5/16)	115	3	3	0.3125		16,560	2,453
L4x4x(.25)	124	4	4	0.25		23,808	2,883
L4x4x(3/8)	119	4	4	0.38		22,848	4,083
L6x6x.5		6	6	0.5		0	0
W10x21	94	10.17	5.75	0.35	0.24	48,346	7,104
W10x45		10.1	8.02	0.62	0.35	0	0
W10x54		10.09	10.03	0.615	0.37	0	0
W12x40	6	11.94	8.005	0.515	0.295	3,982	825
W12x50		12.19	8.08	0.64	0.37	0	0
W12x85		12.5	12.12	0.8	0.51	0	0
W14x48		13.79	8.03	0.595	0.34	0	0
W18x114	160	18.85	11.23	0.975	0.63	156,211	62,487
W18x70	31	18.47	7.635	0.81	0.495	24,734	7,704
W10x17	92	10.11	4.01	0.33	0.24	39,501	5,426
W24x110		24.16	12.78	0.8	0.525	0	0
W24x76		23.92	8.99	0.68	0.44	0	0
W8x17	80	8.13	5.2	0.32	0.22	35,155	4,777
W12x27	24	12.22	6.49	0.38	0.23	14,383	2,180
L5x5x(.5)	50	5	5	0.5		12,000	2,850
L6x6x(.5)	30	6	6	0.5		8,640	2,070
Total						**777,385**	**159,985**

Platform Supports (continued)

Zone 5

Size	Total of Lengths [ft]	d	bf	tf	tw	S.A. [sq.in.]	Volume [cu.in.]
C10x15	586	10	2.6	0.436	0.24	210,397	31,348
C10x30		10	3.033	0.436	0.673	0	0
C12-25		12	3.047	0.501	0.387	0	0
C12x20	120	12	2.94	0.5	0.282	50,682	8,700
C8x11.5	135	8	2.26	0.39	0.22	39,852	5,429
C9x15		9	2.485	0.413	0.285	0	0
L2.5x2.5x.25	101	2.5	2.5	0.25		12,120	1,439
L3.5x3.5x(3/8)	68	3.5	3.5	0.375		11,424	2,027
L3x3x(1/4)	31	3	3	0.25		4,464	535
L3x3x(5/16)	120	3	3	0.3125		17,280	2,559
L4x4x(.25)		4	4	0.25		0	0
L4x4x(3/8)	156	4	4	0.38		29,952	5,353
L6x6x.5		6	6	0.5		0	0
W10x21	94	10.17	5.75	0.35	0.24	48,346	7,104
W10x45		10.1	8.02	0.62	0.35	0	0
W10x54		10.09	10.03	0.615	0.37	0	0
W12x40		11.94	8.005	0.515	0.295	0	0
W12x50		12.19	8.08	0.64	0.37	0	0
W12x85		12.5	12.12	0.8	0.51	0	0
W14x48		13.79	8.03	0.595	0.34	0	0
W18x114	159	18.85	11.23	0.975	0.63	155,235	62,097
W18x70		18.47	7.635	0.81	0.495	0	0
W10x17	92	10.11	4.01	0.33	0.24	39,501	5,426
W24x110		24.16	12.78	0.8	0.525	0	0
W24x76		23.92	8.99	0.68	0.44	0	0
W8x17	80	8.13	5.2	0.32	0.22	35,155	4,777
L5x5x(.5)	65	5	5	0.5		15,600	3,705
L6x6x(3/8)	42	6	6	0.375		12,096	2,197
Total						**682,105**	**142,696**

Zone 6

Size	Total of Lengths [ft]	d	bf	tf	tw	S.A. [sq.in.]	Volume [cu.in.]
C10x15	45	10	2.6	0.436	0.24	16,157	2,407
C10x30		10	3.033	0.436	0.673	0	0
C12-25		12	3.047	0.501	0.387	0	0
C12x20	39	12	2.94	0.5	0.282	16,472	2,828
C8x11.5	116	8	2.26	0.39	0.22	34,243	4,665
C9x15	26	9	2.485	0.413	0.285	8,539	1,367
L2.5x2.5x.25		2.5	2.5	0.25		0	0
L3.5x3.5x(3/8)	40	3.5	3.5	0.375		6,720	1,193
L3x3x(1/4)		3	3	0.25		0	0
L3x3x(5/16)	100	3	3	0.3125		14,400	2,133
L4x4x(.25)		4	4	0.25		0	0
L4x4x(3/8)		4	4	0.38		0	0
L6x6x.5		6	6	0.5		0	0
W10x21	30	10.17	5.75	0.35	0.24	15,430	2,267
W10x45		10.1	8.02	0.62	0.35	0	0
W10x54		10.09	10.03	0.615	0.37	0	0
W12x40	114	11.94	8.005	0.515	0.295	75,664	15,682
W12x50	441	12.19	8.08	0.64	0.37	296,140	76,094
W12x85		12.5	12.12	0.8	0.51	0	0
W14x48	82	13.79	8.03	0.595	0.34	58,076	13,618
W18x114		18.85	11.23	0.975	0.63	0	0
W18x70	15	18.47	7.635	0.81	0.495	11,968	3,728
W10x17	120	10.11	4.01	0.33	0.24	51,523	7,077
W24x110	58	24.16	12.78	0.8	0.525	68,479	22,475
W24x76	184	23.92	8.99	0.68	0.44	183,087	48,913
W8x17	119	8.13	5.2	0.32	0.22	52,293	7,105
Total						**909,192**	**211,553**

Platform Supports (continued)

Zone 7

Size	Total of Lengths [ft]	d	bf	tf	tw	S.A. [sq.in.]	Volume [cu.in.]
C10x15	76	10	2.6	0.436	0.24	27,287	4,066
C10x30	223	10	3.033	0.436	0.673	82,383	23,516
C12-25		12	3.047	0.501	0.387	0	0
C12x20	148	12	2.94	0.5	0.282	62,508	10,731
C8x11.5	106	8	2.26	0.39	0.22	31,291	4,263
C9x15		9	2.485	0.413	0.285	0	0
L2.5x2.5x.25	89	2.5	2.5	0.25		10,680	1,268
L3.5x3.5x(3/8)		3.5	3.5	0.375		0	0
L3x3x(1/4)	13	3	3	0.25		1,872	224
L3x3x(5/16)		3	3	0.3125		0	0
L4x4x(.25)		4	4	0.25		0	0
L4x4x(3/8)	46	4	4	0.38		8,832	1,578
L6x6x.5	60	6	6	0.5		17,280	4,140
W10x21		10.17	5.75	0.35	0.24	0	0
W10x45	301	10.1	8.02	0.62	0.35	186,307	47,121
W10x54	200	10.09	10.03	0.615	0.37	142,944	37,476
W12x40		11.94	8.005	0.515	0.295	0	0
W12x50	888	12.19	8.08	0.64	0.37	596,310	153,224
W12x85	104	12.5	12.12	0.8	0.51	90,430	31,139
W14x48		13.79	8.03	0.595	0.34	0	0
W18x114	167	18.85	11.23	0.975	0.63	163,045	65,221
W18x70	333	18.47	7.635	0.81	0.495	265,694	82,755
W10x17		10.11	4.01	0.33	0.24	0	0
W24x110		24.16	12.78	0.8	0.525	0	0
W24x76		23.92	8.99	0.68	0.44	0	0
W8x17	80	8.13	5.2	0.32	0.22	35,155	4,777
W30x124	60	30.17	10.515	0.93	0.585	72,886	26,006
W36x135	26	35.55	11.95	0.79	0.6	36,722	12,250
W30x99	28	29.65	10.45	0.67	0.52	33,620	9,651
W27x177	54	27.81	14.085	1.19	0.725	71,610	33,669
W18x96	40	18.59	11.145	0.87	0.535	38,731	13,635
C15x34	18	15	3.4	0.65	0.4	9,245	2,138
Total						**1,984,834**	**568,850**

Platform Posts for Zones 6 and 7

	Post Number	Size	Length [ft]	d [in.]	bf [in.]	tf [in.]	tw [in.]	S.A. [sq.in.]	Volume [cu.in.]
Zone 6	P1	W12x50	31	12.25	8.125	0.625	0.375	20925	5312.625
Zone 6	P2	W12x50	31	12.25	8.125	0.625	0.375	20925	5312.625
Zone 6	P3	W12x50	31	12.25	8.125	0.625	0.375	20925	5312.625
Zone 6	P4	W12x50	32	12.25	8.125	0.625	0.375	21600	5484
Zone 6	P5	W12x50	31	12.25	8.125	0.625	0.375	20925	5312.625
Zone 6	P6	W12x50	32	12.25	8.125	0.625	0.375	21600	5484
Zone 6	P7	W12x50	33	12.25	8.125	0.625	0.375	22275	5655.375
Zone 6	P8	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 6	P9	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 7	P10	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 7	P11	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 7	P12	W12x85	32	12.5	12.125	0.8125	0.5	27840	9654
Zone 7	P13	W14x111	32	14.375	14.625	0.875	0.5625	33072	12555
Zone 7	P14	W12x85	32	12.5	12.125	0.8125	0.5	27840	9654
Zone 7	P15	W14x78	25	14	12	0.6875	0.4375	22537.5	6607.03125
Zone 7	P16	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 7	P17	W14x78	13	14	12	0.6875	0.4375	11719.5	3435.65625
Zone 7	P18	W14x78	28	14	12	0.6875	0.4375	25242	7399.875
Zone 7	P19	W14x78	13	14	12	0.6875	0.4375	11719.5	3435.65625
Zone 7	P20	W14x78	32	14	12	0.6875	0.4375	28848	8457
Zone 6	P21	W8x40	13	8.25	8.125	0.5625	0.375	7527	1842.75
Zone 6	P22	W8x40	13	8.25	8.125	0.5625	0.375	7527	1842.75

Totals and Conversion:

Total Surface Area in Zone 6:	221,925	sq.in.	,or	1,541.1	sq.ft
Total Surface Area in Zone 7:	275,363	sq.in.	,or	1,912.2	sq.ft
Total Volume in Zone 6:	58,473	cu.in.	,or	33.8	cu.ft
Total Volume in Zone 7:	86,569	cu.in.	,or	50.1	cu.ft

I-Beams

	Size	Length [ft]	d [in.]	bf [in.]	tf [in.]	tw [in.]	S.A. [sq.in.]	Volume [cu.in.]
Zone 3	W12x45	22	12.06	8.042	0.576	0.336	14,683	3,413
	W18x85	64	18.32	8.838	0.911	0.526	54,482	19,032
	W8x17	16	8	5.25	0.308	0.23	7,016	947
	W27x94	9	26.91	9.99	0.747	0.49	10,022	2,957
	W12x16	23	11.99	3.99	0.265	0.22	10,902	1,280
	W18x114	64	18.48	11.833	0.991	0.595	63,822	25,551
	W18x70	68	18	8.75	0.751	0.438	57,221	16,621
	W18x119	96	19.655	11.265	1.06	0.655	95,685	40,743
	W12x26	19	12.22	6.49	0.38	0.23	11,386	1,726
	Totals:						**325,220**	**112,269**
Zone 4	W12x40	98	11.94	8	0.516	0.294	65,023	13,480
	W18x85	38	18.32	8.838	0.911	0.526	32,349	11,300
	W18x70	11	18	8.75	0.751	0.438	9,256	2,689
	W18x114	128	18.48	11.833	0.991	0.595	127,645	51,102
	W16x78	35	16.32	8.586	0.875	0.529	27,689	9,548
	W18x119	96	19.655	11.265	1.06	0.655	95,685	40,743
	W12x26	41	12.22	6.49	0.38	0.23	24,570	3,724
	Total:						**382,218**	**132,585**
Zone 5	W18x85	136	18.32	8.838	0.911	0.526	115,774	40,442
	W12x40	162	11.94	8	0.516	0.294	107,488	22,284
	W18x70	18	18	8.75	0.751	0.438	15,147	4,400
	W12x161	32	13.88	12.515	1.486	0.905	29,188	18,073
	W8x31	18	8	8	0.433	0.288	10,244	1,940
	W12x120	42	13.12	12.32	1.106	0.71	37,346	17,638
	W12x72	24	12.25	12.04	0.671	0.43	20,678	6,004
	W18x119	96	19.655	11.265	1.06	0.655	95,685	40,743
	W12x26	33	12.22	6.49	0.38	0.23	19,776	2,997
	Total:						**451,326**	**154,522**
Zone 6	W18x85	58	18.32	8.838	0.911	0.526	49,374	17,247
	W12x50	336	12.19	8.077	0.641	0.371	225,574	58,067
	W18x70	55	18	8.75	0.751	0.438	46,282	13,443
	W12x133	25	13.38	12.365	1.236	0.755	22,413	11,641
	W18x105	38	18.32	11.792	0.911	0.554	37,711	13,965
	W12x192	39	14.38	12.67	1.736	1.06	36,186	25,999
	W18x114	20	18.48	11.388	0.991	0.595	19,517	7,773
	W14x111	21	14.37	14.62	0.873	0.54	21,707	8,151
	W18x96	39	18.16	11.75	0.831	0.512	38,515	13,093
	W12x72	30	12.25	12.04	0.671	0.43	25,848	7,505
	W8x28	7	8.06	6.54	0.463	0.285	3,504	679
	W12x120	25	13.12	12.32	1.106	0.71	22,230	10,499
	Total:						**548,861**	**188,062**

Conversion

	S.A. [sq.in.]	Vol. [cu.in.]	S.A. [sq.ft]	Vol. [cu.ft]	
Zone 3	325,220	112,269	2,258	65	
Zone 4	382,218	132,585	2,654	77	
Zone 5	451,326	154,522	3,134	89	
Zone 6	548,861	188,062	3,812	109	
Zone 7	0	0	0	0	(Included in Platform Support Total)

Platforms

Solid Area [sq.ft]	Vol Factor [ft]	S.A. Factor	Volume [cu.ft]	S.A. [sq.ft]
1,686	0.0142	2.0830	23.9	3,511.9
2,168	0.0142	2.0830	30.8	4,515.9
2,167	0.0142	2.0830	30.8	4,513.9
4,942	0.0142	2.0830	70.2	10,294.2
5,710	0.0142	2.0830	81.1	11,893.9

Replace with EXCEL Formula Spreadsheets

PNPP Turbine Building GOTHIC Model[14]

[14] This particular input file represents the Winter – Leak #3 – 2.9468 lb_m/sec case. The required changes for all other cases are noted in this attachment.

Control Volumes

Vol #	Description	Vol (ft3)	Elev (ft)	Ht (ft)	Hyd. D. (ft)	L/V IA (ft2)	Burn Opt
1s	Operating Floor	3452000.	647.5	67.2	183.2	DEFAULT	NONE
2s	TB1-TB4/620.5'	304471.	620.5	27.5	104.8	DEFAULT	NONE
3s	TB9-TB10	264000.	577.5	70.	52.7	DEFAULT	NONE
4s	TB10-TB11	284000.	577.5	70.	55.7	DEFAULT	NONE
5s	TB11-TB12	279500.	577.5	70.	55.1	DEFAULT	NONE
6s	TB12-TB13	270500.	577.5	70.	53.7	DEFAULT	NONE
7s	TB13-TB14	284000.	577.5	70.	55.7	DEFAULT	NONE

Laminar Leakage

Vol #	Lk Rate Factor (%/hr)	Ref Press (psia)	Ref Temp (F)	Ref Humid (%)	Sink /Src BC	Model Option	Rep Wall	Subvol Option	Leak Area (ft2)
1s	0.					CNST	T	UNIFORM	DEFAULT
2s	0.					CNST	T	UNIFORM	DEFAULT
3s	0.					CNST	T	UNIFORM	DEFAULT
4s	0.					CNST	T	UNIFORM	DEFAULT
5s	0.					CNST	T	UNIFORM	DEFAULT
6s	0.					CNST	T	UNIFORM	DEFAULT
7s	0.					CNST	T	UNIFORM	DEFAULT

Turbulent Leakage

Vol # fL/D	Lk Rate Factor (%/hr)	Ref Press (psia)	Ref Temp (F)	Ref Humid (%)	Sink /Src BC	Model Option	Rep Wall	Subvol Option	Leak Area (ft2)
1s	0.					CNST	T	UNIFORM	DEFAULT
2s	0.					CNST	T	UNIFORM	DEFAULT
3s	0.					CNST	T	UNIFORM	DEFAULT
4s	0.					CNST	T	UNIFORM	DEFAULT
5s	0.					CNST	T	UNIFORM	DEFAULT
6s	0.					CNST	T	UNIFORM	DEFAULT
7s	0.					CNST	T	UNIFORM	DEFAULT

X-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Width (ft)
1	0.	85.
2	85.	71.
3	156.	71.
4	227.	218.

Y-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 1s

Cell Plane	Distance (ft)	Height (ft)
1	0.	27.
2	27.	40.2

Cell Blockages
Volume 1s

Bl No.	Typ	X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L
	B	N									

X-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	183.2	0.	0.

Y-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	183.2	0.	0.

Z-Direction Cell Face Variations
Volume 1s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	183.2	0.	0.
1s1	0	1.	1000000.	0.	0.
1s2	0	1.	1000000.	0.	0.
1s3	0	1.	1000000.	0.	0.
1s4	0	1.	1000000.	0.	0.
1s5	0	1.	1000000.	0.	0.
1s6	0	1.	1000000.	0.	0.
1s7	0	1.	1000000.	0.	0.
1s8	0	1.	1000000.	0.	0.
1s9	0	1.	1000000.	0.	0.
1s10	0	1.	1000000.	0.	0.
1s11	0	1.	1000000.	0.	0.
1s12	0	1.	1000000.	0.	0.
1s13	0	1.	1000000.	0.	0.
1s14	0	1.	1000000.	0.	0.
1s15	0	1.	1000000.	0.	0.
1s16	0	1.	1000000.	0.	0.
1s17	0	1.	1000000.	0.	0.
1s18	0	1.	1000000.	0.	0.
1s19	0	1.	1000000.	0.	0.
1s20	0	1.	1000000.	0.	0.
1s21	0	1.	1000000.	0.	0.
1s22	0	1.	1000000.	0.	0.
1s23	0	1.	1000000.	0.	0.
1s24	0	1.	1000000.	0.	0.

Volume Variations
Volume 1s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	183.2
1s1	0	1.	1000000.
1s2	0	1.	1000000.
1s3	0	1.	1000000.
1s4	0	1.	1000000.
1s5	0	1.	1000000.
1s6	0	1.	1000000.
1s7	0	1.	1000000.
1s8	0	1.	1000000.

1s9	0	1.	1000000.
1s10	0	1.	1000000.
1s11	0	1.	1000000.
1s12	0	1.	1000000.
1s13	0	1.	1000000.
1s14	0	1.	1000000.
1s15	0	1.	1000000.
1s16	0	1.	1000000.
1s17	0	1.	1000000.
1s18	0	1.	1000000.
1s19	0	1.	1000000.
1s20	0	1.	1000000.
1s21	0	1.	1000000.
1s22	0	1.	1000000.
1s23	0	1.	1000000.
1s24	0	1.	1000000.

Boundary Slip Conditions
Volume 1s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Width (ft)
1	0.	48.
2	48.	48.

Y-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 2s

Cell Plane	Distance (ft)	Height (ft)
1	0.	27.5

Cell Blockages
Volume 2s

Bl No.	Typ B N	X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L

X-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	104.8	0.	0.

Y-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	104.8	0.	0.

Z-Direction Cell Face Variations
Volume 2s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	104.8	0.	0.

Volume Variations
Volume 2s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	104.8

Boundary Slip Conditions
Volume 2s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 3s

Cell Plane	Distance (ft)	Width (ft)
1	0.	17.
2	17.	17.

Y-Direction Noding
Volume 3s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 3s

Cell Plane	Distance (ft)	Height (ft)
1	0.	12.
2	12.	30.5
3	42.5	27.5

Cell Blockages
Volume 3s

Bl No.	Typ B	N	X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L

X-Direction Cell Face Variations
Volume 3s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	52.7	0.	0.

Y-Direction Cell Face Variations
Volume 3s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	52.7	0.	0.

Z-Direction Cell Face Variations
Volume 3s

Cell Blockage Area Hyd. Dia. Loss Drop De-ent.

No.	No.	Fraction	(ft)	Coeff.	Factor
def	0	1.	52.7	0.	0.
3s1	0	1.	1000000.	0.	0.
3s2	0	1.	1000000.	0.	0.
3s3	0	1.	1000000.	0.	0.
3s4	0	1.	1000000.	0.	0.
3s5	0	1.	1000000.	0.	0.
3s6	0	1.	1000000.	0.	0.
3s7	0	1.	1000000.	0.	0.
3s8	0	1.	1000000.	0.	0.
3s9	0	1.	1000000.	0.	0.
3s10	0	1.	1000000.	0.	0.
3s11	0	1.	1000000.	0.	0.
3s12	0	1.	1000000.	0.	0.
3s13	0	1.	1000000.	0.	0.
3s14	0	1.	1000000.	0.	0.
3s15	0	1.	1000000.	0.	0.
3s16	0	1.	1000000.	0.	0.
3s17	0	1.	1000000.	0.	0.
3s18	0	1.	1000000.	0.	0.

Volume Variations
Volume 3s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	52.7
3s1	0	1.	1000000.
3s2	0	1.	1000000.
3s3	0	1.	1000000.
3s4	0	1.	1000000.
3s5	0	1.	1000000.
3s6	0	1.	1000000.
3s7	0	1.	1000000.
3s8	0	1.	1000000.
3s9	0	1.	1000000.
3s10	0	1.	1000000.
3s11	0	1.	1000000.
3s12	0	1.	1000000.
3s13	0	1.	1000000.
3s14	0	1.	1000000.
3s15	0	1.	1000000.
3s16	0	1.	1000000.
3s17	0	1.	1000000.
3s18	0	1.	1000000.

Boundary Slip Conditions
Volume 3s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 4s

Cell Plane	Distance (ft)	Width (ft)
1	0.	18.5
2	18.5	18.5

Y-Direction Noding
Volume 4s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 4s

Cell Plane	Distance (ft)	Height (ft)
1	0.	12.
2	12.	30.5
3	42.5	27.5

Cell Blockages
Volume 4s

Bl No.	Typ B N	X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L

X-Direction Cell Face Variations
Volume 4s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.

Y-Direction Cell Face Variations
Volume 4s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.

Z-Direction Cell Face Variations
Volume 4s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.
4s1	0	1.	1000000.	0.	0.
4s2	0	1.	1000000.	0.	0.
4s3	0	1.	1000000.	0.	0.
4s4	0	1.	1000000.	0.	0.
4s5	0	1.	1000000.	0.	0.
4s6	0	1.	1000000.	0.	0.
4s7	0	1.	1000000.	0.	0.
4s8	0	1.	1000000.	0.	0.
4s9	0	1.	1000000.	0.	0.
4s10	0	1.	1000000.	0.	0.
4s11	0	1.	1000000.	0.	0.
4s12	0	1.	1000000.	0.	0.
4s13	0	1.	1000000.	0.	0.
4s14	0	1.	1000000.	0.	0.
4s15	0	1.	1000000.	0.	0.
4s16	0	1.	1000000.	0.	0.
4s17	0	1.	1000000.	0.	0.
4s18	0	1.	1000000.	0.	0.

Volume Variations
Volume 4s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	55.7
4s1	0	1.	1000000.
4s2	0	1.	1000000.
4s3	0	1.	1000000.
4s4	0	1.	1000000.
4s5	0	1.	1000000.
4s6	0	1.	1000000.
4s7	0	1.	1000000.
4s8	0	1.	1000000.
4s9	0	1.	1000000.
4s10	0	1.	1000000.
4s11	0	1.	1000000.
4s12	0	1.	1000000.
4s13	0	1.	1000000.
4s14	0	1.	1000000.
4s15	0	1.	1000000.
4s16	0	1.	1000000.
4s17	0	1.	1000000.
4s18	0	1.	1000000.

Boundary Slip Conditions
Volume 4s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 5s

Cell Plane	Distance (ft)	Width (ft)
1	0.	18.
2	18.	18.

Y-Direction Noding
Volume 5s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 5s

Cell Plane	Distance (ft)	Height (ft)
1	0.	12.
2	12.	30.5
3	42.5	27.5

Cell Blockages
Volume 5s

Bl No.	Typ		X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L
	B	N										

X-Direction Cell Face Variations
Volume 5s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.1	0.	0.

Y-Direction Cell Face Variations
Volume 5s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.1	0.	0.

Z-Direction Cell Face Variations
Volume 5s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.1	0.	0.
5s1	0	1.	1000000.	0.	0.
5s2	0	1.	1000000.	0.	0.
5s3	0	1.	1000000.	0.	0.
5s4	0	1.	1000000.	0.	0.
5s5	0	1.	1000000.	0.	0.
5s6	0	1.	1000000.	0.	0.
5s7	0	1.	1000000.	0.	0.
5s8	0	1.	1000000.	0.	0.
5s9	0	1.	1000000.	0.	0.
5s10	0	1.	1000000.	0.	0.
5s11	0	1.	1000000.	0.	0.
5s12	0	1.	1000000.	0.	0.
5s13	0	1.	1000000.	0.	0.
5s14	0	1.	1000000.	0.	0.
5s15	0	1.	1000000.	0.	0.
5s16	0	1.	1000000.	0.	0.
5s17	0	1.	1000000.	0.	0.
5s18	0	1.	1000000.	0.	0.

Volume Variations
Volume 5s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	55.1
5s1	0	1.	1000000.
5s2	0	1.	1000000.
5s3	0	1.	1000000.
5s4	0	1.	1000000.
5s5	0	1.	1000000.
5s6	0	1.	1000000.
5s7	0	1.	1000000.
5s8	0	1.	1000000.
5s9	0	1.	1000000.
5s10	0	1.	1000000.
5s11	0	1.	1000000.
5s12	0	1.	1000000.
5s13	0	1.	1000000.
5s14	0	1.	1000000.
5s15	0	1.	1000000.
5s16	0	1.	1000000.
5s17	0	1.	1000000.
5s18	0	1.	1000000.

Boundary Slip Conditions
Volume 5s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 6s

Cell Plane	Distance (ft)	Width (ft)
1	0.	17.5
2	17.5	17.5

Y-Direction Noding
Volume 6s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 6s

Cell Plane	Distance (ft)	Height (ft)
1	0.	12.
2	12.	30.5
3	42.5	27.5

Cell Blockages
Volume 6s

No.	Bl Typ		X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L
	B	N										

X-Direction Cell Face Variations
Volume 6s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	53.7	0.	0.

Y-Direction Cell Face Variations
Volume 6s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	53.7	0.	0.

Z-Direction Cell Face Variations
Volume 6s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	53.7	0.	0.
6s1	0	1.	1000000.	0.	0.
6s2	0	1.	1000000.	0.	0.
6s3	0	1.	1000000.	0.	0.
6s4	0	1.	1000000.	0.	0.
6s5	0	1.	1000000.	0.	0.
6s6	0	1.	1000000.	0.	0.
6s7	0	1.	1000000.	0.	0.
6s8	0	1.	1000000.	0.	0.
6s9	0	1.	1000000.	0.	0.
6s10	0	1.	1000000.	0.	0.

6s11	0	1.	1000000.	0.	0.
6s12	0	1.	1000000.	0.	0.
6s13	0	1.	1000000.	0.	0.
6s14	0	1.	1000000.	0.	0.
6s15	0	1.	1000000.	0.	0.
6s16	0	1.	1000000.	0.	0.
6s17	0	1.	1000000.	0.	0.
6s18	0	1.	1000000.	0.	0.

Volume Variations
Volume 6s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	53.7
6s1	0	1.	1000000.
6s2	0	1.	1000000.
6s3	0	1.	1000000.
6s4	0	1.	1000000.
6s5	0	1.	1000000.
6s6	0	1.	1000000.
6s7	0	1.	1000000.
6s8	0	1.	1000000.
6s9	0	1.	1000000.
6s10	0	1.	1000000.
6s11	0	1.	1000000.
6s12	0	1.	1000000.
6s13	0	1.	1000000.
6s14	0	1.	1000000.
6s15	0	1.	1000000.
6s16	0	1.	1000000.
6s17	0	1.	1000000.
6s18	0	1.	1000000.

Boundary Slip Conditions
Volume 6s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

X-Direction Noding
Volume 7s

Cell Plane	Distance (ft)	Width (ft)
1	0.	19.
2	19.	19.

Y-Direction Noding
Volume 7s

Cell Plane	Distance (ft)	Depth (ft)
1	0.	38.
2	38.	39.
3	77.	38.

Z-Direction Noding
Volume 7s

Cell Plane	Distance (ft)	Height (ft)
1	0.	12.
2	12.	30.5
3	42.5	27.5

Cell Blockages
Volume 7s

Bl No.	Typ	X1	Y1	Z1	Coord X2	Y2	(ft) Z2	X3	(ft) Y3	Z3	L	B	N

X-Direction Cell Face Variations
Volume 7s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.
7s1	0	1.	**56.8**	0.	0.
7s2	0	1.	**56.8**	0.	0.
7s3	0	1.	**56.8**	0.	0.
7s4	0	1.	**56.8**	0.	0.
7s5	0	1.	**56.8**	0.	0.
7s6	0	1.	**56.8**	0.	0.
7s7	0	1.	**56.8**	0.	0.
7s8	0	1.	**56.8**	0.	0.
7s9	0	1.	**56.8**	0.	0.
7s10	0	1.	**56.8**	0.	0.
7s11	0	1.	**56.8**	0.	0.
7s12	0	1.	**56.8**	0.	0.
7s13	0	1.	**56.8**	0.	0.
7s14	0	1.	**56.8**	0.	0.
7s15	0	1.	**56.8**	0.	0.
7s16	0	1.	**56.8**	0.	0.
7s17	0	1.	**56.8**	0.	0.
7s18	0	1.	**56.8**	0.	0.

Note:
Sensitivity runs with the hydraulic diameter set at 1E+06 had an imperceptible impact on the final results.

Y-Direction Cell Face Variations
Volume 7s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.
7s1	0	1.	**56.8**	0.	0.
7s2	0	1.	**56.8**	0.	0.
7s3	0	1.	**56.8**	0.	0.
7s4	0	1.	**56.8**	0.	0.
7s5	0	1.	**56.8**	0.	0.
7s6	0	1.	**56.8**	0.	0.
7s7	0	1.	**56.8**	0.	0.
7s8	0	1.	**56.8**	0.	0.
7s9	0	1.	**56.8**	0.	0.
7s10	0	1.	**56.8**	0.	0.
7s11	0	1.	**56.8**	0.	0.
7s12	0	1.	**56.8**	0.	0.
7s13	0	1.	**56.8**	0.	0.
7s14	0	1.	**56.8**	0.	0.
7s15	0	1.	**56.8**	0.	0.
7s16	0	1.	**56.8**	0.	0.
7s17	0	1.	**56.8**	0.	0.
7s18	0	1.	**56.8**	0.	0.

Z-Direction Cell Face Variations
Volume 7s

Cell No.	Blockage No.	Area Fraction	Hyd. Dia. (ft)	Loss Coeff.	Drop De-ent. Factor
def	0	1.	55.7	0.	0.

7s1	0	1.	1000000.	0.	0.
7s2	0	1.	1000000.	0.	0.
7s3	0	1.	1000000.	0.	0.
7s4	0	1.	1000000.	0.	0.
7s5	0	1.	1000000.	0.	0.
7s6	0	1.	1000000.	0.	0.
7s7	0	1.	1000000.	0.	0.
7s8	0	1.	1000000.	0.	0.
7s9	0	1.	1000000.	0.	0.
7s10	0	1.	1000000.	0.	0.
7s11	0	1.	1000000.	0.	0.
7s12	0	1.	1000000.	0.	0.
7s13	0	1.	1000000.	0.	0.
7s14	0	1.	1000000.	0.	0.
7s15	0	1.	1000000.	0.	0.
7s16	0	1.	1000000.	0.	0.
7s17	0	1.	1000000.	0.	0.
7s18	0	1.	1000000.	0.	0.

Volume Variations
Volume 7s

Cell No.	Blockage No.	Volume Porosity	Hyd. Dia. (ft)
def	0	1.	55.7
7s1	0	1.	1000000.
7s2	0	1.	1000000.
7s3	0	1.	1000000.
7s4	0	1.	1000000.
7s5	0	1.	1000000.
7s6	0	1.	1000000.
7s7	0	1.	1000000.
7s8	0	1.	1000000.
7s9	0	1.	1000000.
7s10	0	1.	1000000.
7s11	0	1.	1000000.
7s12	0	1.	1000000.
7s13	0	1.	1000000.
7s14	0	1.	1000000.
7s15	0	1.	1000000.
7s16	0	1.	1000000.
7s17	0	1.	1000000.
7s18	0	1.	1000000.

Boundary Slip Conditions
Volume 7s

North	South	East	West	Top	Bottom
SLIP	SLIP	SLIP	SLIP	SLIP	SLIP

Turbulence Parameters

Vol #	Molec Diff.	Turb. Model	Liquid Mix.L. (ft)	Vapor Mix.L (ft)	Liquid Pr/Sc No.	Vapor Pr/Sc No.	Phase Option
1s	NO	NONE			1.	1.	VAPOR
2s	NO	NO			1.	1.	VAPOR
3s	NO	NO			1.	1.	VAPOR
4s	NO	NO			1.	1.	VAPOR
5s	NO	NO			1.	1.	VAPOR
6s	NO	NO			1.	1.	VAPOR
7s	NO	NO			1.	1.	VAPOR

Turbulence Sources

Vol #	Type	Phase	Kinetic Energy (ft2/s2)[*lbm/s]	FF	Dissipation (ft2/s3)[*lbm/s]	FF

Fluid Boundary Conditions - Table 1

BC#	Description	Press. (psia)	FF	Temp. (F)	FF	Flow (lbm/s)	FF	ON Trip	OFF Trip
1P	Outdoors	14.7		**-10**					
2F	Break Source	1100.		e1190.4		**2.9468**		1	
3F	steam tunnel	14.7		121		v41.67		0	
4F	ventilation 1	14.7		63		v103.33		0	
5F	ventilation 2	14.7		63		v105		0	
6F	ventilation 3	14.7		63		v218.33		0	
7F	ventilation 4	14.7		63		v140		0	
8F	ventilation 5	14.7		63		v208.33		0	
9F	ventilation 6	14.7		63		v155		0	
10F	ventilation 7	14.7		63		v150		0	
11F	ventilation 8	14.7		63		v150		0	
12F	ventilation 9	14.7		63		v158.33		0	
13F	ventilation 10	14.7		63		v160		0	

Temperature:
Summer = 104°F
Winter = -10°F
Average = 58°F

Leak Flow Rate:
Flow #1 = 2.9468 lb_m/sec
Flow #2 = 10.99 lb_m/sec
Flow #3 = 19.68 lb_m/sec
Flow #4 = 45.11 lb_m/sec

Fluid Boundary Conditions - Table 2

BC#	Liq. V Frac.	FF	Stm. P.R.	FF	Drop D (in)	FF	Cpld BC#	Flow Frac.	FF	Heat (Btu/s)	FF	Outlet Quality	FF
1P	0.		**h20**		NONE							DEFAULT	
2F	0.		1		NONE							DEFAULT	
3F	0.		h20		NONE							DEFAULT	
4F	0.		h55		NONE							DEFAULT	
5F	0.		h55		NONE							DEFAULT	
6F	0.		h55		NONE							DEFAULT	
7F	0.		h55		NONE							DEFAULT	
8F	0.		h55		NONE							DEFAULT	
9F	0.		h55		NONE							DEFAULT	
10F	0.		h55		NONE							DEFAULT	
11F	0.		h55		NONE							DEFAULT	
12F	0.		h55		NONE							DEFAULT	
13F	0.		h55		NONE							DEFAULT	

Steam Pressure Ratio:
Summer = 100%
Winter = 20%
Average = 100%

Fluid Boundary Conditions - Table 3
Gas Pressure Ratios

BC#	Air Gas 1	FF	Gas 2	FF	Gas 3	FF	Gas 4	FF
1P	1.							
2F	1.							
3F	1.							
4F	1.							
5F	1.							
6F	1.							
7F	1.							
8F	1.							
9F	1.							
10F	1.							
11F	1.							
12F	1.							
13F	1.							

Fluid Boundary Conditions - Table 4
Gas Pressure Ratios

BC#	Gas 5	FF	Gas 6	FF	Gas 7	FF	Gas 8	FF
1P								
2F								
3F								
4F								
5F								
6F								
7F								
8F								
9F								
10F								
11F								
12F								
13F								

Flow Paths - Table 1

F.P. #	Description	Vol A	Elev (ft)	Ht (ft)	Vol B	Elev (ft)	Ht (ft)
1	TB13/N/B	7s8	589.51	30.48	6s7	589.51	30.48
2	TB13/N/T	7s14	620.01	19.48	6s13	620.01	19.48
3	TB13/C/B	7s10	589.51	30.48	6s9	589.51	30.48
4	TB13/C/T	7s16	620.01	19.48	6s15	620.01	19.48
5	TB13/S/B	7s12	589.51	30.48	6s11	589.51	30.48
6	TB13/S/T	7s18	620.01	19.48	6s17	620.01	19.48
7	TB12/N/T	6s14	624.5	13.	5s13	624.5	13.
8	TB12/S/T	6s18	624.5	13.	5s17	624.5	13.
9	TB12/N/B	6s2	577.51	10.	5s1	577.51	10.
10	TB12/S/B	6s6	577.51	10.	5s5	577.51	10.
11	TB11/N/T	5s14	624.5	13.	4s13	624.5	10.
12	TB11/S/T	5s18	624.5	13.	4s17	624.5	10.
13	TB10/N/T	4s14	624.5	13.	3s13	624.5	13.
14	TB10/S/T	4s18	624.5	13.	3s17	624.5	13.
15	3/1N	3s13	647.4	0.01	1s3	647.51	0.1
16	3/1S	3s17	647.4	0.01	1s11	647.51	0.1
17	4/1N	4s13	647.4	0.01	1s3	647.51	0.1
18	4/1S	4s17	647.4	0.01	1s11	647.51	0.1
19	5/1N	5s13	647.4	0.01	1s2	647.51	0.1
20	5/1S	5s17	647.4	0.01	1s10	647.51	0.1
21	leakage path	1s19	714.	0.1	1P	714.	0.1
22	pipe break	**7s12**	**592.**	0.01	2F	**592.**	0.01
23	steam tunnel	7s17	620.5	23.	3F	620.5	23.
24	TB13/N/D	7s2	577.51	7.	6s1	577.51	7.
25	TB13/S/D	7s6	577.51	7.	6s5	577.51	7.
26	6/1N	6s13	647.4	0.01	1s2	647.51	0.1
27	6/2S	6s17	647.4	0.01	1s10	647.51	0.1
28	vent1	3s7	616.25	3.	4F	616.25	3.
29	vent2	3s17	624.6	3.	5F	624.6	3.
30	vent3	4s7	592.	3.	6F	592.	3.
31	vent4	4s17	624.6	3.	7F	624.6	3.
32	vent5	5s7	595.5	3.	8F	595.5	3.
33	vent6	5s17	624.6	3.	9F	624.6	3.
34	vent7	6s7	595.5	3.	10F	595.5	3.
35	vent8	6s11	615.	3.	11F	615.	3.
36	vent9	7s7	595.5	3.	12F	595.5	3.
37	vent10	7s11	607.75	3.	13F	607.75	3.

Leak Locations:
Leak #1 = 7s15
Leak #2 = 7s11
Leak #3 = 7s12

Leak Elevation:
Leak #1 = 624’
Leak #2 = 592’
Leak #3 = 592’

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	915.	20.	30.	1.		0.	-	NONE
2	585.	20.	30.	1.		0.	-	NONE
3	793.	20.	30.	1.		0.	-	NONE
4	507.	20.	30.	1.		0.	-	NONE
5	915.	20.	30.	1.		0.	-	NONE
6	585.	20.	30.	1.		0.	-	NONE
7	390.	20.	30.	1.		0.	-	NONE
8	390.	20.	30.	1.		0.	-	NONE
9	40.	20.	30.	1.		0.	-	NONE
10	40.	20.	30.	1.		0.	-	NONE
11	390.	20.	30.	1.		0.	-	NONE
12	390.	20.	30.	1.		0.	-	NONE
13	390.	20.	30.	1.		0.	-	NONE
14	390.	20.	30.	1.		0.	-	NONE
15	242.	0.1	30.	1.		0.	-	NONE
16	242.	0.1	30.	1.		0.	-	NONE
17	242.	0.1	30.	1.		0.	-	NONE
18	242.	0.1	30.	1.		0.	-	NONE
19	242.	0.1	30.	1.		0.	-	NONE
20	242.	0.1	30.	1.		0.	-	NONE
21	10.	10.	30.	1.		0.	-	NONE
22	0.001	0.001	0.1	0.1		0.	-	NONE
23	500.	20.	70.	1.		0.	-	NONE
24	21.	3.	30.	1.		0.	-	NONE
25	21.	3.	30.	1.		0.	-	NONE
26	115.	5.	30.	1.		0.	-	NONE
27	115.	5.	30.	1.		0.	-	NONE
28	15.	4.	1.	1.		0.	-	NONE
29	15.	4.	1.	1.		0.	-	NONE
30	24.	4.	1.	1.		0.	-	NONE
31	20.	4.	1.	1.		0.	-	NONE
32	32.	4.	1.	1.		0.	-	NONE
33	24.	4.	1.	1.		0.	-	NONE
34	24.	4.	1.	1.		0.	-	NONE
35	24.	4.	1.	1.		0.	-	NONE
36	20.	4.	1.	1.		0.	-	NONE
37	24.	4.	1.	1.		0.	-	NONE

Flow Paths - Table 3

Flow Path #	Fwd. Loss Coeff.	Rev. Loss Coeff.	Comp. Opt.	Critical Flow Model	Exit Loss Coeff.	Drop Breakup Model
1	2.78	2.78	OFF	OFF	0.	OFF
2	2.78	2.78	OFF	OFF	0.	OFF
3	2.78	2.78	OFF	OFF	0.	OFF
4	2.78	2.78	OFF	OFF	0.	OFF
5	2.78	2.78	OFF	OFF	0.	OFF
6	2.78	2.78	OFF	OFF	0.	OFF
7	2.78	2.78	OFF	OFF	0.	OFF
8	2.78	2.78	OFF	OFF	0.	OFF
9	2.78	2.78	OFF	OFF	0.	OFF
10	2.78	2.78	OFF	OFF	0.	OFF
11	2.78	2.78	OFF	OFF	0.	OFF
12	2.78	2.78	OFF	OFF	0.	OFF
13	2.78	2.78	OFF	OFF	0.	OFF
14	2.78	2.78	OFF	OFF	0.	OFF
15	2.78	2.78	OFF	OFF	0.	OFF

16	2.78	2.78	OFF	OFF	0.	OFF
17	2.78	2.78	OFF	OFF	0.	OFF
18	2.78	2.78	OFF	OFF	0.	OFF
19	2.78	2.78	OFF	OFF	0.	OFF
20	2.78	2.78	OFF	OFF	0.	OFF
21	2.78	2.78	OFF	OFF	0.	OFF
22	2.78	2.78	ON	TABLES	1.	OFF
23	2.78	2.78	OFF	OFF	0.	OFF
24	2.78	2.78	OFF	OFF	0.	OFF
25	2.78	2.78	OFF	OFF	0.	OFF
26	2.78	2.78	OFF	OFF	0.	OFF
27	2.78	2.78	OFF	OFF	0.	OFF
28			OFF	OFF	0.	OFF
29			OFF	OFF	0.	OFF
30			OFF	OFF	0.	OFF
31			OFF	OFF	0.	OFF
32			OFF	OFF	0.	OFF
33			OFF	OFF	0.	OFF
34			OFF	OFF	0.	OFF
35			OFF	OFF	0.	OFF
36			OFF	OFF	0.	OFF
37			OFF	OFF	0.	OFF

Thermal Conductors - Table 1

Cond #	Description	Vol A	HT Co	Vol B	HT Co	Cond Type	S. A. (ft2)	Init. T.(F)	Or
1s	east wall	7s6-8	1	7s6-8	7	2	4824.	110.	I
2s	north wall	7s1-8	1	7s1-8	7	2	1700.	110.	I
3s	south wall	7s6-11	1	7s6-11	7	2	1700.	110.	I
4s	north wall	6s1-8	1	6s1-8	7	2	1488.	110.	I
5s	south wall	6s6-11	1	6s6-11	7	2	1488.	110.	I
6s	floor	7s2-5	2	7s2-5	7	2	4370.	110.	I
7s	floor	6s2-5	2	6s2-5	7	2	4024.	110.	I
8s	floor	5s5-2	2	5s5-2	7	2	4140.	110.	I
9s	floor	4s5-2	2	4s5-2	7	2	4255.	110.	I
10s	floor	3s5-2	2	3s5-2	7	2	3910.	110.	I
11s	north wall	5s1-8	1	5s1-8	7	2	1537.	110.	I
12s	south wall	5s6-11	1	5s6-11	7	2	1537.	110.	I
13s	north wall	4s1-8	1	4s1-8	7	2	1562.	110.	I
14s	south wall	4s6-11	1	4s6-11	7	2	1562.	110.	I
15s	north wall	3s1-8	1	3s1-8	7	2	1551.	110.	I
16s	south wall	3s6-11	1	3s6-11	7	2	1551.	110.	I
17s	north wall	1s1-4	1	1s1-4	5	2	12015.	110.	I
18s	south wall	1s9-12	1	1s9-12	5	2	12015.	110.	I
19s	east wall	1s1-5	1	1s1-5	5	2	3105.	110.	I
20s	west wall	1s12-4	1	1s12-4	5	2	3105.	110.	I
21s	roof	1s21-1	5	1s21-1	4	3	51175.	120.	I
22s	N upper wall	1s16-2	1	1s16-2	5	3	17889.	120.	I
23s	S upper wall	1s13-2	1	1s13-2	5	3	17889.	120.	I
24s	E upper wall	1s16-1	1	1s16-1	5	3	4623.	120.	I
25s	W upper wall	1s24-2	1	1s24-2	5	3	4623.	120.	I
26s	V1 heat	1s24-1	1	1s24-1	8	4	10000.	120.	I
27s	V3 heat	3s18-1	1	3s18-1	8	4	10000.	120.	I
28s	V4 heat	4s18-1	1	4s18-1	8	4	10000.	120.	I
29s	V5 heat	5s18-1	1	5s18-1	8	4	10000.	120.	I
30s	V6 heat	6s18-1	1	6s18-1	8	4	10000.	120.	I
31s	V7 heat	7s18-1	1	7s18-1	8	4	10000.	120.	I
32s	CV3 steel	3s1-18	1	3s1-18	1	5	14770.	120.	I
33s	CV4 steel	4s1-18	1	4s1-18	1	5	16256.	120.	I
34s	CV5 steel	5s1-18	1	5s1-18	1	5	16121.	120.	I
35s	CV6 steel	6s1-18	1	6s1-18	1	8	29621.	120.	I

36s	CV7 steel	7s1-18 1	7s1-18 1	9	37221.	120.	I
37s	east upper wall	7s14-1 1	7s14-1 5	2	3121.	120.	I
38s	north upper wal	7s13-1 1	7s13-1 5	2	1100.	120.	I
39s	south upper wal	7s17-1 1	7s17-1 5	2	1100.	120.	I
40s	north upper wal	6s13-1 1	6s13-1 5	2	962.	120.	I
41s	south upper wal	6s17-1 1	6s17-1 5	2	962.	120.	I
42s	north upper wal	5s13-1 1	5s13-1 5	2	995.	120.	I
43s	south upper wal	5s17-1 1	5s17-1 5	2	995.	120.	I
44s	north upper wal	4s14-1 1	4s14-1 5	2	1011.	120.	I
45s	south upper wal	4s17-1 1	4s17-1 5	2	1011.	120.	I
46s	north upper wal	3s13-1 1	3s13-1 5	2	1004.	120.	I
47s	south upper wal	3s17-1 1	3s17-1 5	2	1004.	120.	I

Thermal Conductors - Table 2

Cond #	Therm. Rad. Side A	Emiss. Side A	Therm. Rad. Side B	Emiss. Side B
1s	No		No	
2s	No		No	
3s	No		No	
4s	No		No	
5s	No		No	
6s	No		No	
7s	No		No	
8s	No		No	
9s	No		No	
10s	No		No	
11s	No		No	
12s	No		No	
13s	No		No	
14s	No		No	
15s	No		No	
16s	No		No	
17s	No		No	
18s	No		No	
19s	No		No	
20s	No		No	
21s	No		No	
22s	No		No	
23s	No		No	
24s	No		No	
25s	No		No	
26s	No		No	
27s	No		No	
28s	No		No	
29s	No		No	
30s	No		No	
31s	No		No	
32s	No		No	
33s	No		No	
34s	No		No	
35s	No		No	
36s	No		No	
37s	No		No	
38s	No		No	
39s	No		No	
40s	No		No	
41s	No		No	
42s	No		No	
43s	No		No	
44s	No		No	
45s	No		No	

Outdoor Temperature:
Summer = 104°F
Winter = -10°F
Average = 58°F

46s	No	No
47s	No	No

Heat Transfer Coefficient Types - Table 1

Type #	Heat Transfer Option	Nominal Value	FF	Cnd Cnv Opt	Cnd Opt	Sp Cnv HTC	Nat Cnv Opt	For Cnv Opt	Rad Opt
1	Direct			ADD	MAX		VERT SURF	PIPE FLOW	ON
2	Direct			ADD	MAX		FACE UP	PIPE FLOW	ON
3	Sp Heat	0.							
4	Direct			ADD	MAX		FACE DOWN	PIPE FLOW	ON
5	Sp Ambie	**-10.**				6			
6	Sp Conv	1.46							ON
7	Sp Temp	53.							
8	Sp Heat	**144.**	2						

Heat Rate:
Summer = 155 Btu/sq.ft
Winter = 144 Btu/sq.ft
Average = 148 Btu/sq.ft

Heat Transfer Coefficient Types - Table 2

Type #	Phase Opt	Min Liq Fract	Max Liq Fract	Convect Bulk T Model	FF	Condensa Bulk T Model	FF
1	VAP			Tg-Tf		Tb-Tw	
2	VAP			Tg-Tf		Tb-Tw	
3							
4	VAP			Tg-Tf		Tb-Tw	
5							
6	VAP			Tg-Tw			
7							
8							

Heat Transfer Coefficient Types - Table 3

Type #	Char. Length (ft)	Nat Coef FF	Exp FF	For Coef FF	Exp FF	Nom Vel (ft/s)	Vel FF	Minimum Conv HTC (B/h-f2-F)
1								DEFAULT
2								DEFAULT
3								
4								DEFAULT
5								
6								
7								
8								

HTC Types - Table 4

Type #	Total Heat (Btu)	Peak Time (sec)	Initial Value (B/h-f2-F)	Post-BD Direct FF
1				
2				
3				
4				
5				
6				
7				
8				

Thermal Conductor Types

Type #	Description	Geom	Thick. (in)	O.D. (in)	Regions	Heat (Btu/ft3-s)	Heat FF
1	insul concrete	WALL	12.	0.	7	0.	
2	cond concrete	WALL	36.	0.	16	0.	
3	sheet metal	WALL	0.1	0.	2	0.	

4	area heat	WALL	0.5	0.	1	0.	0
5	Zone 3 steel	WALL	0.17	0.	7	0.	
6	Zone 4 steel	WALL	0.5	0.	10	0.	
7	Zone 5 steel	WALL	0.49	0.	10	0.	
8	Zone 6 steel	WALL	0.15	0.	7	0.	
9	Zone 7 steel	WALL	0.16	0.	7	0.	

Thermal Conductor Type
1
insul concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.12	1	0.
2	1	0.12	0.24	1	0.
3	1	0.36	0.48	1	0.
4	1	0.84	0.96	1	0.
5	1	1.8	1.92	1	0.
6	1	3.72	4.140001	1	0.
7	1	7.860001	4.139999	1	0.

Thermal Conductor Type
2
cond concrete

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.12	1	0.
2	1	0.12	0.24	1	0.
3	1	0.36	0.48	1	0.
4	1	0.84	0.96	1	0.
5	1	1.8	1.92	1	0.
6	1	3.72	3.84	1	0.
7	1	7.56	7.68	1	0.
8	1	15.24	5.190001	1	0.
9	1	20.43	5.19	1	0.
10	1	25.62	3.329996	1	0.
11	1	28.95	3.329993	1	0.
12	1	32.27999	1.920005	1	0.
13	1	34.2	0.960003	1	0.
14	1	35.16	0.480000	1	0.
15	1	35.64	0.240000	1	0.
16	1	35.88	0.119998	1	0.

Thermal Conductor Type
3
sheet metal

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	1	0.	0.05	1	0.
2	1	0.05	0.05	1	0.

Thermal Conductor Type
4
area heat

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.5	1	0.

Thermal Conductor Type
5
Zone 3 steel

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.0132	1	0.
2	2	0.0132	0.0264	1	0.
3	2	0.0396	0.0326	1	0.
4	2	0.0722	0.0326	1	0.
5	2	0.1048	0.026	1	0.
6	2	0.1308	0.026	1	0.
7	2	0.1568	0.0132	1	0.

Thermal Conductor Type
6
Zone 4 steel

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.0132	1	0.
2	2	0.0132	0.0264	1	0.
3	2	0.0396	0.0528	1	0.
4	2	0.0924	0.1056	1	0.
5	2	0.198	0.0755	1	0.
6	2	0.2735	0.0755	1	0.
7	2	0.349	0.0557	1	0.
8	2	0.4047	0.0557	1	0.
9	2	0.4604	0.0264	1	0.
10	2	0.4868	0.0132	1	0.

Thermal Conductor Type
7
Zone 5 steel

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.0132	1	0.
2	2	0.0132	0.0264	1	0.
3	2	0.0396	0.0528	1	0.
4	2	0.0924	0.1056	1	0.
5	2	0.198	0.073	1	0.
6	2	0.271	0.073	1	0.
7	2	0.344	0.0532	1	0.
8	2	0.3972	0.0532	1	0.
9	2	0.4504	0.0264	1	0.
10	2	0.4768	0.0132	1	0.

Thermal Conductor Type
8
Zone 6 steel

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.0132	1	0.
2	2	0.0132	0.0264	1	0.
3	2	0.0396	0.0276	1	0.
4	2	0.0672	0.0276	1	0.
5	2	0.0948	0.021	1	0.
6	2	0.1158	0.021	1	0.
7	2	0.1368	0.0132	1	0.

Thermal Conductor Type
9
Zone 7 steel

Region	Mat. #	Bdry. (in)	Thick (in)	Sub-regs.	Heat Factor
1	2	0.	0.0132	1	0.
2	2	0.0132	0.0264	1	0.
3	2	0.0396	0.0301	1	0.
4	2	0.0697	0.0301	1	0.
5	2	0.0998	0.0235	1	0.
6	2	0.1233	0.0235	1	0.
7	2	0.1468	0.0132	1	0.

Volume Initial Conditions

Vol #	Pressure (psia)	Vapor Temp. (F)	Liquid Temp. F	Relative Humidity (%)	Liquid Volume Fractio	Ice Volume Fract.	Ice Surf.A. (ft2)
def	14.7	80.	80.	60.	0.	0.	0.
1s	14.7	**113.**	**113.**	**20.**	0.	0.	0.
2s	14.7	105.	105.	50.	0.	0.	0.
3s	14.7	**113.**	**113.**	**20.**	0.	0.	0.
4s	14.7	**113.**	**113.**	**20.**	0.	0.	0.
5s	14.7	**113.**	**113.**	**20.**	0.	0.	0.
6s	14.7	**113.**	**113.**	**20.**	0.	0.	0.
7s	14.7	**113.**	**113.**	**20.**	0.	0.	0.

Initial Conditions:
Summer = 130°F, 90% RH
Winter = 113°F, 20% RH
Average = 122°F, 50% RH

Initial Gas Pressure Ratios

Vol #	Air Gas 1	Gas 2	Gas 3	Gas 4	Gas 5	Gas 6	Gas 7	Gas 8
def	1.	0.	0.	0.	0.	0.	0.	0.
1s	1.	0.	0.	0.	0.	0.	0.	0.
2s	1.	0.	0.	0.	0.	0.	0.	0.
3s	1.	0.	0.	0.	0.	0.	0.	0.
4s	1.	0.	0.	0.	0.	0.	0.	0.
5s	1.	0.	0.	0.	0.	0.	0.	0.
6s	1.	0.	0.	0.	0.	0.	0.	0.
7s	1.	0.	0.	0.	0.	0.	0.	0.

Noncondensing Gases

Gas No.	Description	Symbol	Type	Mol. Weight	Lennard-Jones Parameters Diameter (Ang)	e/K (K)
1	Air	Air	POLY	28.97	3.617	97.

Noncondensing Gases - Cp/Visc. Equations

Gas No.	Cp Equation (Required) Tmin (R)	Tmax (R)	Cp (Btu/lbm-R)	Visc. Equation (Optional) Tmin (R)	Tmax (R)	Viscosity (lbm/ft-hr)
1	360.	2280.	0.238534-6.2006			

Materials

Type #	Description
1	concrete
2	steel

Material Type
1
concrete

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
0.	140.	1.	0.2
1000.	140.	1.	0.2

Material Type
2
steel

Temp. (F)	Density (lbm/ft3)	Cond. (Btu/hr-ft-F)	Sp. Heat (Btu/lbm-F)
0.	490.	11.	0.11
5000.	490.	11.	0.11

Ice Condenser Parameters

Initial Temp. (F)	Bulk Density (lbm/ft3)	Surface Area Multiplier Function	Heat Transfer Option
15.	33.43		UCHIDA

Functions

FF#	Description	Ind. Var.	Dep. Var.	Points
0	Constant	-	-	0
1	break flow rati	Ind. Var.	Dep. Var.	4
2	heat rate	Ind. Var.	Dep. Var.	3

Function
1
break flow ratio
Ind. Var.:
Dep. Var.:

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.	3600.	0.
3601.	1.	1000000.	1.

Function
2
heat rate
Ind. Var.:
Dep. Var.:

Ind. Var.	Dep. Var.	Ind. Var.	Dep. Var.
0.	0.7	1000.	1.
1000000.	1.		

FPDOSE Control

Options	Setting	Units
Generate FPDOSE Input	NO	
Transfer Time Interval	0.0	s
Isolation Valve #	-	
Washout Factor	0.0	
Containment Leak Rate/Pressure	0.0	%/hr-psig
Vacuum Bldg Leak Rate/Pressure	0.0	%/hr-psig

FPDOSE Volume Types

Vol #	Type	FP Transfer Option	Transfer Vol. Frac.
1s	NORMAL	NORMAL	0.
2s	NORMAL	NORMAL	0.
3s	NORMAL	NORMAL	0.

4s	NORMAL	NORMAL	0.
5s	NORMAL	NORMAL	0.
6s	NORMAL	NORMAL	0.
7s	NORMAL	NORMAL	0.

Run Control Parameters (Seconds)

Time Dom	DT Min	DT Max	DT Ratio	End Time	Print Int	Graph Int	Max CPU	Dump Int	Phs Chng Time Scale
1	1e-008	10.	1e+009	10.	10.	1.	1e+006	0.	DEFAULT
2	1e-008	20.	1.	7200.	7200.	20.	1e+006	0.	DEFAULT
3	1e-008	20.	1.	90000.	90000.	1000.	1e+006	0.	DEFAULT

Solution Options

Time Dom	Solution Method	Imp Conv Limit	Imp Iter Limit	Pres Sol Method	Pres Conv Limit	Pres Iter Limit	Differ Scheme	Burn Sharp
1	SEMI-IMP	0.	1	DIRECT	0.	1	FOUP	0.0
2	SEMI-IMP	0.	1	DIRECT	0.	1	FOUP	0.0
3	SEMI-IMP	0.	1	DIRECT	0.	1	FOUP	0.0

Run Options

Options	Setting
Restart Time (sec)	0.0
Restart Time Step #	0
Restart Time Control	NEW
Revaporization Fraction	DEFAULT
Fog Model	OFF
Maximum Mist Density	DEFAULT
Drop Diam. From Mist	DEFAULT
Minimum HT Coeff.	0.0
Reference Pressure	IGNORE
Forced Ent. Drop Diam.	DEFAULT
Vapor Phase Head Correction	INCLUDE
Kinetic Energy	IGNORE
Vapor Phase	INCLUDE
Liquid Phase	INCLUDE
Drop Phase	INCLUDE
Force Equilibrium	IGNORE
Drop-Liq. Conversion	INCLUDE
QA Logging	OFF
Debug Output Level	0
Restart Dump on CPU Interval (sec)	3600.

Graphs

Graph #	Title	Mon	Curve Number 1	2	3	4	5
1			TV7s16	TV6s15	TV1s19	TV7s15	
2			TV4s14	TV4s8	TV4s2		
3			PR7s16	PR1s7			
4			1R7s15	SR7s15			
5			TV6s15	TV5s15	TV4s15	TV3s15	
6			FV21	FV23	FV22	FL22	FD22
7			FV15	FV16	FV17	FV18	FV19
8			LL7s3	LL6s3			
9			TV7s15	TV7s12			
10			TP1s8t1				
11			TL7s3				
12			TV6s11	TV7s16	TV7s18	TV7s13	
13			TV7s15	**TV7s12**			
14			TP6s1t1	TP6s1t1	TP6s1t4	TP6s1t8	

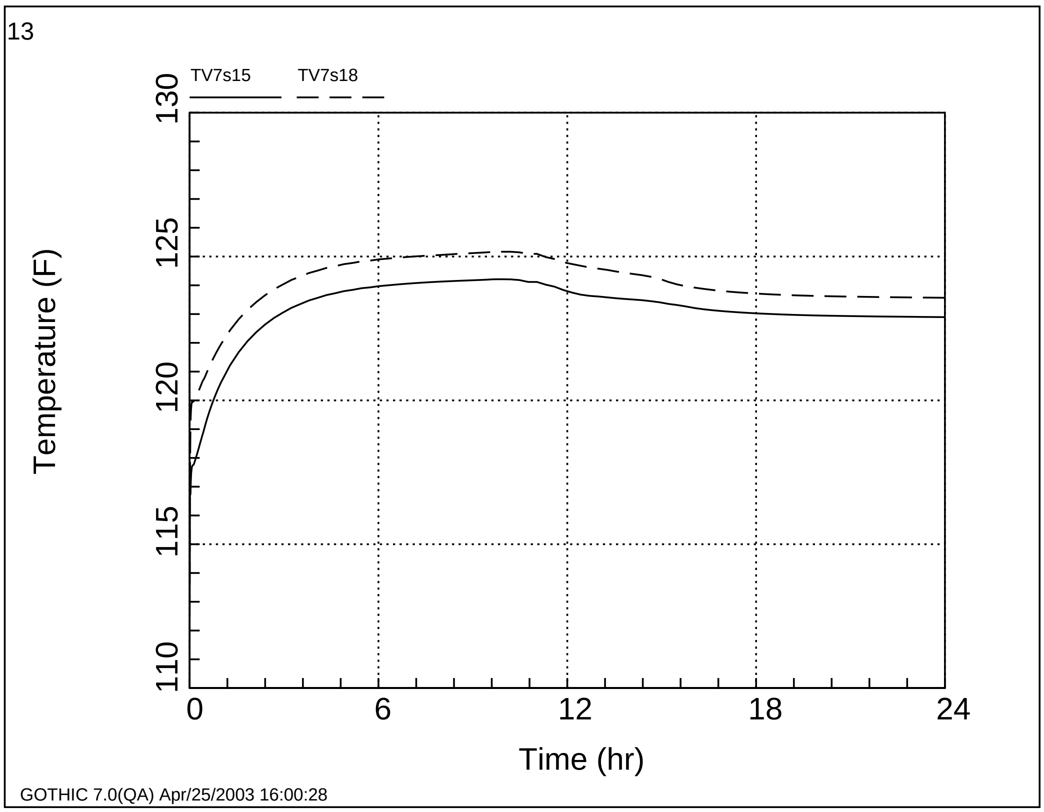
Leak Location:
Leak #1 = V7s15
Leak #2 = V7s11
Leak #3 = V7s12

15	TP36s1t TP36s1t TP36s1t TP36s1t TP36s1t
16	TP31s1t TP31s1t TP31s1t TP31s1t
17	RH7s15
18	AL7s3

Envelope Sets

Set No.	Set Type	Description	No. Items

Leak Location 4 – Winter
2.9468 Lb_m/sec leak rate



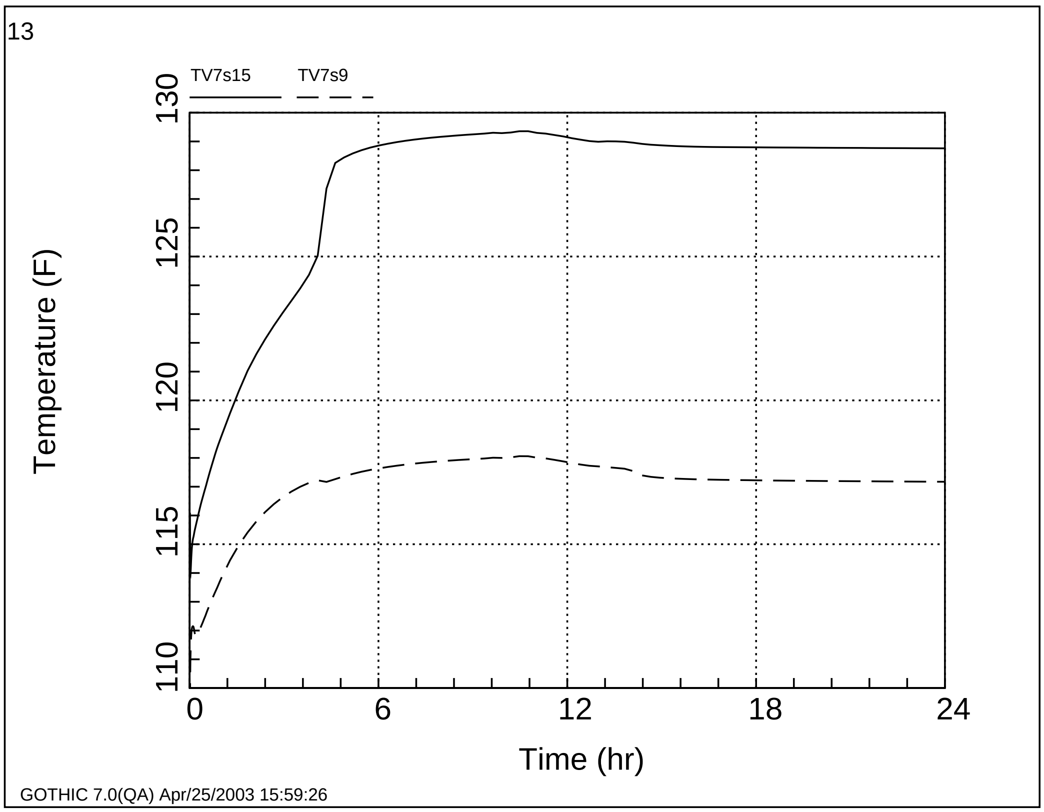
GOTHIC Sub-Volume V7s15

Maximum temperature realized – 124.2°F after 9 hrs 55 min 20 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

Leak Location 5 – Winter
2.9468 Lb_m/sec leak rate



GOTHIC Sub-Volume V7s15

Maximum temperature realized – 129.4°F after 10 hrs 45 min 20 sec

Time required to reach 145°F – N/A

Time required to reach 160°F – N/A

INTRODUCTION TO UNSTEADY THERMOFLUID MECHANICS

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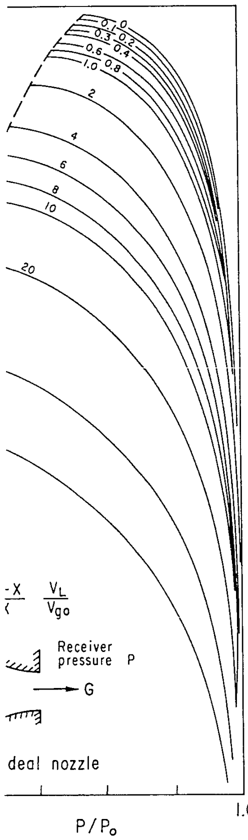

ɪressible Liquid–Perfect Gas Mixture in Ideal

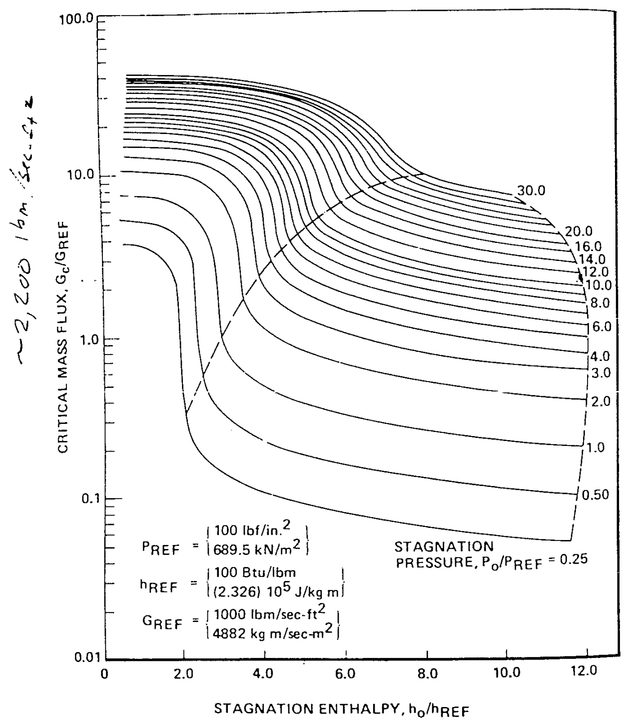

Figure 2.20(*a*) Homogeneous, Bubbly, Equilibrium, Steam-Water Critical Mass Flux

Figures 2.20(*a*) and 2.20(*b*) include the subcooled region where G, at lower values of h_0, approaches the value obtained from Eq. (2.64) for an incompressible liquid. Figure 2.21 shows a comparison of calculated and measured critical flow rates of saturated water.

Maximum values of G for liquid-vapor mixtures are more difficult to determine accurately when h_0 is farther into the subcooled region, because the maximizing condition $dG/dP = 0$ occurs on a steep spike, as indicated in