ERRATA SHEET

PAGE 5-9:

Equation 4 add T_0 to denominator	Typo
Revise g = to 9.81 from 9.1 m/s^2	Typo

PAGE 5-13:

Box 16 add (See Worksheet 1A) to first sentence	Clarification
Box 18 Equation 8 σ unit correction = $°K^4$, $°R^4$	Typo

PAGE 5-17:

Box 9 add "Tables 1E,2 and 3" to second sentence	Clarification

PAGE 5-22:

Box 25:	
Revise Table 10 to read Table 13	Typo
Revise units σ = $°K^4$, $°R^4$	Typo
Revise σ = 4.76 $x10^{-13}$	Typo
Revise provide to provided	Grammar error

PAGE 5-26:

Box 3 add (See Worksheet 1A) to first sentence	Clarification

PAGE 5-27:

Box 11 Revise units for T_0 = (°K,°F)	Typo

PAGE 5-29:

Box 2, Revise Table 5 to read Table 1E	Typo

PAGE 5-33:

Box 18 for "L" Revise Box 5 to read Box 10	Typo

ERRATA SHEET

PAGE A2-3:		
Example 1:	add: Thermo-lag "(1hr)"	Clarification
	Fire size confined to 12.25 ft^2	Clarification
	Fire located in center of room	Clarification
PAGE A2-4:		
Step 4.2	Revise 394 to 397	Rounding error
	Revise 950 to 953	Rounding error
PAGE A2-6:		
	Revise two places 35420 to 35700	Rounding error
	Revise two places 354200 to 357000	Rounding error
PAGE A2-7:		
	Box 4 Revise to "Tables 1E-2"	Clarification
	Box 5 Revise to "4 for corner"	Typo
PAGE A2-8:		
	Box 15 Revise from figure 1A to worksheet 1A	Typo
	Box 16 Revise from figure 1A to worksheet 1A	Typo
	Box 25 Revise from figure 1A to worksheet 1A	Typo
PAGE A2-9:		
	Revise 354200 to 357000	Rounding error
PAGE A2-11:		
Example 2:	add: Thermo-lag "(1hr)"	Clarification
	Fire size confined to 12.25 ft^2	Clarification
	Fire located in center of room	Clarification
PAGE A2-12:		
Step 4.2	Revise 3542 to 3570	Rounding error
	Revise 8542 to 8570	Rounding error

ERRATA SHEET

PAGE A2-14:

Revise two places 35420 to 35700	Rounding error
Revise two places 354200 to 357000	Rounding error

PAGE A2-15:

Box 4 Revise to "Tables 1E-2"	Clarification
Box 5 Revise to "4 for corner"	Typo

PAGE A2-16:

Box 15 Revise from figure 1A to worksheet 1A	Typo
Box 16 Revise from figure 1A to worksheet 1A	Typo
Box 25 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-17:

Revise 354200 to 357000	Rounding error

PAGE A2-19:

Example 3: add: Thermo-lag "(1hr)"	Clarification
Fire size confined to 12.25 ft^2	Clarification

PAGE A2-20:

Step 4.2 Revise 394 to 397	Rounding error
Revise 950 to 953	Rounding error

PAGE A2-22:

Revise two places 35420 to 35700	Rounding error
Revise two places 354200 to 357000	Rounding error

PAGE A2-23:

Revise 354200 to 357000	Rounding error

PAGE A2-24:

Box 6 Revise Box 2 to Box 3	Typo
Box 9 Revise to "Tables 1E-2"	Clarification
Box 10 Revise to "4 for corner"	Typo

ERRATA SHEET

PAGE A2-25:

Box 22 Revise from figure 1A to worksheet 1A	Typo
Box 23 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-26:

Box 32 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-27:

Example 4: add: Thermo-lag "(1hr)"	Clarification
Fire size confined to 12.25 ft^2	Clarification
Fire located in center of room	Clarification

PAGE A2-28:

Step 4.2 Revise 3542 to 3570	Rounding error
Revise 8542 to 8570	Rounding error

PAGE A2-30:

Revise two places 35420 to 35700	Rounding error
Revise two places 354200 to 357000	Rounding error

PAGE A2-31:

Revise 354200 to 357000	Rounding error

PAGE A2-32:

Box 4 Revise to "Tables 1E-2"	Clarification
Box 5 Revise to "4 for corner"	Typo

PAGE A2-33:

Box 22 Revise from figure 1A to worksheet 1A	Typo
Box 23 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-34:

Box 32 Revise from figure 1A to worksheet 1A	Typo

ERRATA SHEET

PAGE A2-35:

Example 5: add: Thermo-lag "(lhr)"	Clarification
Fire size confined to 12.25 ft^2	Clarification
Fire located in center of room	Clarification

PAGE A2-36:

Step 4.2 Revise 3542 to 3570	Rounding error
Revise 8542 to 8570	Rounding error

PAGE A2-38:

Revise two places 35420 to 35700	Rounding error
Revise two places 354200 to 357000	Rounding error

PAGE A2-39:

Revise 354200 to 357000	Rounding error

PAGE A2-40:

Box 4 Revise to "Tables 1E-2"	Clarification
Box 5 Revise to "4 for corner"	Typo

PAGE A2-41:

Box 22 Revise from figure 1A to worksheet 1A	Typo
Box 23 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-42:

Box 32 Revise from figure 1A to worksheet 1A	Typo

PAGE A2-43:

Example 6: add: Thermo-lag "(lhr)"	Clarification
Fire size confined to 12.25 ft^2	Clarification
Fire located in center of room	Clarification
Revise Radial distance to "4.8 ft"	Typo

ERRATA SHEET

PAGE A2-44:

Step 4.2	Revise 3542 to 3570	Rounding error
	Revise 8542 to 8570	Rounding error

PAGE A2-46:

Revise two places 35420 to 35700	Rounding error
Revise two places 354200 to 357000	Rounding error

PAGE A2-47:

Revise 354200 to 357000	Rounding error

PAGE A2-48:

Box 3 Revise to "Tables 1E-2"	Clarification
Box 8 Revise Figure 1A to worksheet 1A	Typo
Box 10 2 to 2.3	Rounding error
Box 11 553 to 600	Rounding error
Box 13 447 to 400	Rounding error

PAGE A2-55:

Box 14 Revise to Tables 1E-2"	Clarification
Box 15 Revise to "4 for corner"	Typo

Page A2-56:

Box 29 Revise table 10 to table 13	Typo

PAGE A2-65:

Box 14 Revise to Tables 1E-2"	Clarification
Box 15 Revise to "4 for corner"	Typo

Page A2-66:

Box 29 Revise table 10 to table 13	Typo

ERRATA SHEET

PAGE A2-70:

Step 4.2	Revise 3542 to 3570	Rounding error
	Revise 8542 to 8570	Rounding error

PAGE A2-74:

Step 4.2	Revise 3542 to 3570	Rounding error
	Revise 8542 to 8570	Rounding error

PAGE A2-78:

Step 4.2	Revise 3542 to 3570	Rounding error
	Revise 8542 to 8570	Rounding error

PAGE A3-2:

Add Note:	"The 1/4" overlay quantities are only for the 1/4" overlay and do not include the base 1/2".	Clarification

PAGE A3-4:

Add Note:	"The 1/4" overlay quantities are only for the 1/4" overlay and do not include the base 1/2".	Clarification

PAGE A3-30:

Revise HRR units to Btu/s	Typo
Revise Radiant Flux units to Btu/s ft^2	Typo

PAGE A3-31:

Revise HRR units to kW	Typo

PAGE A4-6:

Box 4 Revise to "Tables 1E-2"	Clarification
Box 5 Rev'se to "4 for corner"	Typo

ERRATA SHEET

PAGE A4-7:

Box 15 Revise from figure 1A to worksheet 1A	Typo
Box 16 Revise from figure 1A to worksheet 1A	Typo
Box 25 Revise from figure 1A to worksheet 1A	Typo

PAGE A4-8:

Box 4 Revise to "Tables 1E-2"	Clarification
Box 5 Revise to "4 for corner"	Typo

PAGE A4-9:

Box 15 Revise from figure 1A to worksheet 1A	Typo
Box 16 Revise from figure 1A to worksheet 1A	Typo
Box 25 Revise from figure 1A to worksheet 1A	Typo

PAGE A4-11:

Box 6 Revise Box 2 to Box 3	Typo
Box 9 Revise to "Tables 1E-2"	Clarification
Box 10 Revise to "4 for corner"	Typo

PAGE A4-12:

Box 22 Revise from figure 1A to worksheet 1A	Typo
Box 23 Revise from figure 1A to worksheet 1A	Typo

PAGE A4-13:

Box 32 Revise from figure 1A to worksheet 1A	Typo

PAGE A4-14:

Box 6 Revise Box 2 to Box 3	Typo
Box 9 Revise to "Tables 1E-2"	Clarification
Box 10 Revise to "4 for corner"	Typo

PAGE A4-15:

Box 22 Revise from figure 1A to worksheet 1A	Typo
Box 23 Revise from figure 1A to worksheet 1A	Typo

ERRATA SHEET

PAGE A4-16:

Box 32 Revise from figure 1A to worksheet 1A	Typo

PAGE A4-18:

Box 14 Revise to Tables 1E-2"	Clarification
Box 15 Revise to "4 for corner"	Typo

Page A4-19:

Box 29 Revise table 10 to table 13	Typo

PAGE A4-22:

Box 14 Revise to Tables 1E-2"	Clarification
Box 15 Revise to "4 for corner"	Typo

Page A4-23:

Box 29 Revise table 10 to table 13	Typo

PAGE A4-25:

Box 3 Revise to "Tables 1E-2"	Clarification
Box 8 Revise Figure 1A to worksheet 1A	Typo

PAGE A4-26:

Box 3 Revise to "Tables 1E-2"	Clarification
Box 8 Revise Figure 1A to worksheet 1A	Typo

The fire location factor to be entered in Box 5 accounts for the effect of walls and corners. Suitable fire location factors are: (ref 6.20)

4 for fires located in corners
2 for fires located against walls
1 for fires located in the open

Box 6 - Effective Heat Release Rate

Once the appropriate peak fire intensity and fire location factor have been determined, an effective fire intensity can be calculated as the product of the actual intensity (Box 4) multiplied by the fire location factor (Box 5) and entered in Box 6. (ref. 6.20)

Box 7 - Plume Temperature Rise at Target

The plume temperature rise at the target is entered in Box 7, and is based on the height of the target above the exposure fire (Box 2) and the effective heat release rate of the exposure fire (Box 6). The plume temperature rise at the target can be looked up in Table 5 or can be calculated directly as: (ref 6.10, 6.20, 6.36)

$$\Delta T_{max} = \frac{9.1 * T_o}{[g(\rho_o * c_p * T_o)^2]^{1/3}} * \frac{q_c^{2/3}}{(z-z_o)^{5/3}} \quad (4)$$

or

$$\frac{\Delta T_{max}}{T_o} = \frac{9.1}{[g(\rho_o * c_p * T_o)^2]^{1/3}} * \frac{q_c^{2/3}}{(z-z_o)^{5/3}} \quad (5)$$

Where:

ΔT_{max} = Plume centerline temperature rise (°K ,°F)

T_o = Ambient temperature, room temperature (°K, °F)

g = gravitational acceleration constant (9.81 m/s^2, 32.2 ft/s^2)

ρ_o = density of air at T_o (Kg/m^3, lbs/ft^3)

c_p = Specific heat of air at T_o (KJ/kg, Btu/lbs)

q_c = convective heat release rate of fire (kW, Btu/s)

z = height for the fire source to the target (m, ft)

z_o = Virtual Origin (m, ft)

z_o = $-1.02d + 0.083Q^{2/5}$ (SI m, kW) or
$-1.02d + 0.263Q^{2/5}$ (IP, ft Btu/s)

These equations are based on Heskestad (ref 6.10) reviews on theory of axisymmetric turbulent fire plumes. Heskestad's equations were used instead of Alpert's equations (ref 6.13) since they result in higher plume temperatures which are conservative (ref 6.2 chap. 1-9).

The Virtual Origin for the purposes of the document will be assumed to be the top of the actual fuel surface or $z_o = 0$. The Virtual Origin for the sizes of the fires modeled in this document will be within a couple of feet of the fuel surface and would have a negligible effect on the results.

For normal atmospheric conditions with T_o = 293 °K, equation 4 and 5 can be reduced to (ref. 6.2 chap. 1-7)

$$\Delta T_{max} = 25 \frac{q_c^{2/3}}{z^{5/3}} \qquad \text{SI (6)}$$

$$\Delta T_{max} = 340 \frac{q_c^{2/3}}{z^{5/3}} \qquad \text{IP (7)}$$

Where: ΔT_{max} = Plume centerline temperature rise (°K, °F)

q_c = convective heat release rate of fire (kW, Btu/s)

z = height for the fire source to the target (m, ft)

For the purposes of this document, the peak heat release rate will be used instead of the convective heat release rate. The convective heat release rate ranges from about 80% to as low as 25% of the peak heat release rate (ref 6.2 chap. 1-7, 6.20, 6.36); Therefore using the peak heat release rate is conservative.

Note: if ΔT_{max} is greater than 1600°K (2900°R), the temperatures are above the adiabatic flame temperatures and the conditions are outside of the limits of these equations. For most fire scenarios expected in a nuclear power plant, the flame temperature should not exceed 900°K (1600°R) (ref 6.2 chap. 1-7).

Box 16 - Total Energy in Fire Source

The total energy (total Btu value (kW)(see Worksheet 1A)) of the fire source (Q) in Box 4 is entered in Box 16. Boxes 16 through 19 are used to determine if there is sufficient energy from the fire source to raise the Thermo-Lag to its ignition temperature.

Box 17 - Time to Consume Fire Source

The value entered in Box 17 is the dividend of the Value in Box 16 divided by the value of fire intensity (Q") in Box 4. This is the time required to consume the fire source in the plume analysis.

Box 18 - Target Temperature

Based on the temperature of the fire plume (Box 7 plus ambient temperature (T_o)) and the time (t) to consume the fire source (Box 17) the surface temperature of the target can be calculated. This value can be looked up in Table 13 or can be calculated directly as: (ref eq 2)

$$T_s = T_o + 2\sqrt{\frac{t}{\pi k \rho c}} * [h * (T_\infty - T_o) + \sigma * (T_\infty^4 - T_o^4)] \quad (8)$$

Where:

T_s	=	the surface temperature of the material (°K,°R)
T_o	=	the ambient temperature at time t = 0 (°K,°R)
T_∞	=	the flame/plume temperature (°K,°R)
h	=	the convective heat transfer coefficient (kW/m^2 °K,Btu/s ft^2 °F)
$k\rho c$	=	the thermal inertia of the material (kW^2/m^4°K^2 s, Btu^2/ft^4°R^{2}s)
σ	=	the Stefan-Boltzmann constant (5.67*10^{-11} kW/m^2 °K^4, 4.76*10^{-13} Btu/s ft^2 °R^4)
t	=	the time to consume the fire (Box 17) (s)

A value of 0.025 kW/m^2°K (.0012 Btu/s ft^2 °F) will be used for the convective heat transfer coefficient (h). This value nominally ranges between 0.015 and 0.025 kW/m^2°K, therefore 0.025 kW/m^2 provides conservative results. (ref 6.2 chap. 3-6)

The thermal inertia of various materials ($k\rho c$) is provided in Attachment 1, Table A. For Thermo-Lag the value is 3.0 kW^2/m^4°K^2,s (.0072 Btu^2/ft^4°R^{2}s). See Section 5.1 for the basis of this equation.

Box 19 - Ignition Temperature - Surface Temperature

The difference between the ignition temperature (Box 1) and the surface temperature (Box 18) is entered in Box 19. If the value in Box 19 is greater than zero then complete Boxes 20 through 25 to determine if there is sufficient energy in the room to preheat the Thermo-Lag enough to cause ignition. If the number in Box 19 is less than or equal to zero, then the Thermo-Lag will ignite under this scenario and the scenario does not pass the basic screening procedure and further analysis is required.

Box 20 - Net Energy Addition per Unit Volume to Achieve Ignition Temperature Rise

The net energy addition per unit volume needed to raise the average air temperature in the enclosure to the critical value (Box 19) is entered in Box 20. The value can be looked up in Table 7 or can be calculated directly as: (ref 6.20 , 6.35)

$$Q_{net}/V = 353 \ln (\Delta T/T_o + 1) \qquad \text{SI (8a)}$$

$$Q_{net}/V = 9.54 \ln (\Delta T/T_o + 1) \qquad \text{IP (8b)}$$

Where: Q_{net}/V = net energy addition per unit volume
ΔT = hot gas layer temperature rise (°K,°R) (Box 19)
T_o = ambient room temperature (°K,°R)

Boxes 20 through 25 are used to calculate the amount of energy (combustible material) required to raise the hot gas layer temperature to a point where the surface temperature of the target will be high enough for the fire plume to raise the target's surface temperature to the target's surface ignition temperature. This approach is basically the same as that used in Boxes 10 through 15 and the basis are discussed in those boxes. The approach is conservative since the rise in the surface temperature of the target by the difference in temperature between the calculated surface temperature (T_s in Box 18) and the ambient temperature T_o will not actually raise the surface temperature from T_s to the ignition temperature T_{ig}. Also to add to the conservatism, this approach does not take into account the thermal inertia of the target during the initial heating process.

Box 21 - Enclosure Volume (V)

The enclosure volume is entered in Box 21. The volume to use for this entry is the volume of the space between the elevation of the exposure fire source and the ceiling (the hot gas layer volume). The value entered in Box 21 should be calculated as the product of the floor area of the space times the value entered in Box 3.

Box 22 - Critical Net Energy Addition to The Space (Q_{net})

The value to be entered in Box 22 is calculated as the product of the value in Box 20 times the value in Box 21. The entry in Box 22 represents the net energy addition needed to raise the average air temperature of the hot gas layer to the critical value.

If the entry in Box 4 is greater than or equal to 0.85 then Boxes 5 through 13 must be completed to evaluate the ceiling jet temperature rise at the target. Otherwise, a value of 0 can be entered in Box 14 indicating the target is located beneath the ceiling.

The ceiling jet is a continuation of the fire plume along the ceiling and has a thickness of approximately 10% of the distance between the fire source and the ceiling. The ceiling jet is estimated to form radially along the ceiling from the plume starting at a radial distance from the centerline of the plume of about .2 times the height of the distance from the fire source to the ceiling.(ref 6.2 chap. 1-9, 6.20, 6.36)

<u>Box 5 - Longitudinal Distance From The Source to The Target.</u>

The horizontal distance between the assumed fire source location and the target location is entered in Box 5. This entry requires knowledge of the scenario geometry under consideration. (ref. 6.20)

<u>Box 6 - Longitudinal Distance to Height Ratio, L/H</u>

The longitudinal distance from the fire source to the target (Box 5) is divided by the fire source to ceiling distance (Box 3) and the result is entered in Box 6. This value is used to determine the appropriate ceiling jet factor to be entered in Box 13. (ref. 6.20)

<u>Box 7 - Enclosure Width, W</u>

The width of the enclosure in the direction perpendicular to the fire source to target axis is entered in Box 7. Generally, this will be the smaller of the two horizontal dimensions of the enclosure. An exception to this occurs when the target-fire source axis is along this dimension. This value is used to determine the appropriate ceiling jet factor to be entered in Box 13. (ref. 6.20)

<u>Box 8 - Height to Width Ratio, H/W</u>

The height from the fire source to the ceiling (Box 3) is divided by the enclosure width (Box 7) and the result is entered in Box 8. This value is used to determine the appropriate ceiling jet factor to be used in Box 13. (ref. 6.20)

<u>Box 9 - Estimated Peak Fire Intensity</u>

This step estimates the peak heat release rate/fire intensity of the exposure fires by the methods outlined in Section 5.2. The peak heat release rate is entered in Box 9. Tables 1E, 2 and 3, and Figures 4 and 5 can be used for guidance in selection of the appropriate exposure fire intensity. (ref. 6.20)

Box 10 - Fire Location Factor

The fire location factor to be entered in Box 10 accounts for the effect of walls and corners. Suitable fire location factors are: (ref. 6.20)

- 4 for fires located in corners
- 2 for fires located against walls
- 1 for fires located in the open

Box 11 - Effective Heat Release Rate

Once the appropriate peak fire intensity and fire location factor have been determined, an effective fire intensity can be calculated as the product of the actual intensity (Box 9) by the fire location factor (Box 10) and entered in Box 11. (ref 6.20)

Box 12 - Plume Temperature Rise at Ceiling

The plume temperature rise at the ceiling is entered in Box 12 based on the height of the ceiling above the exposure fire (Box 3) and the effective heat release rate of the exposure fire (Box 11). The plume temperature rise at the target can be looked up in Table 5 or can be calculated directly as:

$$\Delta T_{max} = 25\frac{q_c^{2/3}}{z^{5/3}} \qquad \text{SI (9)}$$

$$\Delta T_{max} = 340\frac{q_c^{2/3}}{z^{5/3}} \qquad \text{IP (10)}$$

Where: ΔT_{max} = plume centerline temperature rise (°K, °F)
q_c = convective heat release rate of fire (kW, Btu/s)
z = height for the fire source to the target (m, ft)

See Section 5.3 for a discussion on the above equations.(ref. 6.20)

Box 13 - Ceiling Jet Temperature Factor at Target

A ceiling jet temperature rise factor is entered in Box 13. If the entry in Box 4 has a value of less than 0.85, a value of zero should be entered in Box 13, indicating that the target is located beneath the ceiling jet lay.r. Otherwise, two ceiling jet factors, unconfined and confined are possible, depending on the geometry of the enclosure. The unconfined ceiling jet factor can be looked up in Table 6A or calculated using the equation below, based on the dimensionless radial distance entered in Box 6. (ref 6.2 chap. 1-9, 6.20, 6.36)

Box 18 - Enclosure Volume (V)

The enclosure volume is entered in Box 18. The volume to use for this entry is the volume of the space between the elevation of the exposure fire source and the ceiling (the hot gas layer volume). The value entered in Box 18 should be calculated as the product of the floor area of the space times the value entered in Box 3. (ref 6.20)

$$V = A\ floor(H\ space - H\ fire) \qquad (12c)$$

Box 19 - Critical Net Energy Addition to The Space (Q_{net})

The value to be entered in Box 19 is calculated as the product of the value in Box 17 times the value in Box 18. The entry in Box 19 represents the net energy addition needed to raise the average air temperature of the hot gas layer to the critical value. (ref 6.20)

Box 20 - Heat Loss Factor (X_l)

The fraction of the total energy released by the exposed fire that is transferred to the enclosure boundaries is entered in Box 20. A value of 0.7 represents a normally conservative value for this parameter. See Section 5.3 for further discussion. (ref. 6.20)

Box 21 - Critical Total Energy Release

Once the heat loss factor is estimated, the total energy release needed to raise the average hot gas temperature to its critical value can be calculated as: (ref. 6.20)

$$Q_{crit} = Q_{net}/(1-X_l) \qquad (12d)$$

Where Q_{net} is the value entered in Box 19 and X_l is the heat loss factor entered in Box 20.

Box 22 - Estimate of Actual Total Energy Release

The value entered here should represent the total effective energy contents of the exposure fire source (see Worksheet 1A). If this value is less than the value entered in Box 21, then critical conditions are not met for the scenario being evaluated. Otherwise the Thermo-Lag will ignite and this area does not pass the basic screening procedure and further analysis is required. Note, the Thermo-Lag being targeted should not be included in the total effective energy.

Box 23 - Total Energy in Fire Source

The total energy (total KJ (Btu) value) of the peak fire intensity ($\dot{Q}$) in Box 9 is entered in Box 23. Boxes 23 through 26 are used to determine if there is sufficient energy from the fire source to raise the Thermo-Lag to its ignition temperature.

Box 24 - Time to Consume Fire Source

The value entered in Box 24 is the quotient of the value in Box 23 divided by the value of Q" in Box 9. This is the time required to consume the fire source in the analysis. Note: if the value in Box 14 is zero then determine the value for Box 9 at this time.

Box 25 - Target Temperature

Based on the temperature of the ceiling jet/layer (Box 14 plus ambient temperature (T_o)) and the time to consume the fire source (Box 24), the surface temperature of the target can be calculated. This value can be looked up in Table 13 or can be calculated directly as:

$$T_s = T_o + 2\sqrt{\frac{t}{\pi k \rho c}} * [h * (T_\infty - T_o) + \sigma * (T_\infty^4 - T_o^4)] \quad (13)$$

Where:

	T_s	=	the surface temperature of the material (°K,°R)
	T_o	=	the ambient temperature at time t = 0 (°K,°R)
	T_∞	=	the flame/plume temperature (°K,°R)
	h	=	the convective heat transfer coefficient (kW/m²°K,Btu/s ft²°R)
	$k\rho c$	=	the thermal inertia of the material ($kW^2/m^4 °K^2$ s $Btu^2/ft^4 °R^2 s$)
	σ	=	the Stefan-Boltzmann constant ($5.67*10^{-11}$ kW/m² °K⁴, $4.76*10^{-13}$ Btu/s ft² °R⁴)
	t	=	the time to consume the fire (Box 24) (s)

Note: if the value in Box 14 is zero then use the value in Box 16 for T_∞.

Value of 0.025 kW/m² °K (.0012 Btu/s ft² °R) will be used for the convective heat transfer coefficient (h). This value nominally range between 0.020 and 0.025 kW/m²°K, therefore 0.025 kW/m²°K provides conservative results. (ref. 6.2 chap. 3-6)

The thermal inertia of various materials ($k\rho c$) is provided in Attachment 1, Table A. For Thermo-Lag the value is 3.0 $kW^2/m^4 °K^2$ s (.0072 $Btu^2/ft^4 °R^2 s$). See Section 5.1 for the basis of this equation.

Box 26 - Ignition Temperature - Surface Temperature

The difference between the ignition temperature (Box 1) and the surface temperature (Box 25) is entered in Box 26. If the value in Box 26 is greater than zero, then complete Boxes 27 through 32 to determine if there is sufficient energy in the room to preheat the Thermo-Lag high enough to cause ignition. If the number in Box 26 is less than or equal to zero, then the Thermo-Lag will ignite under this scenario and the scenario does not pass the basic screening procedure and further analysis is required. Note: if the value in Box 14 is zero then stop here.

5.5 Critical Radiant Flux

Thermal radiation can be the significant mode of heat transfer for situations where a target (Thermo-Lag) is located laterally from the exposure fire source. This would be the case, for example, for a floor-based exposure fire located some distance away from the target where the target is not ignited by either the ceiling jet or the hot gas layer. Thermal radiation from a fire source is not generally a significant mode of heat transfer to targets immersed in a hot gas layer for a number of reasons: (ref. 6.20, 6.36)

- Targets are normally located relatively large distances from the exposure fire.
- The hot gas layer is usually optically thick and shields the target from the incident thermal radiation.
- Convection and radiation from the hot gas layer to the target is the dominant mode of heat transfer. This is considered by assuming the target reaches its ignition temperature shortly after the hot gas layer reaches the ignition temperature.
- For ignition temperatures in the range of 371°C to 538°C (700°F to 1000°F) which are generally of interest in this document, targets will be located a number of feet above the flame region and the radiant flux will dominate.
- Due to the relatively high velocities of the gases associated with fire plumes and ceiling jets, convection will dominate the heat transfer mode to the targets.
- The analysis developed here identifies the range of distances within which critical radiant heat fluxes (the radiant flux level at which Thermo-Lag will ignite) exists for a given scenario. This range can be used to compute whether or not for a given fire scenario if the Thermo-Lag will be within the threshold radius (i.e., close enough to ignite). Use Worksheet 3 for this analysis.

Box 1 - Critical Radiant Flux of Target

The critical heat flux or the heat flux at which ignition occurs depends on the thermal properties of the material and the ignition temperature of the material. For Thermo-Lag, the critical flux is 25 kW/m^2 (2.2 $Btu/s\ ft^2$). The values for other materials are given in Attachment 1, Table A.

Box 2 - Longitudinal Distance from Fire Source to Target (L)

The value entered in Box 2 is the radial distance from the fire source to the target (Thermo-Lag).

Box 3 - Peak Fire Intensity

This step estimates the peak heat release rate/fire intensity of the exposure fires by the methods outlined in Section 5.2. The peak heat release rate is entered in Box 4 (see worksheet 1A). Tables 1E, 2 and 3, and Figures 4 and 5 can be used for guidance in selecting an appropriate exposure fire intensity. Ref 6.20)

Box 4 - Radiant Fraction of Heat Release

Typically, 20 to 40 percent of the total heat release rate of accidental fires is radiative with the remainder being convective heat release. For screening purposes, 40 percent is suggested as a reasonably conservative value. (6.20)

Box 5 - Radiant Heat Release Rate

The radiant heat release rate is calculated as the product of the peak fire intensity (Box 3) times the Radiant Fraction (Box 4). The result is entered in Box 5. (ref. 6.20)

Box 6 - Critical Radiant Flux Distance

The critical radiant flux distance to be entered in Box 6 can be looked up in Table 10, based on the critical flux of the target (Box 1) and the radiant heat release rate (Box 5). lternatively, this distance can be calculated directly as: (ref 6.1, 6.20, 6.36)

$$R_{crit} = \sqrt{\frac{\dot{Q}_R}{4\pi \dot{q}_{crit}}} \quad (14)$$

Where: R_{crit} = critical radial distance (m, ft)
$\dot{Q}_R$ = radiant heat release rate (Box 5)(kW, Btu/s)
$\dot{q}_{crit}$ = critical radiant flux at target (Box 1) (kW/m^2,Btu/s ft^2)

Note: the equation is good for both SI and IP units.

Box 7 - The Distance From the Fire to the Target - the Critical Flux Distance

The difference between the distance from the fire source to the target (Box 2) minus the critical radiant flux distance (Box 6) is entered in Box 7. If the value entered in Box 7 is greater than zero, the Thermo-Lag is outside of the radial distance and there is insufficient radiant energy to ignite the Thermo-Lag and no further analysis is required. Otherwise continue with Boxes 8 through 13.

Box 8 - Total Energy in Fire Source

The total energy (total Btu value) of the peak fire intensity (Q) in Box 3 is entered in Box 8. Boxes 8 through 11 are used to determine if there is sufficient energy from the fire source to raise the Thermo-Lag to its ignition temperature.)

Box 9 - Time to Consume Fire Source

The value entered in Box 9 is the dividend of the value in Box 8 divided by the value of Q in Box 3. This is the time required to consume the fire source in the analysis.

Box 10 - Radiant Flux at Target

The radiant flux to be entered in Box 10 can be looked up in Table 11 based on the radial distance from the fire source (Box 2) and the radiant heat release rate (Box 5). Alternatively, this distance can be calculated directly as: (ref 6.1)

$$\dot{q}_{crit} = \frac{\dot{Q}_R}{4\pi L^2} \qquad \textbf{(15)}$$

Where:

L	=	longitudinal distance (Box 2)(m, ft)
$\dot{Q}_R$	=	radiant heat release rate (Box 5)(kW, Btu/s)
$\dot{q}_{crit}$	=	critical radiant flux at target (kW/m^2,Btu/s ft^2)

Box 11 - Target Surface Temperature

Based on the radiant flux at the target (Box 10) and the time to consume the fire source (Box 9) the surface temperature of the target can be calculated. This value can be looked up in Table 14 or can be calculated directly as:

$$T_s = T_o + 2\dot{q}_{crit}\sqrt{\frac{t}{\pi k\rho c}} \qquad \textbf{(16)}$$

Where:

T_s	=	the surface temperature of the material (°K,°F)
T_o	=	the ambient temperature at time t = 0 (°K,°F)
$\dot{q}_{crit}$	=	the radiant flux at target (Box 10) (kW/m^2, Btu/s ft^2)
$k\rho c$	=	the thermal inertia of the material (kW^2/m^4°K^2 s, Btu^2/ft^4°R^{2}s)
t	=	the time to consume the fire (Box 9) (s)

The thermal inertia of various materials ($k\rho c$) is provided in Attachment 1, Table A. For Thermo-Lag the value is 3.0 kW^2/m^4°K^2 s (.0072 Btu^2/ft^4°R^{2}s). See Section 5.1 for the basis of this equation.

Box 12 - Target Ignition Temperature.

The target ignition temperature is entered in Box 12. This entry is intended to simply document the value for the analysis. Representative ignition temperatures are provided in Table A. Typically, a value of 538°C (1000°F) will be entered in Box 12 for Thermo-Lag.

Box 13 - Ignition Temperature - Surface Temperature

The difference between the ignition temperature (Box 12) and the surface temperature (Box 11) is entered in Box 13. If the value in Box 13 is greater than zero then the Thermo-Lag will not ignite under this scenario and the scenario passes the basic screening procedure and no further analysis is required.

5.6 Thermo-Lag Flame Propagation

The radial size of the fire plume is small enough that if Thermo-Lag ignites in the fire plume, it will continue to burn beyond the fire plume. Therefore, the targets will be located outside the fire plume for this evaluation. For these scenarios, it is assumed that the target is subjected to the combined effects of the ceiling jet sublayer and the average hot gas layer temperature rises. In some situations, the target will be located below the ceiling jet sublayer. For these cases, the ceiling jet temperature rise becomes zero. The critical temperature rise to be evaluated for this scenario therefore becomes the difference between the ignition temperature and the ceiling jet or hot gas layer temperature. The quantity of energy release needed to achieve the average temperature rise is estimated and compared with the total energy content of the exposure fire fuel.

A separate worksheet (Worksheet 2A) has been developed to aid and guide the analysis for this type of scenario. Much of the input required is the same as for the ceiling jet worksheet (Worksheet 2).

<u>Box 1 - Target Extinguishment Temperature.</u>

The target extinguishment temperature is entered in Box 1. Typically, a value of (538°C) (1000°F) will be entered in Box 1 for Thermo-Lag.

<u>Box 2 - Critical Flux for the Safe Shutdown Equipment</u>

The critical heat flux or the heat flux at which damage to the equipment occurs depends on the emissivity and damage threshold temperature of the target. Values in the range of 15 to 20 kW/m_2 (1.32 to 1.76 Btu/ft^2 s) (ref 6.20, 6.36) are representative for targets with emissivities of 0.57 to 1.0 and damage temperatures near 370°C (700°F). For qualified cable, a value of 10 kW/m^2 (.88 Btu/ft^2 s) is suggested for typical screening purposes. This value should normally be used, but Table 1E can be used for guidance to determine if other values are appropriate for a given scenario.

<u>Box 3 - Peak Fire Intensity (Thermo-Lag)</u>

This step estimates the peak heat release rate/fire intensity of the Thermo-Lag as an exposure fire to the safe shutdown component. The peak heat release can be estimated by the equation discussed in Section 5.2.5 for Thermo-Lag. The area is the surface area of the Thermo-Lag from the exposure fire to the safe shutdown component. This is a rough estimate and can be refined when the threshold distance in Box 6 is determined by repeating this box through Box 6.

<u>Box 4 - Radiant Fraction of Heat Release</u>

Typically, 20 to 40 percent of the total heat release rate of accidental fires is radiative. For screening purposes, 40 percent is suggested as a reasonably conservative value.

Box 5 - Radiant Heat Release Rate

The radiant heat release rate is calculated as the product of the peak fire intensity (Box 3 times the Radiant Fraction (Box 4). The result is entered in Box 5.

Box 6 - Critical Radiant Flux Distance

The critical radiant flux distance to be entered in Box 6 can be looked up in Table 10, based on the critical flux of the target (Box 2) and the radiant heat release rate (Box 5). Alternatively, this distance can be calculated directly as: (ref 6.1, 6.36)

$$R_{crit} = \sqrt{\frac{\dot{Q}_R}{4\pi\dot{q}_{crit}}} \tag{17}$$

Where:

	R_{crit}	=	critical radial distance (m, ft)
	$\dot{Q}_R$	=	radiant heat release rate (Box 5)(kW/m^2, Btu/s ft^2)
	$\dot{q}_{crit}$	=	critical radiant flux at target (Box 2) (kW/m^2,Btu/s ft^2)

Note: the equation is good for both SI and IP units.

This is the distance to which the fire can propagate without causing failure of the component.

Box 7 - Height of Target Above Fire Source (z)

The vertical distance between the fire source elevation and the target (Thermo-Lag at the distance from the safe shutdown component determined in Box 6) elevation is entered in Box 7. This entry should be as accurate as possible.

Box 8 - Height from Fire Source to Ceiling (H)

The vertical distance between the assumed fire source elevation and the ceiling of the enclosure is entered in Box 8. For three-dimensional fire sources, such as electrical cabinets, the top of the fuel should be used as the assumed fire source elevation. The value entered in Box 8 is used in Box 23, where the volume of the enclosure above the exposure fire source is calculated.

Where:	ΔT_{max}	=	Plume centerline temperature rise (°K, °F)
	q_c	=	convective heat release rate of fire (kW, Btu/s)
	z	=	height from the fire source to the ceiling (m, ft)

See Section 5.3 for a discussion on the above equations.

Box 18 - Ceiling Jet Temperature Factor at Target

A ceiling jet temperature rise factor is entered in Box 18. If the entry in Box 9 has a value of less than 0.85, a value of zero should be entered in Box 18, indicating that the target is located beneath the ceiling jet layer. Otherwise, two ceiling jet factors, unconfined and confined are possible, depending on the geometry of the enclosure. The unconfined ceiling jet factor can be looked up in Table 6A or calculated per the equation below, based on the dimensionless longitudinal distance entered in Box 11. (ref 6.2 chap 1-8, 6.36)

$$\frac{\Delta T_{cj}}{\Delta T_{pl,ceil}} = \frac{0.3}{(\frac{L}{H})^{2/3}} \qquad (20)$$

Where:	$\Delta T_{cj}/\Delta T_{pl,ceil}$	=	The temperature rise factor in the ceiling jet at the target (Box 13).
	L	=	The longitudinal distance for the fire plume centerline to the target (Box 10).
	H	=	The height from the fire source to the ceiling (Box 8).
	L/H	=	Ratio of longitudinal distance to target/ceiling height (Box 11).

This equation is a correlation of the equations for ceiling jet and fire plume temperature by Alpert and Ward (ref 6.13) which provides conservative results. This correlation yields higher temperatures then the correlation using Heskestad and Delichatsios (ref 6.7). In general, Table 6A and equation (20) above apply when L/W <1/2. This equation is for unconfined ceiling jets, that is for ceiling jets where the walls are far enough away from the fire and target not to effect the temperatures at the target. If the ceiling jet is influenced by the walls then equation (21) for confined fire should be used.

The confined ceiling jet factor can be looked up in Table 6B or calculated per the equation (21) below, based on the dimensionless longitudinal distance entered in Box 11. (ref 6.2 chap. 1-9)

Where the variables are the same as equation (20) above except W (Box 12) which is the distance from the enclosure wall to the fire source and H/W is the height to width ratio

$$\frac{\Delta T_{ci}}{\Delta T_{pl,ceil}} = 0.37\left(\frac{H}{W}\right)^{1/3} * \exp\left[-0.16\left(\frac{L}{H}\right) * \left(\frac{W}{H}\right)^{1/3}\right] \quad \textbf{(21)}$$

(Box 13).

This equation is based on the equation developed by Delichatsios except that the distance W is twice that used by Delichatsios (ref 6.2 chap. 1-9) and the equation has been adjusted to account for this difference.

Table 6A or equation (20) applies when L/W <1/2 and Table 6B or equation (21) when L/W >1/2. Table 6B or equation (21) should not be applied to situations where H/W (Box 13) >2.5. Where there is a question as to which table or equation to use, both unconfined and confined ceiling jet factors can be determined and the one with the higher value used in Box 18.

Box 19 - Ceiling Jet Temperature Rise at Target

The temperature rise of the ceiling jet at the target is calculated by multiplying the values in Boxes 17 and 18. The value entered in Box 19 represents the expected ceiling jet temperature rise at the target for the scenario being evaluated.

Box 20 - Critical Temperature Rise at Target

The critical temperature rise at the target is entered in Box 20. The value in Box 20 is the difference between the extinguishment temperature of the target (Thermo-Lag) (Box 1) and the maximum ambient temperature of the space. For example, for Thermo-Lag with an extinguishment temperature of 538°C (1000°F) and a space with an ambient temperature of 24°C (75°F), the value entered in this box would be 514°C (925°F).

Box 21 - Critical Temperature Rise - Ceiling Jet Temperature Rise

The difference between the critical temperature rise (Box 20) and the ceiling jet temperature rise (Box 19) is entered in Box 21. If the entry in Box 21 has a value less than zero, then the ceiling jet temperature rise exceeds the extinguishment temperature and the Thermo-Lag will continue to burn and does not meet the screening process and further analysis is required. Otherwise, the value entered in Box 21 serves as the critical average temperature rise of the hot gas layer.

Box 22 - Net Energy Addition per Unit Volume to Achieve Critical Temperature Rise

The net energy addition per unit volume needed to raise the average air temperature in the enclosure to the critical value (Box 21) is entered in Box 22. The value can be looked up in Table 7 or can be calculated directly as: (ref 6.20, 6.35)

$$Q_{net}/V = 353 \ln (\Delta T/T_o + 1) \quad \text{SI (21a)}$$

$$Q_{net}/V = 9.54 \ln (\Delta T/T_o + 1) \quad \text{IP (21b)}$$

Where: Q_{net}/V = net energy addition per unit volume
ΔT = hot gas layer temperature rise (Box 21)
T_o = ambient room temperature (°K, °R)

Box 22 through 27 are used to calculate the amount of energy (combustible material) required to raise the hot gas layer temperature to a point where the surface temperature of the target will be high enough for the ceiling jet to raise the target's surface temperature above the target's surface extinguishment temperature. See Section 5.3 for further discussion.

Box 23 - Enclosure Volume (V)

The enclosure volume is entered in Box 23. The volume to use for this entry is the volume of the space between the elevation of the exposure fire source and the ceiling (the hot gas layer volume). The value entered in Box 18 should be calculated as the product of the floor area of the space times the value entered in Box 8.

$$V = A\ floor(H\ space - H\ fire)$$

Box 24 - Critical Net Energy Addition to The Space (Q_{net})

The value to be entered in Box 24 is calculated as the product of the value in Box 22 times the value in Box 23. The entry in Box 24 represents the net energy addition needed to raise the average air temperature of the hot gas layer to the critical value.

Box 25 - Heat Loss Factor (X_l)

The fraction of the total energy released by the exposed fire that is transferred to the enclosure boundaries is entered in Box 25. A value of 0.7 represent a normally conservative value for this parameter. See Section 5.3 for further discussion.

Box 26 - Critical Total Energy Release

Once the heat loss factor is estimated, the total energy release needed to raise the average hot gas temperature to its critical value can be calculated as:

$$Q_{crit} = Q_{net}/(1-X_l)$$

Where Q_{net} is the value entered in Box 24 and X_l is the heat loss factor entered in Box 25.

Box 27 - Estimate of Actual Total Energy Release

The value entered here should represent the total effective energy contents of the exposure fire source (see Worksheet 1A). If this value is less than the value entered in Box 26, then critical conditions are not met for the scenario being evaluated and steps 36 through 38 should be performed to ensure that the radiant flux level is not high enough to continue flame propagation.

Box 28 - Time to Consume Fire Source

The value entered in Box 28 is the dividend of the value in Box 27 divided by the value of peak fire intensity (Q") in Box 14. This is the time required to consume the fire source in the analysis.

Box 29 - Target Temperature

Based on the temperature of the ceiling jet/layer (Box 19 plus ambient temperature (T_o)) and the time to consume the fire source (Box 28) the surface temperature of the target can be calculated. This value can be looked up in Table 13 or can be calculated directly as:

$$T_s = T_o + 2\sqrt{\frac{t}{\pi k \rho c}} * [h * (T_\infty - T_o) + \sigma(T_\infty^4 - T_o^4)] \qquad (22)$$

Where:

	T_s	=	the surface temperature of the material (°K,°R)
	T_o	=	the ambient temperature at time t = 0 (°K,°R)
	T_∞	=	the flame/plume temperature (°K,°R)
	h	=	the convective heat transfer coefficient (kW/m²°K,Btu/s ft²°R)
	$k\rho c$	=	the thermal inertia of the material (kW^2/m^4 $°K^2$ s Btu^2/ft^4 $°R^2s$).
	σ	=	the Stefan-Boltzmann constant ($5.67*10^{-11}$ kW/m² $°K^4$, $4.76*10^{-13}$ Btu/s ft² $°R^4$)
	t	=	the time to consume the fire (Box 28) (s)

Note: if the value in Box 19 is zero then use the value in Box 21 instead.

Value of 0.025 kW/m² °K (.0012 Btu/s ft² °R) will be used for the convective heat transfer coefficient (h). This value nominally range between 0.020 and 0.025 kW/m²°K, therefore 0.025 kW/m²°K provides conservative results.(ref. 6.2 chap. 3-6)

The thermal inertia of various materials ($k\rho c$) is provided in Attachment 1 Table A. For Thermo-Lag the value is 3.0 kW^2/m^4 $°K^2$ s (.0072 Btu^2/ft^4 $°R^2s$). See Section 5.1 for the basis of this equation. |

Box 30 - Ignition Temperature - Surface Temperature

The difference between the ignition temperature (Box 1) and the surface temperature (Box 29) is entered in Box 30. If the value in Box 30 is greater than zero then the fire will burn itself out before the Thermo-Lag reaches the critical point. Otherwise the Thermo-Lag will continue to burn and this area does not pass the basic screening procedure and further analysis is required. If the Thermo-Lag extinguishes under this scenario continue on with Boxes 31 through 35 to ensure the radiant energy from the fire source is not high enough to propagate the flame beyond the critical point.

Box 31 - Critical Radiant Flux of Target

The critical heat flux or the heat flux at which burning of the Thermo-Lag is selfsustaining. For Thermo-Lag the Critical flux is 25 kW/m^2 (2.2 Btu/s ft^2).

Box 32 - Radiant Fraction of Heat Release

Typically, 20 to 40 percent of the total heat release rate of accidental fires is radiative with the remainder being convective heat release. For screening purposes, 40 percent is suggested as a reasonably conservative value.

Box 33 - Radiant Heat Release Rate

The radiant heat release rate is calculated as the product of the peak fire intensity (Box 14 times the radiant fraction (Box 32)). The result is entered in Box 33. Note if the value in Box 19 is xero then calculate the value in Box 14 at this time.

Box 34 - Critical Radiant Flux Distance

The critical radiant flux distance to be entered in Box 34 can be looked up in Table 10, based on the critical flux of the target (Box 31) and the radiant heat release rate (Box 33). Alternatively, this distance can be calculated directly as:

$$R_{crit} = \sqrt{\frac{\dot{Q}_R}{4\pi \dot{q}_{crit}}} \qquad (23)$$

Where: R_{crit} = critical radial distance (m, ft)
$\dot{Q}_R$ = radiant heat release rate (Box 33) (kW,Btu/s)
$\dot{q}_{crit}$ = critical radiant flux at target (Box 31) (kW/m^2,Btu/s ft^2)

If the extinguishment point of the Thermo-Lag (Box 10) is outside of the radial distance there is insufficient radiant energy for the Thermo-Lag to burn to a point where the safe shutdown equipment can be damaged. Otherwise, further analysis is required.

Box 35 - Longitudinal Distance to Target - Critical Radiant Flux Distance

The value entered in Box 35 is the difference of Box 10 minus Box 34. If the value in Box 35 is less than or equal to zero then the fire will burn itself out before the Thermo-Lag reaches the critical point. Otherwise, continue with Boxes 36 through 38.

Box 36 - Longitudinal Flux at Target

The radiant flux to be entered in Box 36 can be looked up in Table 11 based on the longitudinal distance to the extinguishment point of Thermo-Lag (Box 10)) and the radiant heat release rate (Box 33). Alternatively, this distance can be calculated directly as: (ref 6.1)

$$\dot{q}_{crit} = \frac{\dot{Q}_R}{4\pi L^2} \tag{24}$$

Where:

	$\dot{Q}_R$	=	radiant heat release rate (Box 33)(kW, Btu/s)
	$\dot{q}_{crit}$	=	critical radiant flux at target (kW/m_2, Btu/s ft_2)
	L	=	Longitudinal distance (Box 10) (m,ft)

Box 37 - Target Surface Temperature

Based on the radiant flux at the target (Box 36) and the time to consume the fire source (Box 28) the surface temperature of the target can be calculated. This value can be looked up in Table 14 or can be calculated directly as:

$$T_s = T_o + 2 * \dot{q}_{crit} \sqrt{\frac{t}{\pi k\rho c}} \tag{25}$$

Where:

	T_s	=	the surface temperature of the material (°K,°R)
	T_o	=	the ambient temperature at time t = 0 (s)
	$\dot{q}_{crit}$	=	the radiant flux at target (Box 36) (kW/m^2, Btu/s ft^2)
	$k\rho c$	=	the thermal inertia of the material ($kW^2/m^4{}^\circ K^2$ s $Btu^2/ft^4{}^\circ R^2s$)
	t	=	the time to consume the fire source (Box 28) (s)

The thermal inertia of various materials ($k\rho c$) is provided in Attachment 1, Table A. For Thermo-Lag the value is 3.0 $kW^2/m^4{}^\circ K^2$ s (.0072 $Btu^2/ft^4{}^\circ R^2s$). See Section 5.1 for the basis of this equation.

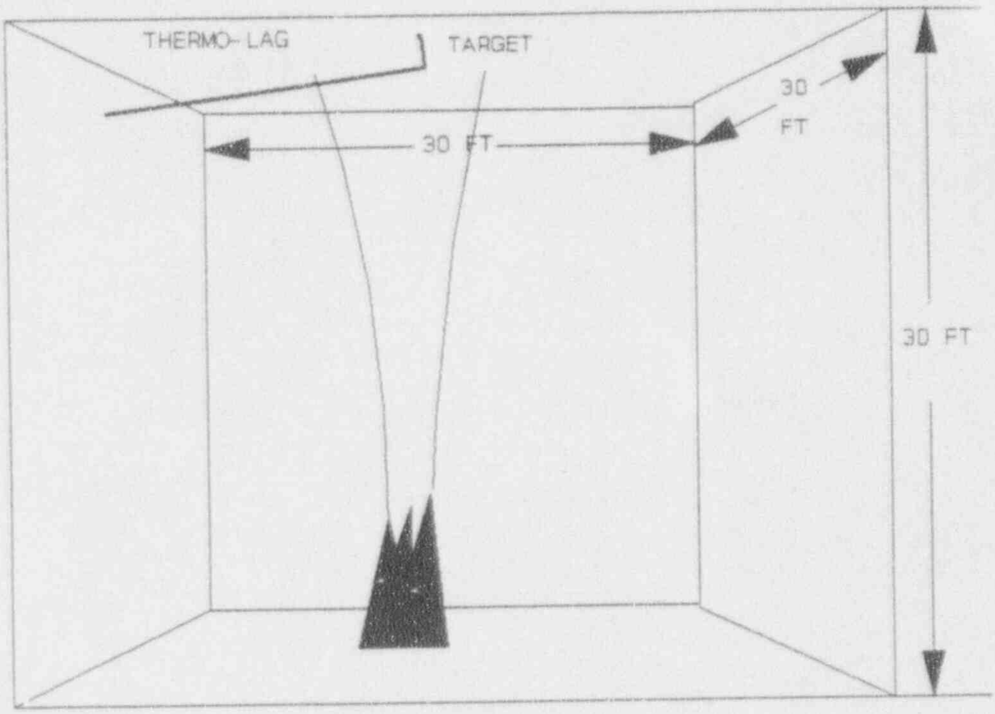
Box 38 - Ignition Temperature - Surface Temperature

The difference between the ignition temperature (Box 1) and the surface temperature (Box 37) is entered in Box 38. If the value in Box 38 is greater than zero then the Thermo-Lag will not ignite under this scenario and the scenario passes the basic screening procedure and no further analysis is required.

ATTACHMENT 2

EXAMPLE 1

THERMO-LAG IN FIRE PLUME



SCENARIO: NONCOMBUSTIBLE RADIANT ENERGY SHIELD IN CONTAINMENT

SOURCE OF FIRF: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1 HR)

ROOM IS: 30' X 30' X 30'

FIRE SIZE CONFINED TO 12.25 SQFT

FIRE IS LOCATED IN CENTER OF ROOM

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 1

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 30' x 30' = 900 ft^2	Use Table 1 for Btu values	Increase in Loading 397 Btu/ft^2 Present Loading 556 Btu/ft^2 Total Loading 953 Btu/ft^2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No YES
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No YES
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No NO
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 1

STEP	PROCEDURE	REFERENCE	DATA
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No NO
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No. ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

ATTACHMENT 2

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 1

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT (1hr)	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

ATTACHMENT 2

WORKSHEET 1

Target In Plume Scenarios (IP Units)

WORKSHEET 1: FIRE AREA EXAMPLE 1 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)	1000	°F
2	Height of Target above Fire Source (Based on scenario geometry)	30	ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)	30	ft
4	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)	1654	Btu/s
5	Fire Location Factor (1 for center, 2 for wall, 4 for corner)	1	N/A
6	Effective Heat Release Rate (Box 4 times Box 5)	1654	Btu/s
7	Plume Temperature Rise at Target (Use Table [illegible] or calculate equation(7))	164	°F
8	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
9	Critical Temp. Rise - Plume Temp. Rise (Box 8 minus Box 7)	768	°F
	If the entry in Box 9 has a value of < 0 then go to step 16 else continue with steps 10 through 15.		
10	Net Energy Addition per Unit Volume (Use Table 7 or eq.(7b) based on Box 9)	8.57	Btu/ft^3
11	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	27,000	ft^3
12	Calculated Critical Q_{net} (Q) (Box 10 times Box 11)	231,390	Btu
13	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
14	Estimate of Critical Total Energy Release (Box 12 / [1- Box 13])	771,300	Btu

ATTACHMFNT 2

WORKSHEET 1

Target In Plume Scenarios (IP Units)

WORKSHEET 1: FIRE AREA EXAMPLE 1 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 15 is less than the entry in Box 14, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 15 is equal to or greater than Box 14 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
16	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 4)		Btu
17	Time To Consume Fire Source (Box 16 divided by Box 4)		s
18	Target Temperature (Use Table 13 or equation (8))		°F
19	Ignition Temperature - Surface Temp. (Box 1 minus Box 18)		°F
If the value in Box 19 is greater than zero then continue with Boxes 20 through 25. If the value in Box 19 is less than or equal to zero stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1.			
20	Q_{net}/V to Achieve Temp. Rise in Box 19 (lookup value in Table 7 or use equation 8b)		Btu/ft^3
21	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
22	Calculated Critical Energy Add to Space (Box 20 times Box 21)		Btu
23	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
24	Critical Total Energy Release (Box 22/ [1-Box 23])		Btu
25	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 25 is less than the entry in Box 24 the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 25 is equal to or greater than Box 24 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

ATTACHMENT 2

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 1

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	30 FT DIRECTLY BELOW CONDUIT	25	499,950
2. 2" COND. THERMO-LAG	THERMO-LAG OF CONCERN	51	357,000 NOTE 1
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Exposed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

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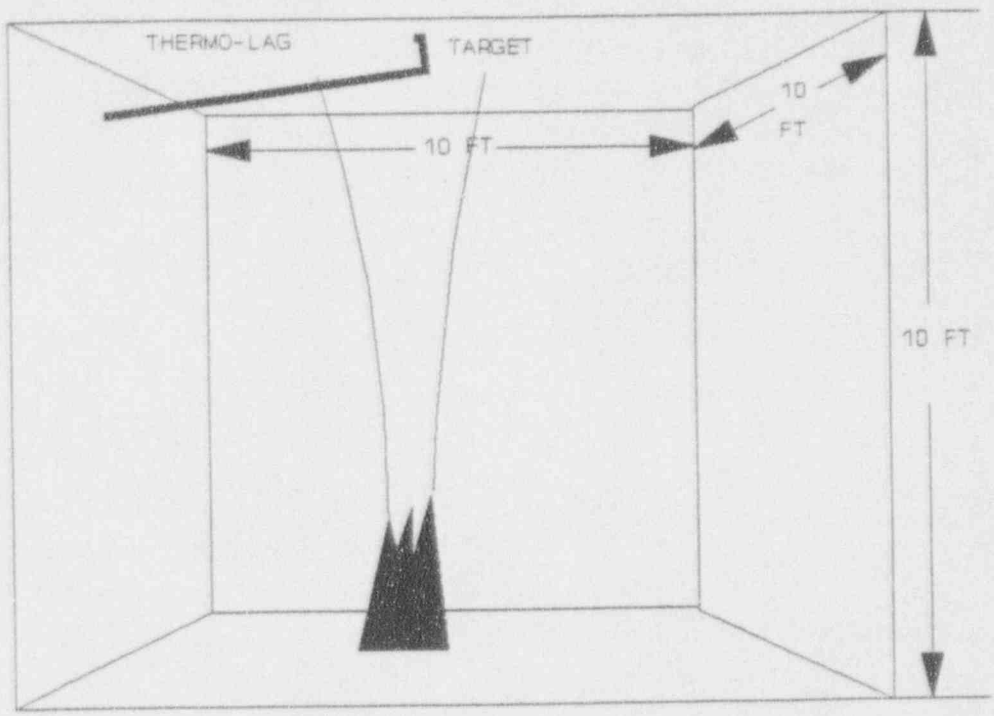
ATTACHMENT 2

EXAMPLE 2

THERMO-LAG IN FIRE PLUME

PLUME TEMPERATURE ABOVE IGNITION TEMP



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1HR)

ROOM IS: 10' X 10' X 10'

AMBIENT ROOM TEMP: 68 Deg F

FIRE SIZE CONFINED TO 12.25 SQFT

FIRE IS LOCATED IN CENTER OF ROOM

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 2

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft^2	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft^2 Present Loading 5,000 Btu/ft^2 Total Loading 8,570 Btu/ft^2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No ____
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No ____
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No YES

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 2

STEP	PROCEDURE	REFERENCE	DATA
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No. ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 2

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT (1hr)	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

ATTACHMENT 2

WORKSHEET 1

Target In Plume Scenarios (IP Units)

WORKSHEET 1: FIRE AREA EXAMPLE 2 SCENARIO:________			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)	1000	°F
2	Height of Target above Fire Source (Based on scenario geometry)	10	ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)	10	ft
4	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)	1654	Btu/s
5	Fire Location Factor (1 for center, 2 for wall, 4 for corner)	1	N/A
6	Effective Heat Release Rate (Box 4 times Box 5)	1654	Btu/s
7	Plume Temperature Rise at Target (Use Table 5 or calculate equation(7))	1024	°F
8	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
9	Critical Temp. Rise - Plume Temp. Rise (Box 8 minus Box 7)	-92	°F
	If the entry in Box 9 has a value of < 0 then go to step 16 else continue with steps 10 through 15.		
10	Net Energy Addition per Unit Volume (Use Table 7 or eq.(7b) based on Box 9)		Btu/ft^3
11	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
12	Calculated Critical Q_{net} (Q) (Box 10 times Box 11)		Btu
13	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
14	Estimate of Critical Total Energy Release (Box 12 / [1- Box 13])		Btu

WORKSHEET 1

Target In Plume Scenarios (IP Units)

WORKSHEET 1: FIRE AREA EXAMPLE 2 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 15 is less than the entry in Box 14, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 15 is equal to or greater than Box 14 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
16	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 4)	499,950	Btu
17	Time To Consume Fire Source (Box 16 divided by Box 4)	302	s
18	Target Temperature (Use Table 13 or equation (8))	982	°F
19	Ignition Temperature - Surface Temp. (Box 1 minus Box 18)	18	°F
If the value in Box 19 is greater than zero then continue with Boxes 20 through 25. If the value in Box 19 is less than or equal to zero stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1.			
20	Q_{net}/V to Achieve Temp. Rise in Box 19 (lookup value in Table 7 or use equation 8b)	0.32	Btu/ft^3
21	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	1000	ft^3
22	Calculated Critical Energy Add to Space (Box 20 times Box 21)	320	Btu
23	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
24	Critical Total Energy Release (Box 22/ [1-Box 23])	1067	Btu
25	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 25 is less than the entry in Box 24 the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 25 is equal to or greater than Box 24 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 2

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	10 FT DIRECTLY BELOW CONDUIT	25	499,950
2. 2" COND. THERMO-LAG (1hr)	THERMO-LAG OF CONCERN	51	357,000[1]
3.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Ex-posed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

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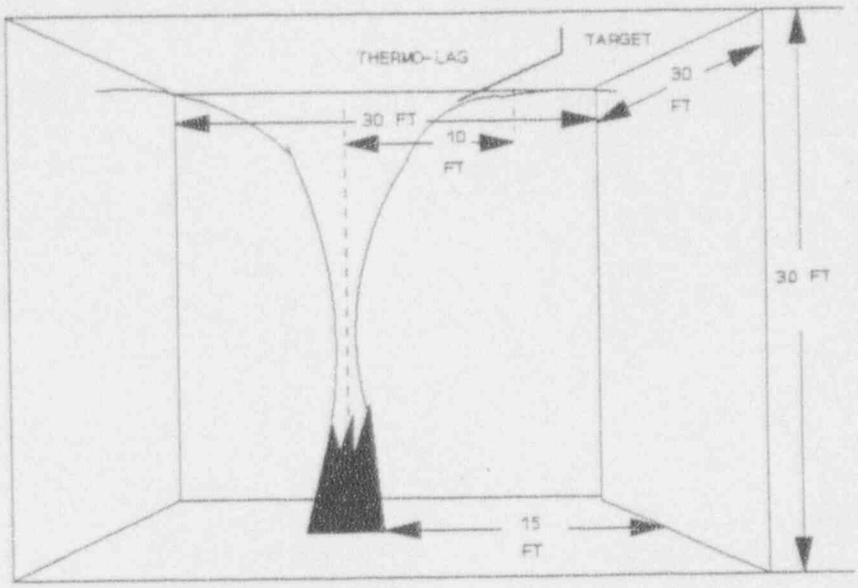
ATTACHMENT 2

EXAMPLE 3

THERMO-LAG OUTSIDE OF FIRE PLUME



SCENARIO: NONCOMBUSTIBLE RADIANT ENERGY SHIELD IN CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1HR)

ROOM IS: 30' X 30' X 30'

FIRE SOURCE TO WALL: 15 FT

THERMO-LAG (TARGET) ABOVE FIRE SOURCE: 28 FT

LONG. DIST. FROM FIRE SOURCE TO TARGET: 10 FT

FIRE SOURCE TO CEILING: 30 FT

FIRE SIZE CONFINED TO 12.25 SQFT

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 3

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 30' X 30' = 900 ft²	Use Table 1 for Btu values	Increase in Loading 397 Btu/ft² Present Loading 556 Btu/ft² Total Loading 953 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No YES
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No YES
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No NO
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No NO

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 3

STEP	PROCEDURE	REFERENCE	DATA
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 3

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT (1hr)	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

ATTACHMENT 2

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 3

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	30 FT BELOW CONDUIT	25	499,950
2. 2" COND. THERMO-LAG	THERMO-LAG OF CONCERN (1hr)	51	357,000 NOTE 1
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Ex-posed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 3 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)	1000	°F
2	Height of Target above Fire Source (Based on scenario geometry)	28	ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)	30	ft
4	Ratio of Target Height to Ceiling Height (Box 2 divided by Box 3)	0.93	N/A
If the value in Box 4 is > 0.85, Complete Boxes 5 through 13; Else enter a value of zero (0) in Box 14			
5	Radial Distance From Source to Target (Based on Scenario Geometry)	10	ft
6	Radial Distance to Height Ratio (L/H) (Box 5 divided by Box 3)	0.3	N/A
7	Enclosure Width (W) (Based on Scenario Geometry)	30	ft
8	Height to Width Ratio (H/W) (Box 3 divided by Box 7)	1	N/A
9	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)	1654	Btu/s
10	Fire Location Factor (1 for center, 2 for wall, 4 for corner)	1	N/A
11	Effective Heat Release Rate (Box 9 times Box 10)	1654	Btu/s
12	Plume Temperature Rise at Target (Use Table 5 or calculate using equation(10))	164	°F
13	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (11) or (12) use the higher value)	0.62	N/A

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 3 SCENARIO:____________

BOX NO	DESCRIPTION	ENTRY	UNITS
14	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 12 times Box 13)	102	°F
15	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
16	Critical Temp. Rise - Plume Temp. Rise (Box 15 minus Box 14)	830	°F
If the entry in Box 16 has a value of $<$ 0 then go to step 23 else continue with steps 17 through 22.			
17	Net Energy Addition per Unit Volume (Use Table 7 or eq.(12b) based on Box 16)	9.01	Btu/ft^3
18	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	27,000	ft^3
19	Calculated Critical Q_{net} (Q) (Box 17 times Box 18)	243,270	Btu
20	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
21	Estimate of Critical Total Energy Release (Box 19 / [1- Box 20])	810,900	Btu
22	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 22 is less than the entry in Box 21, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 22 is equal to or greater than Box 21 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
23	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 9)		Btu
24	Time To Consume Fire Source (Box 23 divided by Box 9)		s
25	Target Temperature (Use Table 13 or equation (13))		°F

WORKSHEET 2

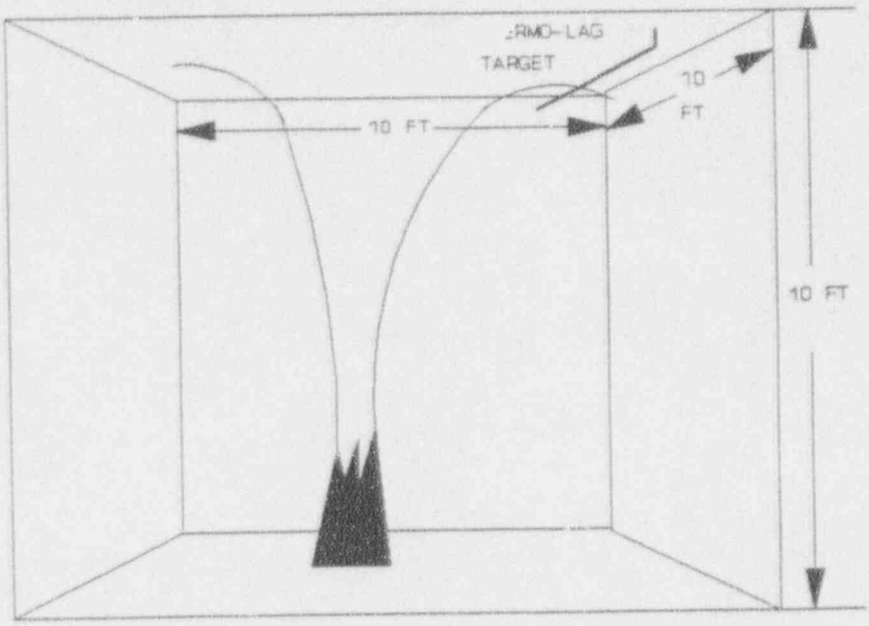
Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 3 SCENARIO:______			
BOX NO	DESCRIPTION	ENTRY	UNITS
26	Ignition Temperature - Surface Temp. (Box 1 minus Box 25)		°F
If the value in Box 26 is greater than zero, then continue with boxes 27 through 32. If the value in Box 26 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1. Note: if Box 14 is zero, stop here.			
27	Q_{net}/V to Achieve Temp. Rise in Box 26 (lookup value in Table 7 or use equation 13b)		Btu/ft^3
28	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
29	Calculated Critical Energy Added to Space (Box 27 times Box 28)		Btu
30	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
31	Critical Total Energy Release (Box 29/ [1-Box 30])		Btu
32	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 32 is less than the entry in Box 31, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 32 is equal to or greater than Box 31 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

ATTACHMENT 2

EXAMPLE 4

THERMO-LAG OUTSIDE OF FIRE PLUME



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1HR)

ROOM IS: 10' X 10' X 10'

AMBIENT ROOM TEMP: 68 Deg F

HEIGHT OF TARGET: 10 FT

HEIGHT FROM FIRE SOURCE TO CEILING: 10 FT

LONG. DIST FROM FIRE TO TARGET: 3 FT

FIRE SIZE CONFINED TO 12.25 SQFT

FIRE IS LOCATED IN CENTER OF ROOM

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 4

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft²	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft² Present Loading 5,000 Btu/ft² Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No YES
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No NO
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No YES

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 4

STEP	PROCEDURE	REFERENCE	DATA
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

ATTACHMENT 2

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 4

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT (1hr)	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

ATTACHMENT 2

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 4

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	10 FT BELOW CONDUIT	25	499,950
2. 2" COND. THERMO-LAG	THERMO-LAG OF CONCERN (1hr)	51	357,000[1]
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Exposed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 4 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)	1000	°F
2	Height of Target above Fire Source (Based on scenario geometry)	10	ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)	10	ft
4	Ratio of Target Height to Ceiling Height (Box 2 divided by Box 3)	1.0	N/A
If the value in Box 4 is > 0.85, Complete Boxes 5 through 13; Else enter a value of zero (0) in Box 14			
5	Radial Distance From Source to Target (Based on Scenario Geometry)	3	ft
6	Radial Distance to Height Ratio (L/H) (Box 5 divided by Box 2)	0.3	N/A
7	Enclosure Width (W) (Based on Scenario Geometry)	10	ft
8	Height to Width Ratio (H/W) (Box 3 divided by Box 7)	1	N/A
9	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)	1654	Btu/s
10	Fire Location Factor (1 for center, 2 for wall, 4 for corner)	1	N/A
11	Effective Heat Release Rate (Box 9 times Box 10)	1654	Btu/s
12	Plume Temperature Rise at Target (Use Table 5 or calculate using equation(10))	1024	°F
13	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (11) or (12) use the higher value)	0.67	N/A
14	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 12 times Box 13)	686	°F

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 4 SCENARIO:____________

BOX NO	DESCRIPTION	ENTRY	UNITS
15	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
16	Critical Temp. Rise - Plume Temp. Rise (Box 15 minus Box 14)	246	°F
If the entry in Box 16 has a value of < 0 then go to step 23 else continue with steps 17 through 22.			
17	Net Energy Addition per Unit Volume (Use Table 7 or eq.(12b) based on Box 16)	3.65	Btu/ft^3
18	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	1,000	ft^3
19	Calculated Critical Q_{net} (Q) (Box 17 times Box 18)	3650	Btu
20	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
21	Estimate of Critical Total Energy Release (Box 19 / [1- Box 20])	12,167	Btu
22	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 22 is less than the entry in Box 21, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 22 is equal to or greater than Box 21 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
23	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 9)	499,950	Btu
24	Time To Consume Fire Source (Box 23 divided by Box 9)	302	s
25	Target Temperature (Use Table 13 or equation (13))	489	°F
26	Ignition Temperature - Surface Temp. (Box 1 minus Box 25)	511	°F

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

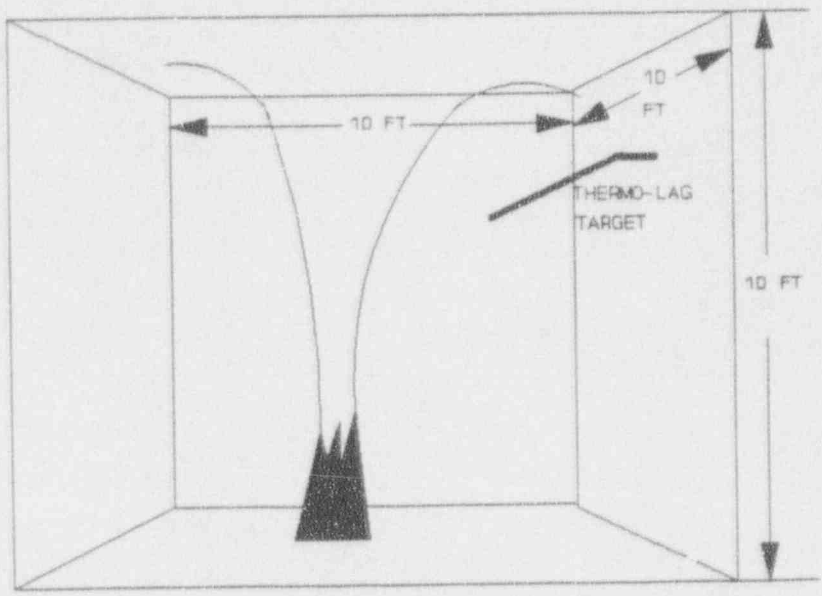
WORKSHEET 2: FIRE AREA EXAMPLE 4 SCENARIO: ____________

BOX NO	DESCRIPTION	ENTRY	UNITS
If the value in Box 26 is greater than zero, then continue with boxes 27 through 32. If the value in Box 26 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1. Note: if Box 14 is zero, stop here.			
27	Q_{net}/V to Achieve Temp. Rise in Box 26 (lookup value in Table 7 or use equation 13b)	6.46	Btu/ft^3
28	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	1000	ft^3
29	Calculated Critical Energy Added to Space (Box 27 times Box 28)	6460	Btu
30	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
31	Critical Total Energy Release (Box 29/ [1-Box 30])	21,533	Btu
32	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 32 is less than the entry in Box 31, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 32 is equal to or greater than Box 31 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

ATTACHMENT 2

EXAMPLE 5

THERMO-LAG OUTSIDE OF FIRE PLUME
THERMO-LAG BELOW CEILING JET



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1HR)

ROOM IS: 10' X 10' X 10'

AMBIENT ROOM TEMP: 68 Deg F

HEIGHT OF TARGET: 7 FT

HEIGHT FROM FIRE SOURCE TO CEILING: 10 FT

LONG. DIST FROM FIRE TO TARGET: 3 FT

FIRE SIZE CONFINED TO 12.25 SQFT

FIRE IS LOCATED IN CENTER OF ROOM

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 5

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft^2	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft^2 Present Loading 5,000 Btu/ft^2 Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No YES
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3c	Is Thermo-Lag used as a radiant energy shield or as a <u>non-combustible</u> fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No NO
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No NO

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 5

STEP	PROCEDURE	REFERENCE	DATA
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No. ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 5

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 5

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	7 FT BELOW CONDUIT THERMO-LAG OF CONCERN	25	499,950
2. 2" COND. THERMO-LAG		51	357,000[1]
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Exposed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 5 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)	1000	°F
2	Height of Target above Fire Source (Based on scenario geometry)	7	ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)	10	ft
4	Ratio of Target Height to Ceiling Height (Box 2 divided by Box 3)	0.70	N/A
If the value in Box 4 is > 0.85, Complete Boxes 5 through 13; Else enter a value of zero (0) in Box 14			
5	Radial Distance From Source to Target (Based on Scenario Geometry)		ft
6	Radial Distance to Height Ratio (L/H) (Box 5 divided by Box 2)		N/A
7	Enclosure Width (W) (Based on Scenario Geometry)		ft
8	Height to Width Ratio (H/W) (Box 3 divided by Box 7)		N/A
9	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)	1654	Btu/s
10	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/A
11	Effective Heat Release Rate (Box 9 times Box 10)		Btu/s
12	Plume Temperature Rise at Target (Use Table 5 or calculate using equation(10))		°F
13	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (11) or (12) use the higher value)		N/A
14	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 12 times Box 13)	0	°F

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 5 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
16	Critical Temp. Rise - Plume Temp. Rise (Box 15 minus Box 14)	932	°F
If the entry in Box 16 has a value of < 0 then go to step 23 else continue with steps 17 through 22.			
17	Net Energy Addition per Unit Volume (Use Table 7 or eq.(12b) based on Box 16)	9.70	Btu/ft^3
18	Calculated Enclosure Volume (V) (Box 3 times floor area of space)	1,000	ft^3
19	Calculated Critical Q_{net} (Q) (Box 17 times Box 18)	9700	Btu
20	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
21	Estimate of Critical Total Energy Release (Box 19 / [1- Box 20])	32,333	Btu
22	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	499,950	Btu
If the entry in Box 22 is less than the entry in Box 21, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 22 is equal to or greater than Box 21 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
23	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 9)	499,950	Btu
24	Time To Consume Fire Source (Box 23 divided by Box 9)	302	s
25	Target Temperature (Use Table 13 or equation (13))	817	°F
26	Ignition Temperature - Surface Temp. (Box 1 minus Box 25)	183	°F

WORKSHEET 2

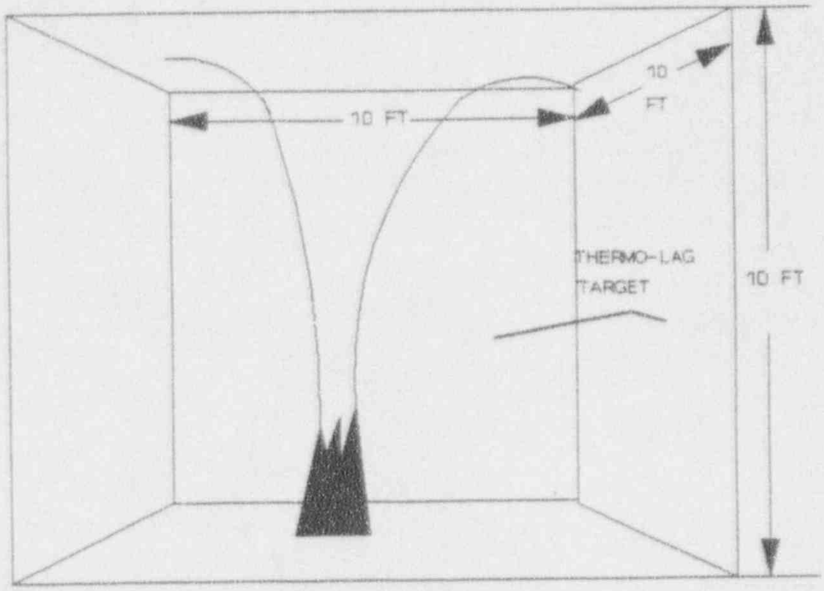
Target Outside of Plume Scenarios (IP Units)

WORKSHEET 2: FIRE AREA EXAMPLE 5 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
If the value in Box 26 is greater than zero, then continue with boxes 27 through 32. If the value in Box 26 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1. Note: if Box 14 is zero, stop here.			
27	Q_{net}/V to Achieve Temp. Rise in Box 26 (lookup value in Table 7 or use equation 13b)		Btu/ft^3
28	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
29	Calculated Critical Energy Added to Space (Box 27 times Box 28)		Btu
30	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
31	Critical Total Energy Release (Box 29/ [1-Box 30])		Btu
32	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 32 is less than the entry in Box 31, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 32 is equal to or greater than Box 31 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

ATTACHMENT 2

EXAMPLE 3

THERMO-LAG RADIANT EXPOSURE



SCENARIO: THERMO-LAG TARGET INSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG (1HR)

ROOM IS: 10' X 10' X 10'

AMBIENT ROOM TEMP: 68 Deg F

RADIAL DISTANCE FROM SOURCE TO TARGET: 4.8 FT

FIRE SIZE CONFINED TO 12.25 SQFT

FIRE IS LOCATED IN CENTER OF ROOM

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 6

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft²	Use Table 1 for Btu values	Increase in Loading 3570 Btu/ft² Present Loading 5,000 Btu/ft² Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No YES
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No NO
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No NO

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 6

STEP	PROCEDURE	REFERENCE	DATA
4.5	Determine if Thermo-Lag will Propagate a flame. If the answer is no then Stop here.	Use Section 5.6	Yes/No ____
4.6	Fire Safe Shutdown Evaluations If the fire area could not be screened out by one of the above steps then further evaluation using the methods below may be used.	N/A	N/A
4.6.1	If the fire area has automatic suppression determine if credit can be taken for automatic suppression.	Use Section 5.7	Yes/No ____
4.6.2	Can credit be taken for the mechanical ventilation system?	Use Section 5.8	Yes/No ____
4.6.3	Can credit be taken for a ventilation controlled fire?	Use Section 5.9	Yes/No. ____
4.6.4	Can credit be taken for Transient Controls?	See Section 4.6.4	Yes/No ____
4.6.5	Does reevaluation of the Fire Safe Shutdown analysis eliminate the concern?	See Section 4.6.5	Yes/No ____

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area EXAMPLE 6

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
2" CONDUIT	10 FT	35,700 Btu/ft	357,000 Btu
	Totals	35,700	357,000

ATTACHMENT 2

Worksheet 1A

Combustible Materials Worksheet

Fire Area EXAMPLE 6

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu)
1. TRANSFORMER OIL	4.9 FT RADIALLY FROM CONDUIT	25	499,950
2. 2" COND. THERMO-LAG	THERMO-LAG OF CONCERN	51	357,000[1]
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Exposed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

NOTE 1: FOR THIS FIRE SCENARIO, ONLY THE TRANSFORMER OIL IS CONSIDERED.

WORKSHEET 3

Critical Radiant Flux (IP Units)(ref 6.20)

WORKSHEET 3: FIRE AREA EXAMPLE 6 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Critical Radiant Flux of Target (Look up value in Table A, for Thermo-Lag use a value of 2.2 Btu/s ft^2	2.2	Btu/s ft^2
2	Radial Distance From Source To Target (Based on Scenario Geometry)	4.8	ft
3	Peak Fire Intensity (Use Table 2 for guidance)	1654	Btu/s
4	Radiant Fraction of Heat Release (Typically 0.4)	0.40	N/A
5	Radiant Heat Release Rate (Box 3 times Box 4)	661.6	Btu/s
6	Critical Radiant Flux Distance (Look up value in Table 10 or use equation (14))	4.9	ft
7	Source Distance - Flux Distance (Box 2 - Box 6)	-0.1	ft
If the value entered in Box 7 is greater than zero stop here and enter a "No" in 4.4 of Worksheet Figure 1. If the value in Box 7 is less than or equal to zero then critical conditions can occur, therefore continue.			
8	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 3)	499,950	Btu
9	Time To Consume Fire Source (Box 8 divided by Box 3)	302	s
10	Radiant Flux at Target Look up value in Table 11 or use equation (15))	2.3	Btu/s ft^2
11	Calculate Surface Temperature of Target (Look up Value in Table 14 or use equation (16)	600	°F
12	Ignition Temperature of Target (For Thermo-Lag the Value is 1000°F)	1000	°F
13	Ignition Temp. - Surface Temp. (Box 12 minus Box 11)	400	°F
If the value in Box 13 is greater than zero the Thermo-Lag will not ignite and enter a "No" in step 4.4 of Worksheet (Figure 1)			

WORKSHEET 2A

Flame Propagation Scenarios (IP Units)

WORKSHEET 2A: FIRE AREA EXAMPLE 7 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
14	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (Use Box 9 from section 5.4 or Box 4 from section 5.3)	750	Btu/s
15	Fire Location Factor (1 for center, 2 for wall, 4 for corner)	1	N/A
16	Effective Heat Release Rate (Box 14 times Box 15)	750	Btu/s
17	Plume Temperature Rise at Target (Use Table 5 or calculate using equation (19))	190	°F
18	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (20) or (21) use the higher value)	0.7	N/A
19	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 17 times Box 18)	133	°F
20	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
21	Critical Temp. Rise - Ceiling Jet Temp. Rise (Box 20 minus Box 19)	799	°F
If the entry in Box 21 has a value of < 0, then stop here and enter a "YES" in step 4.5 of the worksheet (Figure 1); Else continue with Boxes 22 through 27.			
22	Net Energy Addition per Unit Volume (Use Table 7 or eq.(21b) based on Box 21)	8.79	Btu/ft^3
23	Calculated Enclosure Volume (V) (Box 8 times floor area of space)	12,000	ft^3
24	Calculated Critical Q_{net} (Q) (Box 22 times Box 23)	105,480	Btu
25	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
26	Estimate of Critical Total Energy Release (Box 24 / [1- Box 25])	351,600	Btu

WORKSHEET 2A

Flame Propagation Scenarios (IP Units)

WORKSHEET 2A: FIRE AREA EXAMPLE 7 SCENARIO: ____________

BOX NO	DESCRIPTION	ENTRY	UNITS
27	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	320,000	Btu
If the entry in Box 27 is less than the entry in Box 26, the critical conditions are not met and a "NO" is entered in step 4.5 of Worksheet (Figure 1), and Boxes 31 through 35 should be performed to ensure that the radiant energy from the fire will not impact the results. If the entry in Box 27 is equal to or greater than Box 26 then continue with Boxes 28 through 30.			
28	Time To Consume Fire Source (Box 27 divided by Box 14)		s
29	Target Temperature (Use Table 13 or equation (22))		°F
30	Ignition Temperature-Surface Temperature (Box 1 minus Box 29)		°F
If the entry in Box 30 is greater than zero, then the fire will burn itself out before the critical point, therfore continue with Boxes 31 - 35. If entry in Box 30 is less than or equal to zero then the critical conditions are met and a "YES" is entered in step 4.5 of Worksheet (Figure 1)			
31	Critical Radiant Flux at Target (Look up value in Table A, for Thermo-lag use a value of 2.2 Btu/s ft^2)	2.2	Btu/s ft^2
32	Radiant Fraction of Heat Release (Typically 0.4)	.4	N/A
33	Radiant Heat Release Rate (Box 14 times Box 32)	300	Btu/s
34	Critical Radiant Flux Distance (Look up value in Table 10 or use equation (23))	3.29	ft
35	Radial Dist.to Target-Crit. Rad. Flux Dist. (Box 10 minus Box 34)	2.31	ft
If the entry in Box 35 is greater than zero, then the critical point is outside of the Thermo-Lag burn distance and the screening criteria is met. Enter a "NO" in Step 4.5 of Worksheet (Figure 1); Else continue with Boxes 36 through 38.			

WORKSHEET 2A

Flame Propagation Scenarios (IP Units)

WORKSHEET 2A: FIRE AREA EXAMPLE 8 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
14	Peak Fi Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (Use Box 9 from section 5.4 or Box 4 from section 5.3)	750	Btu/s
15	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/A
16	Effective Heat Release Rate (Box 14 times Box 15)		Btu/s
17	Plume Temperature Rise at Target (Use Table 5 or calculate using equation (19))		°F
18	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (20) or (21) use the higher value)		N/A
19	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 17 times Box 18)	0	°F
20	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)	932	°F
21	Critical Temp. Rise - Ceiling Jet Temp. Rise (Box 20 minus Box 19)	932	°F
If the entry in Box 21 has a value of < 0, then stop here and enter a "YES" in step 4.5 of the worksheet (Figure 1); Else continue with Boxes 22 through 27.			
22	Net Energy Addition per Unit Volume (Use Table 7 or eq.(21b) based on Box 21)	9.70	Btu/ft^3
23	Calculated Enclosure Volume (V) (Box 8 times floor area of space)	4000	ft^3
24	Calculated Critical Q_{net} (Q) (Box 22 times Box 23)	38,800	Btu
25	Estimated Heat Loss Fraction (representative value = 0.7)	0.7	N/A
26	Estimate of Critical Total Energy Release (Box 24 / [1- Box 25])	129,333	Btu

WORKSHEET 2A

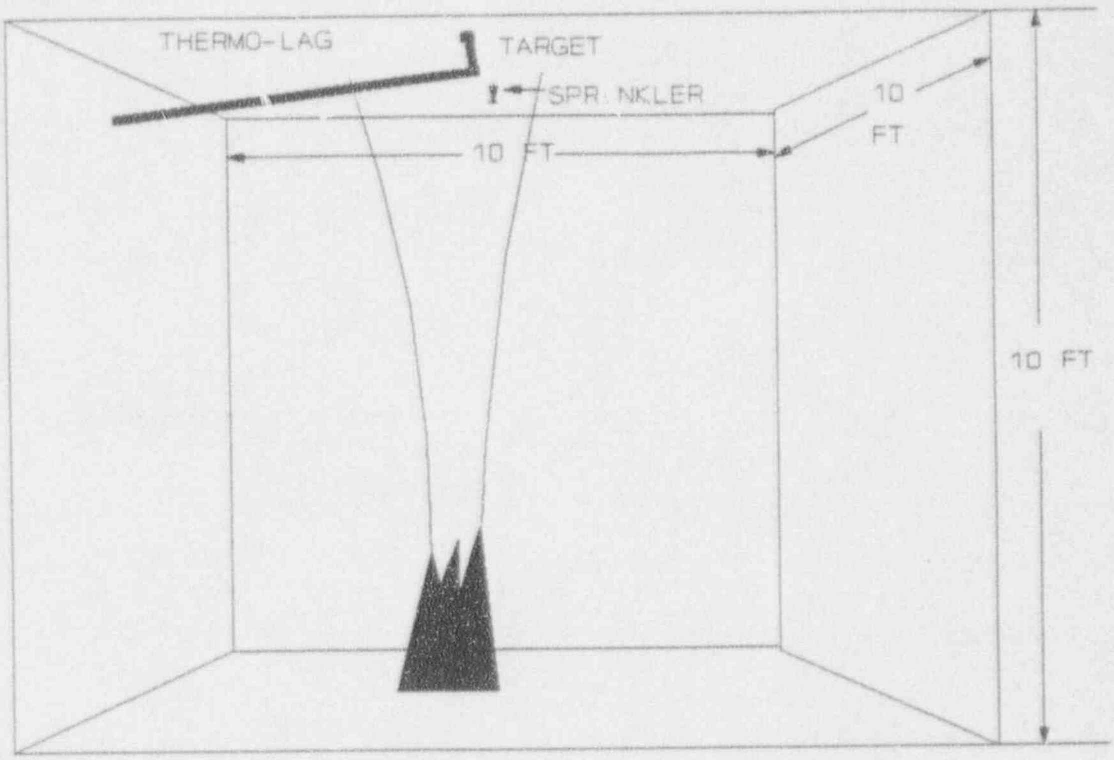
Flame Propagation Scenarios (IP Units)

WORKSHEET 2A: FIRE AREA EXAMPLE 8 SCENARIO:			
BOX NO	DESCRIPTION	ENTRY	UNITS
27	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)	320,000	Btu
If the entry in Box 27 is less than the entry in Box 26, the critical conditions are not met and a "NO" is entered in step 4.5 of Worksheet (Figure 1), and Boxes 31 through 35 should be performed to ensure that the radiant energy from the fire will not impact the results. If the entry in Box 27 is equal to or greater than Box 26 then continue with Boxes 28 through 30.			
28	Time To Consume Fire Source (Box 27 divided by Box 14)	427	s
29	Target Temperature (Use Table 13 or equation (22))	959	°F
30	Ignition Temperature-Surface Temperature (Box 1 minus Box 29)	41	°F
If the entry in Box 30 is greater than zero, then the fire will burn itself out before the critical point, therfore continue with Boxes 31 - 35. If entry in Box 30 is less than or equal to zero then the critical conditions are met and a "YES" is entered in step 4.5 of Worksheet (Figure 1)			
31	Critical Radiant Flux at Target (Look up value in Table A, for Thermo-lag use a value of 2.2 Btu/s ft^2)	2.2	Btu/s ft^2
32	Radiant Fraction of Heat Release (Typically 0.4)	.4	N/A
33	Radiant Heat Release Rate (Box 14 times Box 32)	300	Btu/s
34	Critical Radiant Flux Distance (Look up value in Table 10 or use equation (23))	3.29	ft
35	Radial Dist.to Target-Crit. Rad. Flux Dist. (Box 10 minus Box 34)	-1.04	ft
If the entry in Box 35 is greater than zero, then the critical point is outside of the Thermo-Lag burn distance and the screening criteria is met. Enter a "NO" in Step 4.5 of Worksheet (Figure 1); Else continue with Boxes 36 through 38.			

ATTACHMENT 2

EXAMPLE 9

AUTOMATIC SUPPRESSION RESPONSE
PLUME TEMPERATURE ABOVE IGNITION TEMP



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT
WITH AUTOMATIC SPRINKLERS

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG

ROOM IS: 10' X 10' X 10'

AMBIENT ROOM TEMP: 68 Deg F

SPRINKLER RATING: 160 DEG F

SPRINKLER LOCATED DIRECTLY ABOVE FIRE

SPRINKLER LOCATED AT CEILING (10 FT)

BASED ON EXAMPLE 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

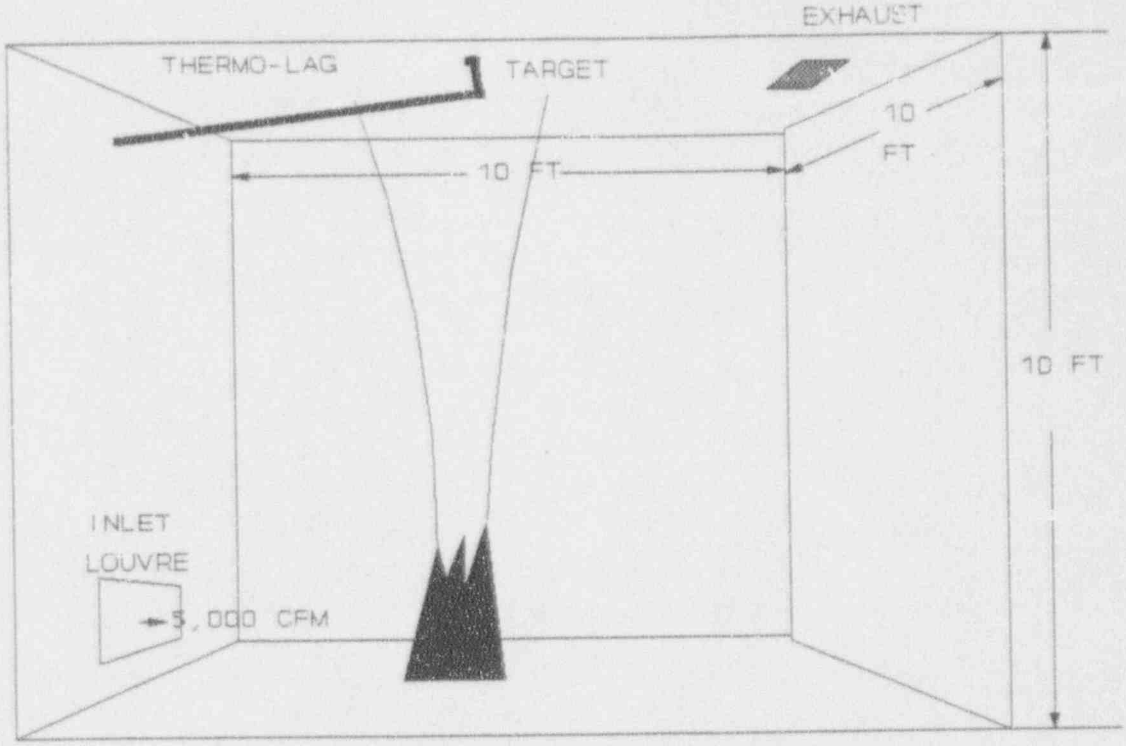
Fire Area EXAMPLE 9

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft²	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft² Present Loading 5,000 Btu/ft² Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No ____
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No ____
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No YES

ATTACHMENT 2

EXAMPLE 10

MECHANICAL VENTILATION EFFECTS
PLUME TEMPERATURE ABOVE IGNITION TEMP.



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS (19998 BTU/LBM))
TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG
ROOM IS: 10' X 10' X 10'
AMBIENT ROOM TEMP: 68 Deg F

VENTILATION SYSTEM
EXHUAST SYSTEM WITH 5,000 CFM FAN
SUPPLY AIR IS 68 DEG F
THERE ARE NO FIRE DAMPERS
OR AUTOMATIC SHUTDOWN DEVICE IN SYSTEM

BASED ON EXAMPLE 2

ATTACHMENT 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

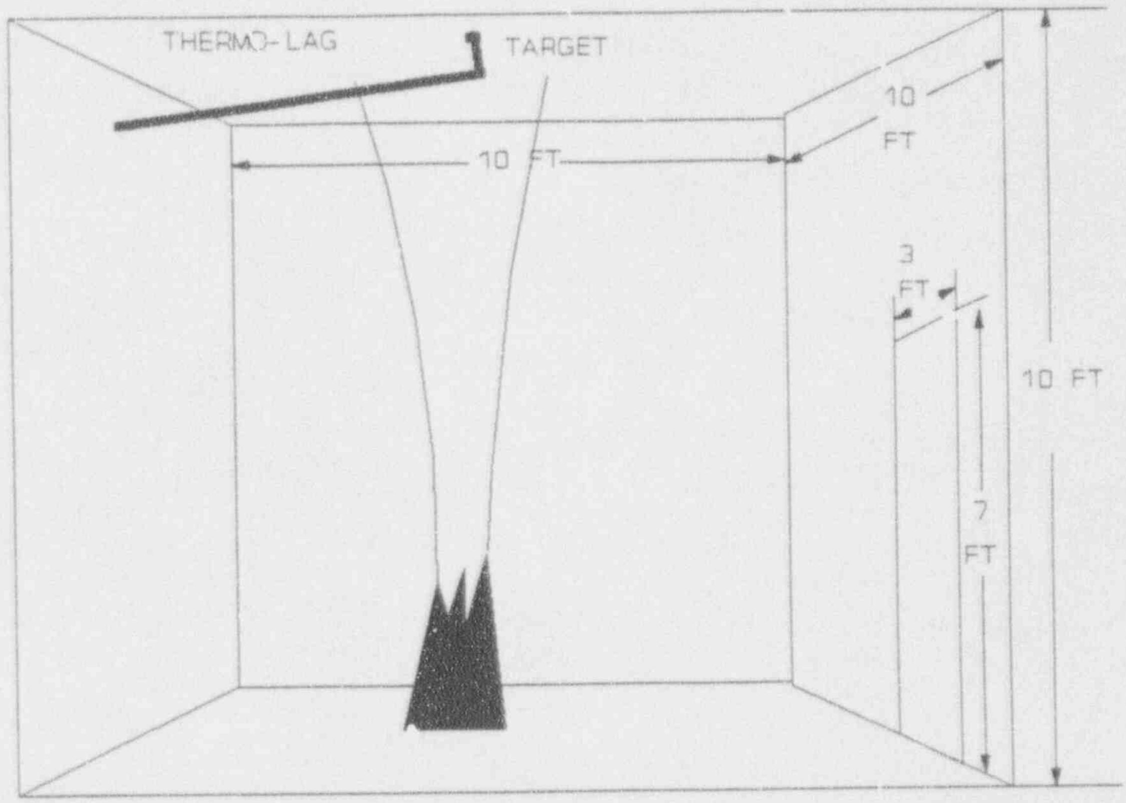
Fire Area EXAMPLE 10

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft²	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft² Present Loading 5,000 Btu/ft² Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No ____
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No ____
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No YES

ATTACHMENT 2

EXAMPLE 11

VENTILATION CONTROLLED/LIMITED FIRE
PLUME TEMPERATURE ABOVE IGNITION TEMP.



SCENARIO: THERMO-LAG TARGET OUTSIDE CONTAINMENT

SOURCE OF FIRE: TRANSFORMER OIL (25 LBS [19998 BTU/LBM])

TARGET: 2" THERMO-LAGGED CONDUIT 10 FEET LONG

ROOM IS: 10' X 10' X 10'
AMBIENT ROOM TEMP: 68 Deg F

ROOM OPENING: DOORWAY 3 FT WIDE X 7 FT HEIGHT

BASED ON EXAMPLE 2

FIGURE 1

Fire Area Thermo-Lag Screen (IP units)

Fire Area EXAMPLE 11

STEP	PROCEDURE	REFERENCE	DATA
4.1	Is there Thermo-Lag in the Fire Area? If there is no Thermo-Lag stop here.	Use Reference material request by G.L. 92-08	Yes/No YES
4.2	Determine Thermo-Lag combustible loading and Add Thermo-Lag to the combustible loading analysis. Area = 10' X 10' = 100 ft²	Use Table 1 for Btu values	Increase in Loading 3,570 Btu/ft² Present Loading 5,000 Btu/ft² Total Loading 8,570 Btu/ft2
4.3	Fire Area Review	See steps below	N/A
4.3a	Is there any fire safe shutdown equipment/cables in the Fire Area? If the answer to this step is No, go to step 4.3.d.	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No NO
4.3b	Is 20 foot separation used in this area to achieve fire safe shutdown? If the answer to this step is Yes, go to step 4.4	Use Reference Material for Fire Safe Shutdown Analysis.	Yes/No ___
4.3c	Is Thermo-Lag used as a radiant energy shield or as a non-combustible fire barrier? If the answers to this step is Yes, go to step 4.4.	Use Reference Materials for Fire Safe Shutdown Analysis.	Yes/No ___
4.3d	Does the increase effect any engineering evaluation (including non-rated openings i.e. penetration seals), Deviations, Exemption Request or Administrative Controls (Transient Limits)? If an analysis is impacted go to Step 4.4 to determine if there is a sufficient fire hazard to ignite the Thermo-Lag.	Fire Hazards Analysis	Yes/No YES
4.3e	If the answer to any of the steps 4.3a through 4.3d is YES, further analysis is required. If the answer to steps 4.3a through 4.3 d is no, stop here.		Yes/No YES
4.4	Determine if the Thermo-Lag will ignite. If the answer is No, then stop here. If the area is containment and this is for determining noncombustibility then stop here with the screening since further evaluation outside of the screening is required.	Use section 5 sections 5.3 through 5.5	Yes/No YES

TABLE 1

Thermo-Lag Combustible Loading Data (IP Units) (Ref 6.35)

Description	Weight of Thermo-lag	Combustible Loading of Thermo-lag
3/4 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	3.1 lbs/linear ft	21,700 Btu/linear ft
1 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	3.4 lbs/linear ft	23,800 Btu/linear ft
1 1/2 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	4.4 lbs/linear ft	30,800 Btu/linear ft
2 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	5.1 lbs/linear ft	35,700 Btu/linear ft
3 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	6.8 lbs/linear ft	47,600 Btu/linear ft
4 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	8.4 lbs/linear ft	58,800 Btu/linear ft
5 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	10.0 lbs/linear ft	70,000 Btu/linear ft
6 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	11.5 lbs/linear ft	80,500 Btu/linear ft
Trays 1/2" thick Thermo-Lag (1hr). This is based on surface area e.g top+side+bottom.	5.25 lbs/square ft	36,750 Btu/ square ft
Trays 1" thick Thermo-Lag (3hr). This is based on surface area e.g top+side+bottom.	10.5 lbs/square ft	73,500 Btu/ square ft
3/4 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	6.1 lbs/linear ft	42,700 Btu/linear ft
1 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	6.9 lbs/linear ft	48,300 Btu/linear ft
1 1/2 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	8.7 lbs/linear ft	60,900 Btu/linear ft
2 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	10.1 lbs/linear ft	70,700 Btu/linear ft
3 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	13.6 lbs/linear ft	95,200 Btu/linear ft

TABLE 1

Thermo-Lag Combustible Loading Data (IP Units) (Ref 6.35)

Description	Weight of Thermo-lag	Combustible Loading of Thermo-lag
4 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	16.7 lbs/linear ft	116,900 Btu/linear ft
5 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	19.9 lbs/linear ft	139,500 Btu/linear ft
6 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	23.0 lbs/linear ft	161,000 Btu/linear ft
3/4 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	3.1 lbs/linear ft	21,700 Btu/linear ft
1 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	3.8 lbs/linear ft	26,600 Btu/linear ft
1 1/2 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	4.4 lbs/linear ft	30,800 Btu/linear ft
2 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	4.8 lbs/linear ft	33,600 Btu/linear ft
1/2" thick Thermo-Lag panel	5.25 lb/ft^2	36,750 Btu/ft^2
1" thick Thermo-Lag panel	10.5 lb/ft^2	73,500 Btu/ft^2

The above table is based on the maximum weight of Thermo-Lag preshaped section plus 15% for any additional trowel grade material times 7,000 Btu/lb of Thermo-Lag.

The 1/4" overlay quantities are for the overlay only and do not include the base 1/2" quantities.

TABLE 1

Thermo-Lag Combustible Loading Data (SI Units) (Ref 6.35)

Description	Weight of Thermo-lag	Combustible Loading of Thermo-lag
3/4 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	4.6 Kg/linear m	75,000 KJ/linear m
1 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	5.1 Kg/linear m	83,100 KJ/linear m
1 1/2 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	6.5 Kg/linear m	106,000 KJ/linear m
2 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	7.6 Kg/linear m	123,900 KJ/linear m
3 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	10.1 Kg/linear m	164,600 KJ/linear m
4 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	12.5 Kg/linear m	203,800 KJ/linear m
5 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	14.9 Kg/linear m	242,900 KJ/linear m
6 in. Conduit 1/2" thick Thermo-Lag (1hr) no upgrades	17.1 Kg/linear m	278,700 KJ/linear m
Trays 1/2" thick Thermo-Lag (1hr). This is based on surface area e.g top+side+bottom.	25.6 Kg/square m	417,300 KJ/square m
Trays 1" thick Thermo-Lag (3hr). This is based on surface area e.g top+side+bottom.	51.3 Kg/square m	836,200 KJ/square m
3/4 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	9.1 Kg/linear m	148,300 KJ/linear m
1 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	10.3 Kg/linear m	167,900 KJ/linear m
1 1/2 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	12.9 Kg/linear m	210,300 KJ/linear m
2 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	15.0 Kg/linear m	244,500 KJ/linear m
3 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	20.2 Kg/linear m	329,300 KJ/linear m

TABLE 1

Thermo-Lag Combustible Loading Data (SI Units) (Ref 6.35)

Description	Weight of Thermo-lag	Combustible Loading of Thermo-lag
4 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	24.9 Kg/linear m	405,900 KJ/linear m
5 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	29.6 Kg/linear m	482,500 KJ/linear m
6 in. Conduit 1" thick Thermo-Lag (3 hr) no upgrades	34.2 Kg/linear m	557,500 KJ/linear m
3/4 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	9.1 Kg/linear m	148,300 KJ/linear m
1 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	11.5 Kg/linear m	187,500 KJ/linear m
1 1/2 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	13.2 Kg/linear m	215,200 KJ/linear m
2 in. Conduit 1/2" thick Thermo-Lag (1hr) 1/4" overlay	14.4 Kg/linear m	234,700 KJ/linear m
1/2" thick Thermo-Lag panel	25.6 Kg/m^2	417,300 KJ/m^2
1" thick Thermo-Lag panel	51.3 Kg/m^2	836,200 KJ/m^2

The above table is based on the maximum weight of Thermo-Lag preshaped section plus 15% for any additional trowel grade material times 16,281 KJ/Kg of Thermo-Lag.

The 1/4" overlay quantities are for the overlay only and do not include the base 1/2" quantities.

TABLE 10

CRITICAL RADIANT FLUX DISTANCES (SI Units)(Ref 6.35)

RADIANT HEAT RELEASE RATE (Kw)	CRITICAL HEAT FLUX (Kw/m2)					
	5.00	10.00	15.00	20.00	25.00	30.00
	CRITICAL RADIAL DISTANCE (m)					
100	1.3	0.9	0.7	0.6	0.6	0.5
200	1.8	1.3	1.0	0.9	0.8	0.7
300	2.2	1.5	1.3	1.1	1.0	0.9
400	2.5	1.8	1.5	1.3	1.1	1.0
500	2.8	2.0	1.6	1.4	1.3	1.2
750	3.5	2.4	2.0	1.7	1.5	1.4
1000	4.0	2.8	2.3	2.0	1.8	1.6
1250	4.5	3.2	2.6	2.2	2.0	1.8
1500	4.9	3.4	2.8	2.4	2.2	2.0
1750	5.3	3.7	3.0	2.6	2.4	2.2
2000	5.6	4.0	3.3	2.8	2.5	2.3
2500	6.3	4.5	3.6	3.2	2.8	2.6

TABLE 11

RADIANT HEAT FLUX AT TARGET (IP Units)(Ref 6.35)

HRR Btu/s	DISTANCE TO TARGET (ft)							
	3	4	5	7.5	10	15	20	25
	RADIANT FLUX AT TARGET (Btu/s ft^2)							
100	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0
200	1.8	1.0	0.6	0.3	0.2	0.1	0.0	0.0
400	3.5	2.0	1.3	0.6	0.3	0.1	0.1	0.1
600	5.3	3.08	1.9	0.8	0.5	0.2	0.1	0.1
800	NA	4.0	2.5	1.1	0.6	0.3	0.2	0.1
1000	NA	5.0	3.2	1.4	0.8	0.4	0.2	0.1
1200	NA	NA	3.8	1.7	1.0	0.4	0.2	0.2
1400	NA	NA	4.5	2.0	1.1	0.5	0.3	0.2
1700	NA	NA	NA	2.4	1.4	0.6	0.3	0.2
1900	NA	NA	NA	2.7	1.5	0.7	0.4	0.2
2400	NA	NA	NA	3.4	1.9	0.8	0.5	0.3
2800	NA	NA	NA	4.0	2.2	1.09	0.6	0.4
3400	NA	NA	NA	4.8	2.7	1.2	0.7	0.4

TABLE 11

RADIANT HEAT FLUX AT TARGET (SI Units)(Ref 6.35)

HRR Kw	DISTANCE TO TARGET (m)						
	1.0	1.5	2.0	3.0	4.0	5.0	7.5
	RADIANT FLUX AT TARGET (kW/m²)						
100	8.0	3.5	2.0	0.9	0.5	0.3	0.1
200	15.9	7.1	4.08	1.8	1.0	0.6	0.3
400	31.8	14.1	8.0	3.5	2.0	1.3	0.6
600	47.7	21.2	11.9	5.3	3.0	1.9	0.8
800	NA	28.3	15.9	7.1	4.0	2.5	1.1
1000	NA	35.4	19.9	8.8	5.0	3.2	1.4
1200	NA	42.4	23.9	10.6	6.0	3.8	1.7
1500	NA	53.0	29.8	13.3	7.5	4.8	2.1
1750	NA	NA	34.8	15.5	8.7	5.6	2.5
2000	NA	NA	39.8	17.7	9.9	6.4	2.8
2500	NA	NA	49.7	22.1	12.4	8.0	3.5
3000	NA	NA	59.7	26.5	14.9	9.5	4.2
3500	NA	NA	NA	30.9	17.4	11.1	5.0

TABLE 12

TIME CONSTANTS FOR FIRE DETECTORS (IP Units)

BASED ON TABLE C-3-2.2.2 OF NFPA 72E-1989

FIXED TEMPERATURE HEAT DETECTORS						
LISTED SPACING (ft)	LISTED DETECTOR ACTUATION TEMPERATURE (F)					
	128	135	145	160	170	196
	DETECTOR TIME CONSTANT (s)					
10	400	330	262	195	160	97
15	250	190	156	110	89	45
20	165	125	105	70	52	17
25	124	100	78	48	32	
30	95	80	61	36	22	
40	71	57	41	18		
50	59	44	30			
70	36	24	9			

AUTOMATIC SPRINKLERS	
TYPE	TIME CONSTANT (s)
STANDARD	
SOLDER TYPE	~ 60 - 120 s
BULB TYPE	~ 120 - 240 s
QUICK RESPONSE	~ 20 - 30 s

SMOKE DETECTORS	
TYPE	TIME CONSTANT (s)
ALL	USE 10 s

FIGURE 1A

Thermo-Lag Combustible Loading Worksheet

Fire Area ____________________

Description of Item	Quantity	Unit Loading (See Table 1)	Total Loading
	Totals		

WORKSHEET 1

Target In Plume Scenarios (IP Units)(ref 6.20)

WORKSHEET 1: FIRE AREA ____________ SCENARIO: ____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)		°F
2	Height of Target above Fire Source (Based on scenario geometry)		ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)		ft
4	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)		Btu/s
5	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/A
6	Effective Heat Release Rate (Box 4 times Box 5)		Btu/s
7	Plume Temperature Rise at Target (Use Table 5 or calculate equation(7))		°F
8	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)		°F
9	Critical Temp. Rise - Plume Temp. Rise (Box 8 minus Box 7)		°F
	If the entry in Box 9 has a value of < 0 then go to step 16 else continue with steps 10 throug 15.		
10	Net Energy Addition per Unit Volume (Use Table 7 or eq.(7b) based on Box 9)		Btu/ft^3
11	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
12	Calculated Critical Q_{net} (Q) (Box 10 times Box 11)		Btu
13	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
14	Estimate of Critical Total Energy Release (Box 12 / [1- Box 13])		Btu

WORKSHEET 1

Target In Plume Scenarios (IP Units)(ref 6.20)

WORKSHEET 1: FIRE AREA ____________ SCENARIO:____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 15 is less than the entry in Box 14, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 15 is equal to or grea than Box 14 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
16	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 4)		Btu
17	Time To Consume Fire Source (Box 16 divided by Box 4)		s
18	Target Temperature (Use Table 13 or equation (8))		°F
19	Ignition Temperature - Surface Temp. (Box 1 minus Box 18)		°F
If the value in Box 19 is greater than zero then continue with Boxes 20 through 25. If the val in Box 19 is less than or equal to zero stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1.			
20	Q_{net}/V to Achieve Temp. Rise in Box 19 (lookup value in Table 7 or use equation 8b)		Btu/ft^3
21	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
22	Calculated Critical Energy Add to Space (Box 20 times Box 21)		Btu
23	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
24	Critical Total Energy Release (Box 22/ [1-Box 23])		Btu
25	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 25 is less than the entry in Box 24 the critical conditions are not met and "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 25 is equal to or grea than Box 24 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

WORKSHEET 1

Target In Plume Scenarios (SI Units)(ref 6.20)

WORKSHEET 1: FIRE AREA ____________ SCENARIO:____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 538°C, 811°K)		°K
2	Height of Target above Fire Source (Based on scenario geometry)		m
3	Height from Fire Source to Ceiling (Based of scenario geometry)		m
4	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)		Kw
5	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/A
6	Effective Heat Release Rate (Box 4 times Box 5)		KW
7	Plume Temperature Rise at Target (Use Table 5 or calculate equation(6))		°K
8	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)		°K
9	Critical Temp. Rise - Plume Temp. Rise (Box 8 minus Box 7)		°K
If the entry in Box 9 has a value of < 0 then go to step 16 else continue with steps 10 throug 15.			
10	Net Energy Addition per Unit Volume (Use Table 7 or eq.(7a) based on Box 9)		KJ/m^3
11	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		m^3
12	Calculated Critical Q_{net} (Q) (Box 10 times Box 11)		KJ
13	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
14	Estimate of Critical Total Energy Release (Box 12 / [1- Box 13])		KJ

WORKSHEET 1

Target In Piume Scenarios (SI Units)(ref 6.20)

WORKSHEET 1: FIRE AREA ____________ SCENARIO:____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		KJ
If the entry in Box 15 is less than the entry in Box 14 the critical conditions are not met and "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 15 is equal to or grea than Box 14 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
16	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 4)		KJ
17	Time To Consume Fire Source (Box 16 divided by Box 4)		s
18	Target Temperature (Use Table 13 or equation (8))		°K
19	Ignition Temperature - Surface Temp. (Box 1 minus Box 18)		°K
If the value in Box 19 is greater than zero then continue with boxes 20 through 25. If the va in Box 19 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1.			
20	Q_{net}/V to Achieve Temp. Rise in Box 19 (lookup value in Table 7 or use equation 8a)		KJ/m^3
21	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		m^3
22	Calculated Critical Energy Add to Space (Box 20 times Box 21)		KJ
23	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
24	Critical Total Energy Release (Box 22/ [1-Box 23])		KJ
25	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		KJ
If the entry in Box 25 is less than the entry in Box 24 the critical conditions are not met and "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 25 is equal to or grea than Box 24 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

Worksheet 1A

Combustible Materials Worksheet

Fire Area ____________

Fixed Combustibles	Distance to Target (m,Ft)	Quantity (KJ,lbs)	Loading (Kw,Btu
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			

Transient Combustibles	Distance to Target (Height only) (m,ft)	Ex-posed Yes/No	Expected Quantity (KJ,lbs)	Loading (Kw,Btu
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)(ref 6.20)

WORKSHEET 2: FIRE AREA ___________ SCENARIO: ___________			
BOX NO	DESCRIPTION	ENTRY	UNITS
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 1000°F)		°F
2	Height of Target above Fire Source (Based on scenario geometry)		ft
3	Height from Fire Source to Ceiling (Based of scenario geometry)		ft
4	Ratio of Target Height to Ceiling Height (Box 2 divided by Box 3)		N/A
If the value in Box 4 is > 0.85, Complete Boxes 5 through 13; Else enter a value of zero (0) in Box 14			
5	Radial Distance From Source to Target (Based on Scenario Geometry)		ft
6	Radial Distance to Height Ratio (L/H) (Box 5 divided by Box 3)		N/A
7	Enclosure Width (W) (Based on Scenario Geometry)		ft
8	Height to Width Ratio (H/W) (Box 3 divided by Box 7)		N/A
9	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)		Btu/s
10	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/A
11	Effective Heat Release Rate (Box 9 times Box 10)		Btu/s
12	Plume Temperature Rise at Target (Use Table 5 or calculate using equation(10))		°F
13	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (11) or (12) use the higher value)		N/A
14	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 12 times Box 13)		°F

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)(ref 6.20)

WORKSHEET 2: FIRE AREA ____________ SCENARIO: ____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
15	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)		°F
16	Critical Temp. Rise - Plume Temp. Rise (Box 15 minus Box 14)		°F
If the entry in Box 16 has a value of < 0 then go to step 23 else continue with steps 17 through 22.			
17	Net Energy Addition per Unit Volume (Use Table 7 or eq.(12b) based on Box 16)		Btu/ft^3
18	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
19	Calculated Critical Q_{net} (Q) (Box 17 times Box 18)		Btu
20	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
21	Estimate of Critical Total Energy Release (Box 19 / [1- Box 20])		Btu
22	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 22 is less than the entry in Box 21, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 22 is equal to or greater than Box 21 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
23	Total Energy in Fire Source (the total Btu loading (Worksheet 1A) of the peak fire intensity in Box 9)		Btu
24	Time To Consume Fire Source (Box 23 divided by Box 9)		s
25	Target Temperature (Use Table 13 or equation (13))		°F
26	Ignition Temperature - Surface Temp. (Box 1 minus Box 25)		°F

WORKSHEET 2

Target Outside of Plume Scenarios (IP Units)(ref 6.20)

WORKSHEET 2: FIRE AREA ____________ SCENARIO:__ __________			
BOX NO	DESCRIPTION	ENTRY	UNITS
If the value in Box 26 is greater than zero, then continue with boxes 27 through 32. If the value in Box 26 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1. Note: if Box 14 is zero, stop here.			
27	Q_{net}/V to Achieve Temp. Rise in Box 26 (lookup value in Table 7 or use equation 13b)		Btu/ft^3
28	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		ft^3
29	Calculated Critical Energy Added to Space (Box 27 times Box 28)		Btu
30	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
31	Critical Total Energy Release (Box 29/ [1-Box 30])		Btu
32	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		Btu
If the entry in Box 32 is less than the entry in Box 31, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 32 is equal to or greater than Box 31 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			

WORKSHEET 2

Target Outside of Plume Scenarios (SI Units)(ref. 6.20)

WORKSHEET 2: FIRE AREA ________ SCENARIO: ________			
BOX NO	DESCRIPTION	ENTRY	UNI
1	Target Ignition Threshold Temperature (Representative value for Thermo-Lag is 538°C, 811°K)		°K
2	Height of Target above Fire Source (Based on scenario geometry)		m
3	Height from Fire Source to Ceiling (Based of scenario geometry)		m
4	Ratio of Target Height to Ceiling Height (Box 2 divided by Box 3)		N/
If the value in Box 4 is > 0.85, Complete Boxes 5 through 13; Else enter a value of zero (0) in Box 14			
5	Radial [illegible] From Source to Target (Based on Scenario Geometry)		m
6	Radial Distance to Height Ratio (L/H) (Box 5 divided by Box 3)		N/
7	Enclosure Width (W) (Based on Scenario Geometry)		m
8	Height to Width Ratio (H/W) (Box 3 divided by Box 7)		N/
9	Peak Fire Intensity (Q) (Use Tables 1E-2 & Figures 4-5 for guidance) (See section 5.2)		Kw
10	Fire Location Factor (1 for center, 2 for wall, 4 for corner)		N/
11	Effective Heat Release Rate (Box 9 times Box 10)		KW
12	Plume Temperature Rise at Target (Use Table 5 or calculate using equation(9))		°K
13	Ceiling Jet Temperature Factor at Target (Use either Table 6a or 6b or calculate using equation (11) or (12) use the higher value)		N/
14	Calc. Ceiling Jet Temp. Rise at Target (Multiply Box 12 times Box 13)		°K

WORKSHEET 2

Target Outside of Plume Scenarios (SI Units)(ref. 6.20)

WORKSHEET 2: FIRE AREA ____________ SCENARIO:____________			
BOX NO	DESCRIPTION	ENTRY	UNI
15	Critical Temperature Rise at Target (Box 1 minus max. ambient space temp.)		°K
16	Critical Temp. Rise - Plume Temp. Rise (Box 15 minus Box 14)		°K
If the entry in Box 16 has a value of < 0 then go to step 23 else continue with steps 17 throu 22.			
17	Net Energy Addition per Unit Volume (Use Table 7 or eq.(12a) based on Box 16)		KJ/
18	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		m
19	Calculated Critical Q_{net} (Q) (Box 17 times Box 18)		KJ
20	Estimated Heat Loss Fraction (representative value = 0.7)		N/
21	Estimate of Critical Total Energy Release (Box 19 / [1- Box 20])		KJ
22	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		KJ
If the entry in Box 22 is less than the entry in Box 21, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 22 is equal to or great than Box 21 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			
23	Total Energy in Fire Source (the total KJ loading (Worksheet 1A) of the peak fire intensity in Box 9)		KJ
24	Time To Consume Fire Source (Box 23 divided by Box 9)		s
25	Target Temperature (Use Table 13 or equation (13))		°K

WORKSHEET 2

Target Outside of Plume Scenarios (SI Units)(ref. 6.20)

WORKSHEET 2: FIRE AREA ____________ SCENARIO:____________			
BOX NO	DESCRIPTION	ENTRY	UNITS
26	Ignition Temperature - Surface Temp. (Box 1 minus Box 25)		°K
If the value in Box 26 is greater than zero, then continue with boxes 27 through 32. If the value in Box 26 is zero or less stop here and enter a "YES" in Step 4.4 of Worksheet Figure 1. Note: if Box 14 is zero, stop here.			
27	Q_{net}/V to Achieve Temp. Rise in Box 26 (lookup value in Table 7 or use equation 13a)		KJ/m^3
28	Calculated Enclosure Volume (V) (Box 3 times floor area of space)		m^3
29	Calculated Critical Energy Added to Space (Box 27 times Box 28)		KJ
30	Estimated Heat Loss Fraction (representative value = 0.7)		N/A
31	Critical Total Energy Release (Box 29/ [1-Box 30])		KJ
32	Estimate of Actual Total Energy Release (Qtot) (Use Worksheet 1A)		KJ
If the entry in Box 32 is less than the entry in Box 31, the critical conditions are not met and a "NO" is entered in step 4.4 of Worksheet Figure 1. If the entry in Box 32 is equal to or greater than Box 31 then a "YES" is entered in Step 4.4 of Worksheet Figure 1.			