SDP - HARRIS FIRE ZONE 1-A-ACP
(AKA SAFE SHUTDOWN ANALYSIS AREA 1-A-ACP)

- Ignition sources: Transients
  Electrical junction boxes
  Miscellaneous hydrogen fires
  Welding/Ordinary Combustibles and Welding/Cables

- Combustibles: 2 gal. transient flammable liquids, with no transient combustible permit required (per FPP-004)
  5 gal. transient combustible liquids, with no transient combustible permit required (per FPP-004)
  Cable insulation, unknown quantity (IEEE-383)
  Rubber mats up to 150 sq. ft. may be installed without continuous attendance - per FPP-004.
  Transient combustibles up to one million Btu above the analyzed combustible loading for a given fire zone are considered a low fire load and no fire watch or other compensatory action is required - per FPP-004.

Dimensions: The 1-A-ACP fire area is approximately 336 sq. ft.; with a length of about 28 ft., width of about 12 ft., and ceiling height of about 23 ft. Assume natural ventilation with a vent opening of 3 ft. wide by 7 ft. high (a doorway). Unprotected horizontal cable trays are approximately 9 ft. above the floor, near the door. Also, many unprotected cables are at the far end of the room, in a vertical cable run from the floor up to about 10 ft. above the floor, where they turn and run horizontally into a tunnel and away from the ACP room. Assume the fire starts in front of the vertical cable run.

Analysis: 5 gallons of transient oil spill on 50 sq. ft. of rubber mat. Also present is 125 lbs of solid transient combustibles (poly bags, rags, rubber, wood). All get ignited by a portable electrical implement (e.g., grinder, drill, heater, light bulb). Assume the rubber mat has a HRR of 354 Kw/sq. meter, an area of 5.5 sq. meters, and a total HRR of 1,950 Kw. Assume the 125 lbs of solid transient combustibles have a HRR of 500 Kw/ sq. meter, an exposed area of 2 sq. meters, and a total HRR of 1000 Kw. The heat release rates from the rubber mat and the solid transient combustibles are added to the heat release rate from the oil in analyzing the Hot Gas Layer and Plume C/L Temperatures.

NN/66

Pool Fire Area (sq. ft.)	Pool Fire Heat Release Rate (kW)	Pool Fire Flame Height (ft.)	Flame Impingement to Cable Tray	Pool Fire Burning Duration (min.)	Hot Gas Layer Temp. After 1 Minute (deg. F)	Hot Gas Layer Temp. After 2 Minutes (deg. F)	Hot Gas Layer Temp. After 3 Minutes (deg. F)	Hot Gas Layer Temp. After 4 Minutes (deg. F)	Plume C/L Temp (deg. F)
20	3333	14.6	yes	3.3	783	869	925	966	590
40	6667	18.8	yes	1.7	1014	1129	1203	1258	732
60	10000	21.8	yes	1.1	1220	1360	1450	1518	857

Conclusion: A hot gas layer in excess of the 700 degrees F needed to burn all IEEE 383 cables in the room could occur.

1-A-ACP

5 GAL LUBE OIL + 50 ft² of RUBBER MAT
+ 125# TRANSIENT COMBUSTIBLES

METHOD OF PREDICTING HOT GAS LAYER TEMPERATURE AND SMOKE LAYER HEIGHT IN ROOM FIRE WITH NATURAL VENTILATION COMPARTMENT WITH THERMALLY THICK BOUNDARIES $\delta > 1$ inch

VERSION 1.03

The following calculations estimate the hot gas layer temperature and smoke layer height in enclosure fire.
Parameters should be specified ONLY IN THE YELLOW INPUT PARAMETER BOXES.
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INPUT PARAMETERS

COMPARTMENT INFORMATION

Compartment Width (w_c)	23.00	ft	7.0104 m
Compartment Length (l_c)	28.00	ft	8.5344 m
Compartment Height (h_c)	23.00	ft	7.0104 m
Vent Width (w_v)	3.00	ft	0.914 m
Vent Height (h_v)	7.00	ft	2.134 m
Top of Vent from Floor (V_T)	7.00	ft	2.134 m
Interior Lining Thickness (δ)	12.00	in	0.3048 m

For thermally thick case the interior lining thickness should be greated then 1 inch.

AMBIENT CONDITIONS

Ambient Air Temperature (T_0)	77.00	°F	25.00 °C 298.00 K
Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient air Density (ρ_0)	1.20	kg/m³	

THERMAL PROPERTIES OF COMPARTMENT ENCLOSING SURFACES FOR

Interior Lining Thermal Inertia ($k\rho c$)	2.9	(kW/m²-K)²-sec
Interior Lining Thermal Conductivity (k)	0.0016	kW/m-K
Interior Lining Specific Heat (c_p)	0.75	kJ/kg-K
Interior Lining Density (ρ)	2400	kg/m³

INTERIOR LINING EXPERIMENTAL THERMAL PROPERTIES FOR COMMON MATERIALS

Material	$k\rho c$ (kW/m²-K)²-sec	k (kW/m-K)	c_p (kJ/kg-K)	ρ (kg/m³)
Aluminum (pure)	500	0.206	0.895	2710
Steel (0.5% Carbon)	197	0.054	0.465	7850
Concrete	2.9	0.0016	0.75	2400
Brick	1.7	0.0008	0.8	2600
Glass, Plate	1.6	0.00076	0.8	2710
Brick/Concrete Block	1.2	0.00073	0.84	1900
Gypsum Board	0.18	0.00017	1.1	960
Plywood	0.16	0.00012	2.5	540
Fiber Insulation Board	0.16	0.00053	1.25	240
Chipboard	0.15	0.00015	1.25	800
Aerated Concrete	0.12	0.00026	0.96	500
Plasterboard	0.12	0.00016	0.84	950
Calcium Silicate Board	0.098	0.00013	1.12	700
Alumina Silicate Block	0.036	0.00014	1	260
Glass Fiber Insulation	0.0018	3.7E-05	0.8	60
Expanded Polystyrene	0.001	3.4E-05	1.5	20

Reference: Klote J., Milke J., *Principles of Smoke Management*, 2002 (Page 270)

FIRE SPECIFICATIONS

Fire Heat Release Rate (Q) 12950.00 kW

METHOD OF McCAFFREY, QUINTIERE, AND HARKLEROAD (MQH)

Reference: SFPE Handbook of Fire Protection Engineering 2nd Edition (Page 3-139)

$$\Delta T_g = 6.85[Q^2/(A_0(h_v)^{1/2})(A_T h_k)]^{1/3}$$

Where $\Delta T_g = T_g - T_0$, *upper layer gas temperature rise above ambient* (K)
Q = heat release rate of the fire (kW)
A_0 = area of ventilation opening (m^2)
h_v = height of ventilation opening (m)
h_k = convective heat trensfer coefficient (kW/m^2-K)
A_T = total area of the compartment enclosing surface boundaries excluding area of vent openings (m^2)

Area of Ventilation Opening Calculation

$A_0 = (w_v)(h_v)$

$A_0 =$ **1.95** m^2

Thermal Penetration Time Calculation Thermally Thick Material

$t_p = (\rho c_p/k)(\delta/2)^2$

Where ρ = interior construction density (kg/m^3)
c_p = interior construction heat capacity (kJ/Kg-K)
k = interior construction thermal conductivity (kW/m-K)
δ = interior construction thickness (m)

$t_p =$ **26128.98** sec

Heat Transfer Coefficient Calculation

$h_k = (k\rho c/t)^{1/2}$ for $t < t_p$

Where $k\rho c$ = interior construction thermal inertia $(kW/m^2\text{-}K)^2$-sec
(a thermal property of material responsible for the rate of temperature rise)
t = time after ignition (sec)

Area of Compartment Enclosing Surface Boundaries

$A_T = [2(w_c x l_c) + 2(h_c x w_c) + 2(h_c x l_c)] - A_0$

$A_T =$ **335.66** m^2

Compartment Hot Gas Layer Temperature With Natural Ventilation

$\Delta T_g = 6.85[Q^2/(A_0(h_v)^{1/2})(A_T h_k)]^{1/3}$

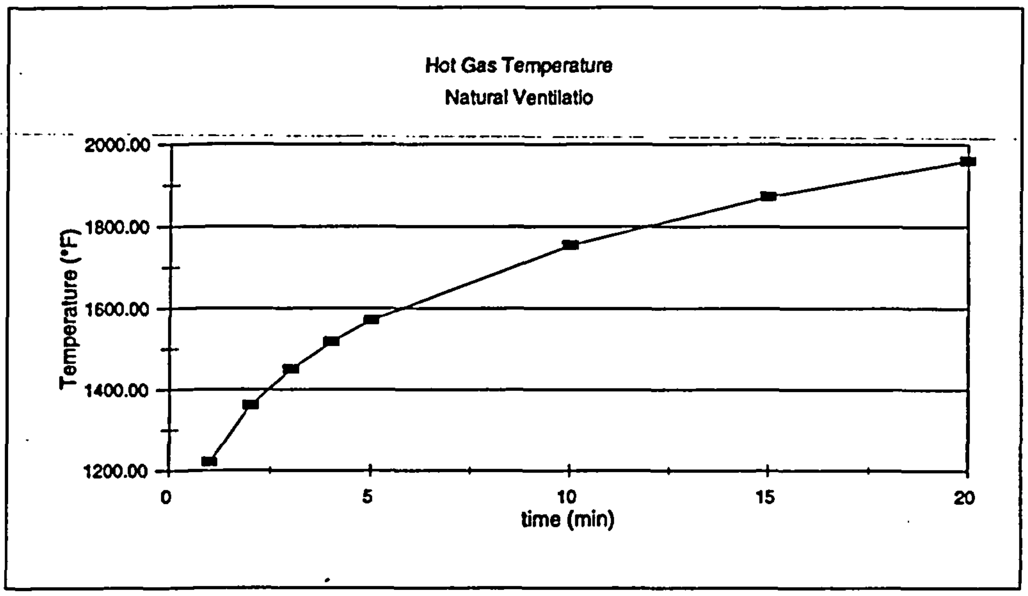
$\Delta T_g = T_g - T_0$

$T_g = \Delta T_g + T_0$

RESULTS:

Time After		h_k	ΔT_g	T_g	T_g	T_g
(min)	(s)	(kW/m^2-K)	(K)	(K)	(°C)	(°F)
1	60	0.22	635.23	933.23	660.23	1220.41
2	120	0.16	713.02	1011.02	738.02	1360.43
3	180	0.13	762.87	1060.87	787.87	1450.16
4	240	0.11	800.33	1098.33	825.33	1517.60
5	300	0.10	830.66	1128.66	855.66	1572.19

10	600	0.07	932.38	1230.38	957.38	1755.29
15	900	0.06	997.57	1295.57	1022.57	1872.63
20	1200	0.05	1046.57	1344.57	1071.57	1960.82



ESTIMATING SMOKE LAYER HEIGHT METHOD OF YAMANA AND TANAKA

$z = ((2kQ^{1/3}t/3A_c) + (1/h_c^{2/3}))^{-3/2}$

Where z = smoke layer height (m)
Q = heat release rate of the fire (kW)
t = time after ignition (sec)
h_c = compartment height (m)
A_c = compartment floor area (m^2)
k = a constant given by $k = 0.076/\rho_g$
ρ_g = hot gas layer density (kg/m^3)
ρ_g is given by $\rho_g = 353/T_g$
T_g = hot gas layer temperature (K)

Compartment Area Calculation

$A_c =$ $(w_c)(l_c)$

$A_c =$ 59.83 m^2

Hot Gas Layer Density Calculation

$\rho_g =$ $353/T_g$

Calculation for Constant K

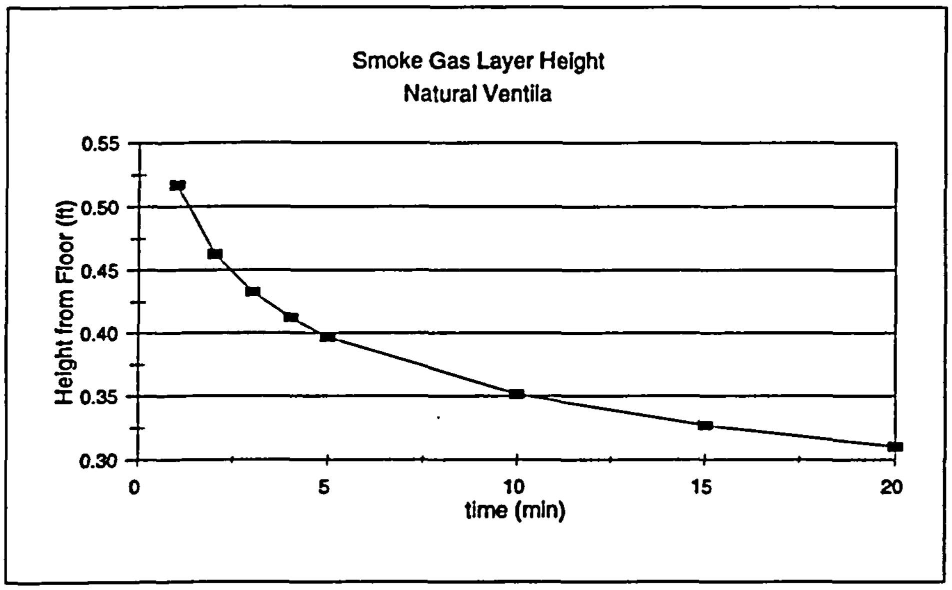
$k =$ $0.076/\rho_g$

Smoke Gas Layer Height With Natural Ventilation

$z =$ $((2kQ^{1/3}t/3A_c) + (1/h_c^{2/3}))^{-3/2}$

RESULTS:

t	ρ_g	k	z	z
(min)	kg/m^3		(m)	(ft)
1	0.38	0.201	0.16	0.52
2	0.35	0.218	0.14	0.46
3	0.33	0.228	0.13	0.43
4	0.32	0.236	0.13	0.41
5	0.31	0.243	0.12	0.40
10	0.29	0.265	0.11	0.35
15	0.27	0.279	0.10	0.33
20	0.26	0.289	0.09	0.31



NOTE

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ACP

METHOD OF PREDICTING HOT GAS LAYER TEMPERATURE AND SMOKE LAYER HEIGHT IN ROOM FIRE WITH NATURAL VENTILATION COMPARTMENT WITH THERMALLY THICK BOUNDARIES $\delta > 1$ inch

VERSION 1.03

The following calculations estimate the hot gas layer temperature and smoke layer height in enclosure fire.
Parameters should be specified ONLY IN THE YELLOW INPUT PARAMETER BOXES.
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INPUT PARAMETERS

COMPARTMENT INFORMATION

Compartment Width (w_c)	23.00	ft	7.0104 m
Compartment Length (l_c)	28.00	ft	8.5344 m
Compartment Height (h_c)	23.00	ft	7.0104 m
Vent Width (w_v)	3.00	ft	0.914 m
Vent Height (h_v)	7.00	ft	2.134 m
Top of Vent from Floor (V_T)	7.00	ft	2.134 m
Interior Lining Thickness (δ)	12.00	in	0.3048 m

For thermally thick case the interior lining thickness should be greated then 1 inch.

AMBIENT CONDITIONS

Ambient Air Temperature (T_0)	77.00	°F	25.00 °C 298.00 K
Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient air Density (ρ_0)	1.20	kg/m³	

THERMAL PROPERTIES OF COMPARTMENT ENCLOSING SURFACES FOR

Interior Lining Thermal Inertia ($k\rho c$)	2.9	$(kW/m^2\text{-}K)^2$-sec
Interior Lining Thermal Conductivity (k)	0.0016	kW/m-K
Interior Lining Specific Heat (c_p)	0.75	kJ/kg-K
Interior Lining Density (ρ)	2400	kg/m³

INTERIOR LINING EXPERIMENTAL THERMAL PROPERTIES FOR COMMON MATERIALS

Material	$k\rho c$ $(kW/m^2\text{-}K)^2$-sec	k (kW/m-K)	c_p (kJ/kg-K)	ρ (kg/m³)
Aluminum (pure)	500	0.206	0.895	2710
Steel (0.5% Carbon)	197	0.054	0.465	7850
Concrete	2.9	0.0016	0.75	2400
Brick	1.7	0.0008	0.8	2600
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Expanded Polystyrene	0.001	3.4E-05	1.5	20

Reference: Klote, J., Milke, J., *Principles of Smoke Management*, 2002, (Page 270)

FIRE SPECIFICATIONS

Fire Heat Release Rate (Q) 9617.00 kW

METHOD OF McCAFFREY, QUINTIERE, AND HARKLEROAD (MQH)

Reference: SFPE Handbook of Fire Protection Engineering 2nd Edition (Page 3-189)

$\Delta T_g = 6.85[Q^2/(A_0(h_v)^{1/2}) (A_T h_k)]^{1/3}$

Where $\Delta T_g = T_g - T_0$, upper layer gas temperature rise above ambient (K)
Q = heat release rate of the fire (kW)
A_0 = area of ventilation opening (m^2)
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Area of Ventilation Opening Calculation

$A_0 = (w_v)(h_v)$
$A_0 =$ **1.95** m^2

Thermal Penetration Time Calculation Thermally Thick Material

$t_p = (\rho c_p/k)(\delta/2)^2$
Where ρ = interior construction density (kg/m^3)
c_p = interior construction heat capacity (kJ/Kg-K)
k = interior construction thermal conductivity (kW/m-K)
δ = interior construction thickness (m)
$t_p =$ **26128.98** sec

Heat Transfer Coefficient Calculation

$h_k = (k\rho c/t)^{1/2}$ for $t < t_p$
Where $k\rho c$ = interior construction thermal inertia $(kW/m^2\text{-}K)^2$-sec
(a thermal property of material responsible for the rate of temperature rise)
t = time after ignition (sec)

Area of Compartment Enclosing Surface Boundaries

$A_T = [2(w_c x l_c) + 2(h_c x w_c) + 2(h_c x l_c)] - A_0$
$A_T =$ **335.66** m^2

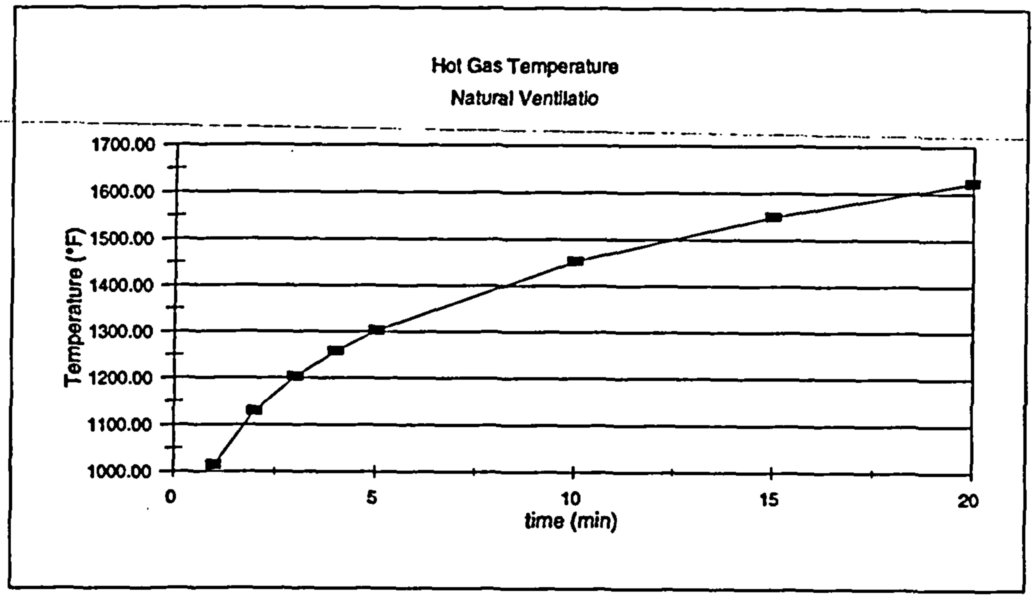
Compartment Hot Gas Layer Temperature With Natural Ventilation

$\Delta T_g = 6.85[Q^2/(A_0(h_v)^{1/2}) (A_T h_k)]^{1/3}$
$\Delta T_g = T_g - T_0$
$T_g = \Delta T_g + T_0$

RESULTS:

Time After		h_k	ΔT_g	T_g	T_g	T_g
(min)	(s)	(kW/m^2-K)	(K)	(K)	(°C)	(°F)
1	60	0.22	520.92	818.92	545.92	1014.66
2	120	0.16	584.72	882.72	609.72	1129.49
3	180	0.13	625.60	923.60	650.60	1203.08
4	240	0.11	656.32	954.32	681.32	1258.38
5	300	0.10	681.19	979.19	706.19	1303.15

10	600	0.07	764.61	1062.61	789.61	1453.30
15	900	0.06	818.07	1116.07	843.07	1549.52
20	1200	0.05	858.25	1156.25	883.25	1621.85



ESTIMATING SMOKE LAYER HEIGHT METHOD OF YAMANA AND TANAKA

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Where z = smoke layer height (m)
Q = heat release rate of the fire (kW)
t = time after ignition (sec)
h_c = compartment height (m)
A_c = compartment floor area (m^2)
k = a constant given by $k = 0.076/\rho_g$
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$A_c =$ $(w_c)(l_c)$
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Calculation for Constant K

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Smoke Gas Layer Height With Natural Ventilation

$z =$ $((2kQ^{1/3}t/3A_c) + (1/h_c^{2/3}))^{-3/2}$

RESULTS:

t	ρ_g	k	z	z
(min)	kg/m³		(m)	(ft)
1	0.43	0.176	0.22	0.71
2	0.40	0.190	0.19	0.64
3	0.38	0.199	0.18	0.60
4	0.37	0.205	0.18	0.57
5	0.36	0.211	0.17	0.55
10	0.33	0.229	0.15	0.50
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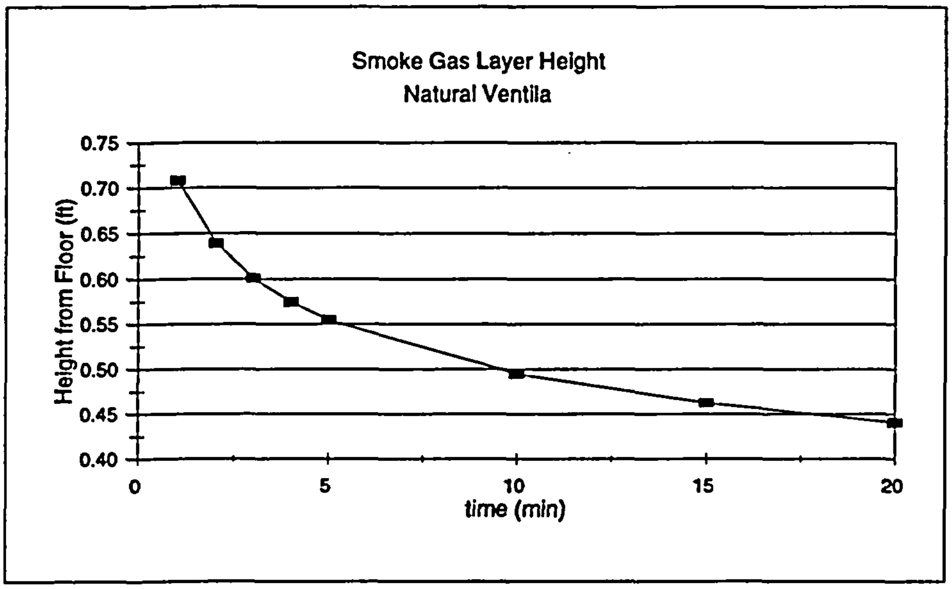

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Interior Lining Thickness (δ)	12.00	in	0.3048 m

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Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient air Density (ρ_0)	1.20	kg/m³	

THERMAL PROPERTIES OF COMPARTMENT ENCLOSING SURFACES FOR

Interior Lining Thermal Inertia ($k\rho c$)	2.9	$(kW/m^2\text{-}K)^2$-sec
Interior Lining Thermal Conductivity (k)	0.0016	kW/m-K
Interior Lining Specific Heat (c_p)	0.75	kJ/kg-K
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Expanded Polystyrene	0.001	3.4E-05	1.5	20

Reference: Klote J. Milke J. Principles of Smoke Management 2002 (Page 270)

FIRE SPECIFICATIONS

Fire Heat Release Rate (Q) 6283.00 kW

METHOD OF McCAFFREY, QUINTIERE, AND HARKLEROAD (MQH)

Reference: SFPE Handbook of Fire Protection Engineering 2nd Edition (Page 3-139)

$\Delta T_g = 6.85[Q^2/(A_0(h_v)^{1/2})(A_T h_k)]^{1/3}$

Where $\Delta T_g = T_g - T_0$, upper layer gas temperature rise above ambient (K)
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h_k = convective heat trensfer coefficient (kW/m^2-K)
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Area of Ventilation Opening Calculation

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$A_0 =$ **1.95** m^2

Thermal Penetration Time Calculation Thermally Thick Material

$t_p = (\rho c_p/k)(\delta/2)^2$

Where ρ = interior construction density (kg/m^3)
c_p = interior construction heat capacity (kJ/Kg-K)
k = interior construction thermal conductivity (kW/m-K)
δ = interior construction thickness (m)

$t_p =$ **26128.98** sec

Heat Transfer Coefficient Calculation

$h_k = (k\rho c/t)^{1/2}$ for $t < t_p$

Where $k\rho c$ = interior construction thermal inertia $(kW/m^2\text{-}K)^2$-sec
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$A_T = [2(w_c x l_c) + 2(h_c x w_c) + 2(h_c x l_c)] - A_0$
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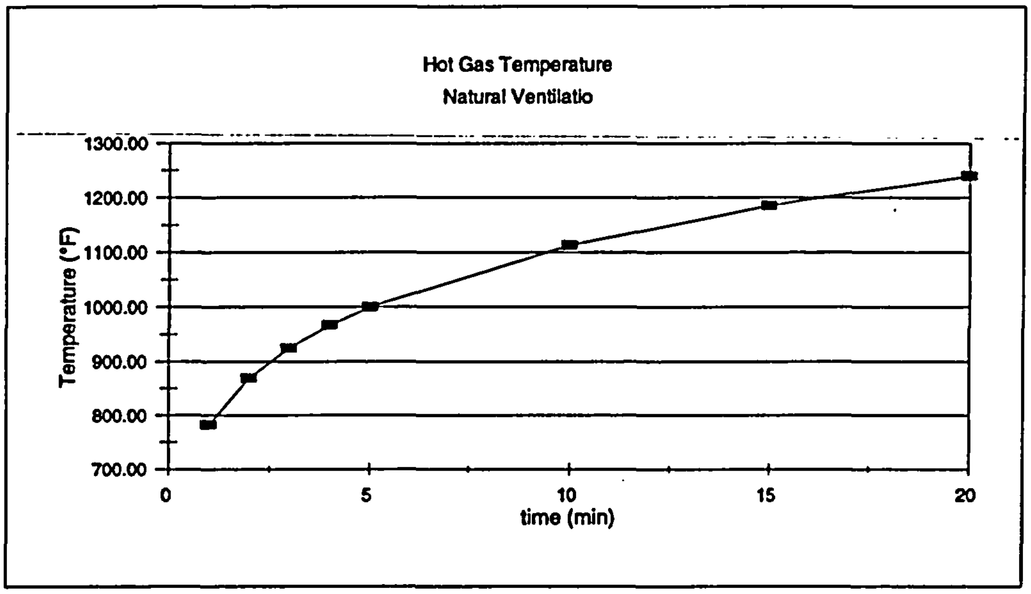
$\Delta T_g = T_g - T_0$
$T_g = \Delta T_g + T_0$

RESULTS:

Time After		h_k	ΔT_g	T_g	T_g	T_g
(min)	(s)	(kW/m^2-K)	(K)	(K)	(°C)	(°F)
1	60	0.22	392.22	690.22	417.22	782.99
2	120	0.16	440.25	738.25	465.25	869.45
3	180	0.13	471.03	769.03	496.03	924.85
4	240	0.11	494.16	792.16	519.16	966.49
5	300	0.10	512.89	810.89	537.89	1000.20

10	600	0.07	575.70	873.70	600.70	1113.25
15	900	0.06	615.94	913.94	640.94	1185.70
20	1200	0.05	646.20	944.20	671.20	1240.15



ESTIMATING SMOKE LAYER HEIGHT
METHOD OF YAMANA AND TANAKA

$z = ((2kQ^{1/3}t/3A_c) + (1/h_c^{2/3}))^{-3/2}$

Where z = smoke layer height (m)
Q = heat release rate of the fire (kW)
t = time after ignition (sec)
h_c = compartment height (m)
A_c = compartment floor area (m^2)
k = a constant given by $k = 0.076/\rho_g$
ρ_g = hot gas layer density (kg/m^3)
ρ_g is given by $\rho_g = 353/T_g$
T_g = hot gas layer temperature (K)

Compartment Area Calculation

$A_c = (w_c)(l_c)$

$A_c =$ 59.83 m^2

Hot Gas Layer Density Calculation

$\rho_g = 353/T_g$

Calculation for Constant K

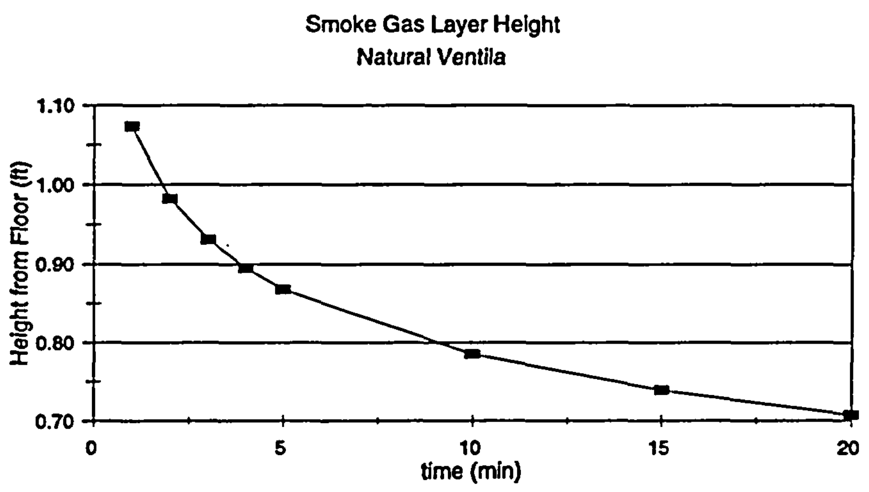
$k = 0.076/\rho_g$

Smoke Gas Layer Height With Natural Ventilation

$z = ((2kQ^{1/3}t/3A_c) + (1/h_c^{2/3}))^{-3/2}$

RESULTS:

t	ρ_g	k	z	z
(min)	kg/m³		(m)	(ft)
1	0.51	0.149	0.33	1.07
2	0.48	0.159	0.30	0.98
3	0.46	0.166	0.28	0.93
4	0.45	0.171	0.27	0.90
5	0.44	0.175	0.26	0.87
10	0.40	0.188	0.24	0.79
15	0.39	0.197	0.23	0.74
20	0.37	0.203	0.22	0.71



NOTE

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METHOD OF ESTIMATING TEMPERATURE OF A BUOYANT FIRE PLUME VERSION 1.0

The following calculations estimate the centerline plume temperature in a compartment fire
Parameters should be specified ONLY IN THE YELLOW INPUT PARAMETER BOXES.
All subsequent values are calculated by the spreadsheet, and based on values specified in the input parameters.

INPUT PARAMETERS

Heat Rlease Rate of the Fire (Q)	12950.00	kW	
Distance from the Top of the Fuel to the Ceiling (z)	23.00	ft	7.01
Area of Combustible Fuel (A_c)	60.00	ft²	5.57

AMBIENT CONDITIONS

Ambient Air Temperature (T_0)	77.00	°F	25.00 298.00
Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient Air Density (ρ_0)	1.20	kg/m³	
Acceleration of Gravity (g)	9.81	m/sec²	
Convective Heat Release Fraction (χ_c)	0.50		

ESTIMATING PLUME CENTERLINE TEMPERATURE

Reference: SFPE Handbook of Fire Protection Engineering 2nd Edition (Page 2-9)

$$T_{p(centerline)} - T_0 = 9.1\ (T_0/g\ c_p^2\ \rho_0^2)^{1/3}\ Q_c^{2/3}\ (z - z_0)^{-5/3}$$

Where
Q_c = Convective portion of the heat release rate (kW)
T_0 = ambient air temperature (K)
g = acceleration of gravity (m/sec²)
c_p = specific heat of air (kJ/kg-K)
ρ_0 = ambient air density (kg/m³)
z = distance from the top of the fuel package to the ceiling (m)
z_0 = hypothetical virtual origin of the fire (m)

Convective Heat Release Rate Calculation

$$Q_c = \chi_c\, Q$$

Where
Q = heat release rate of the fire (kW)
χ_c = convective heat release fraction
Q_c = **6475 kW**

Pool Fire Diameter Calculation

$A_{dike} = \pi D^2/4$
$D = (4\ A_{dike}/\pi)^{1/2}$
D = **2.66** m

Hypothetical Virtual Origin Calculation

$z_0/D = -1.02 + 0.083\ (Q^{2/5})/D$

Where
z_0 = virtual origin of the fire (m)
Q = heat release rate of fire (kW)
D = diameter of pool fire (m)

z_0/D = 0.36
z_0 = **0.95** m

Centerline Plume Temperature Calculation

$T_{p(centerline)} - T_0 = 9.1\ (T_0/g\ c_p^2\ \rho_0^2)^{1/3}\ Q_c^{2/3}\ (z - z_0)^{-5/3}$

$T_{p(centerline)} - T_0 =$	**433.24**
$T_{p(centerline)} =$	**731.24** K

$T_{p(centerline)} =$ **458.24 °C** **856.82 °F** **ANSWER**

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METHOD OF ESTIMATING TEMPERATURE OF A BUOYANT FIRE PLUME VERSION 1.0

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INPUT PARAMETERS

Heat Rlease Rate of the Fire (Q)	9617.00	kW	
Distance from the Top of the Fuel to the Ceiling (z)	23.00	ft	7.01
Area of Combustible Fuel (A_c)	40.00	ft^2	3.72

AMBIENT CONDITIONS

Ambient Air Temperature (T_0)	77.00	°F	25.00
			298.00
Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient Air Density (ρ_0)	1.20	kg/m^3	
Acceleration of Gravity (g)	9.81	m/sec^2	
Convective Heat Release Fraction (χ_c)	0.50		

ESTIMATING PLUME CENTERLINE TEMPERATURE

Reference: SFPE Handbook of Fire Protection Engineering 2[nd] Edition (Page 2-9)

$T_{p(centerline)} - T_0 = 9.1\,(T_0/g\,c_p^2\,\rho_0^2)^{1/3}\,Q_c^{2/3}\,(z - z_0)^{-5/3}$

Where
- Q_c = Convective portion of the heat release rate (kW)
- T_0 = ambient air temperature (K)
- g = acceleration of gravity (m/sec^2)
- c_p = specific heat of air (kJ/kg-K)
- ρ_0 = ambient air density (kg/m^3)
- z = distance from the top of the fuel package to the ceiling (m)
- z_0 = hypothetical virtual origin of the fire (m)

Convective Heat Release Rate Calculation

$Q_c = \chi_c\,Q$

Where
- Q = heat release rate of the fire (kW)
- χ_c = convective heat release fraction
- Q_c = **4808.5 kW**

Pool Fire Diameter Calculation

$A_{dike} = \pi D^2/4$

$D = (4\,A_{dike}/\pi)^{1/2}$

D = **2.18** m

Hypothetical Virtual Origin Calculation

$z_0/D = -1.02 + 0.083\,(Q^{2/5})/D$

Where
- z_0 = virtual origin of the fire (m)
- Q = heat release rate of fire (kW)
- D = diameter of pool fire (m)

z_0/D = 0.48

z_0 = **1.03** m

Centerline Plume Temperature Calculation

$T_{p(centerline)} - T_0 = 9.1\ (T_0/g\ c_p^2\ \rho_0^2)^{1/3}\ Q_c^{2/3}\ (z - z_0)^{-5/3}$

$T_{p(centerline)} - T_0 =$	**363.99**
$T_{p(centerline)} =$	**661.99** K

$T_{p(centerline)}$ = 388.99 °C 732.18 °F ANSWER

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METHOD OF ESTIMATING TEMPERATURE OF A BUOYANT FIRE PLUME VERSION 1.0

The following calculations estimate the centerline plume temperature in a compartment fire.
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INPUT PARAMETERS

Heat Rlease Rate of the Fire (Q)	6283.00	kW	
Distance from the Top of the Fuel to the Ceiling (z)	23.00	ft	7.01
Area of Combustible Fuel (A_c)	20.00	ft^2	1.86

AMBIENT CONDITIONS

Ambient Air Temperature (T_0)	77.00	°F	25.00 / 298.00
Specific Heat of Air (c_p)	1.00	kJ/kg-K	
Ambient Air Density (ρ_0)	1.20	kg/m^3	
Acceleration of Gravity (g)	9.81	m/sec^2	
Convective Heat Release Fraction (χ_c)	0.50		

ESTIMATING PLUME CENTERLINE TEMPERATURE

Reference: SFPE Handbook of Fire Protection Engineering 2nd Edition (Page 2-9)

$T_{p(centerline)} - T_0 = 9.1\,(T_0/g\,c_p^2\,\rho_0^2)^{1/3}\,Q_c^{2/3}\,(z - z_0)^{-5/3}$

Where
Q_c = Convective portion of the heat release rate (kW)
T_0 = ambient air temperature (K)
g = acceleration of gravity (m/sec^2)
c_p = specific heat of air (kJ/kg-K)
ρ_0 = ambient air density (kg/m^3)
z = distance from the top of the fuel package to the ceiling (m)
z_0 = hypothetical virtual origin of the fire (m)

Convective Heat Release Rate Calculation

$Q_c = \chi_c\,Q$

Where
Q = heat release rate of the fire (kW)
χ_c = convective heat release fraction
Q_c = **3141.5** kW

Pool Fire Diameter Calculation

$A_{dike} = \pi D^2/4$
$D = (4\,A_{dike}/\pi)^{1/2}$
D = **1.54** m

Hypothetical Virtual Origin Calculation

$z_0/D = -1.02 + 0.083\,(Q^{2/5})/D$

Where
z_0 = virtual origin of the fire (m)
Q = heat release rate of fire (kW)
D = diameter of pool fire (m)

z_0/D = 0.76
z_0 = **1.17** m

Centerline Plume Temperature Calculation

$T_{p(centerline)} - T_0 = 9.1 \, (T_0/g \, c_p^2 \, \rho_0^2)^{1/3} \, Q_c^{2/3} \, (z - z_0)^{-5/3}$

$T_{p(centerline)} - T_0 =$	**285.14**
$T_{p(centerline)} =$	**583.14** K

$T_{p(centerline)}$ = 310.14 °C   590.26 °F   ANSWER

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