ATTACHMENT (1)

PHILADELPHIA ELECTRIC COMPANY

LIMERICK GENERATING STATION

UNIT 1

STRUCTURAL STEEL SURVIVABILITY EVALUATION

February 24, 1984

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PLC Professional Loss Control, Inc.

EEC PROLC

SECTION 1

METHODOLOGY FOR EVALUATION OF

FIRE RESISTANCE OF

STRUCTURAL STEEL

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I. INTRODUCTION

Structural steel members which form a part of or support fire barriers should be capable of withstanding the fire exposure presented by all combustibles contained within the fire area. Structural steel need not be protected if it can withstand this fire exposure. The methodology is intended as a screening tool for evaluating the severity of fire exposure to structural steel members.

This is a two part evaluation: first, the fire exposure is determined and second, the response of the structural steel member is assessed. The approach as described treats the evaluation in a systematic way by assessing simple and conservatively realistic limitations on the combustion process, the resultant room environment and finally, temperature histories of the structural steel members when required.

The conclusions reached will then be used to determine acceptability of the structural steel as a unique part of the fire barrier and to evaluate any needed modifications if deemed necessary.

II. ASSESSING FIRE DEVELOPMENT

The types of fixed combustible materials found in a nuclear power plant which can burn in such a way as to present a significant fire exposure to the general area in which they are located are very few. The prevalent materials encountered in the plant areas analyzed were cable insulation and lubricating oil. The insulation and jacketing on the cabling in cable trays are susceptible to ignition from internal or external sources. The heat output from a cable tray fire will affect the atmosphere of the room in which it is located. Lubricating oil, present in large pumps and certain other types of plant equipment, can escape and burn. Other types of combustibles contained within substantial metal enclosures (e.g. cabling in conduit and charcoal in filter units) have been assumed not to contribute to fires.

The methodology for assessing fire development can be divided into three different parts: limits on fire development, fire modeling techniques, and local heating effects. Each part will be examined in turn.

III. LIMITS ON FIRE DEVELOPMENT

In this section, practical limitations which govern the combustion process in a room are discussed. This will include physical limitations on the combustion of any fuel and fire test data regarding the burning characteristics of cable trays and combustible liquids such as lube oil.

A. Ventilation Limited Fires

One of the best understood and most extensively tested modes of combustion is that of ventilation controlled fires. In this type of fire the rate of burning is limited by the fire-induced air flow into the room. A balance is set up at each opening into the enclosure where heated gases flow out the top of the opening and clean air feeds in through the bottom. The boundary layer between the inflowing and outflowing gases is referred to as the neutral plane.

Many relationships, both empirical and analytical, have been developed to predict velocity profiles and mass flow rates at openings during ventilation controlled fires as well as resultant heat release rates and peak fire temperatures. This analysis employs a relationship developed by Coulbert(1) which predicts the heat release rate that can be supported by the fire induced air flow. The relation is:

$$Q = 1580\ A\sqrt{H}$$

where Q = heat output (kW)

A = area of opening (m^2)

H = height of opening (m)

The term $A\sqrt{H}$ is often called the ventilation factor. Any empirical relationship for the heat release rate or mass burning rate will be proportional to the ventilation factor. If there is more than one ventilation opening, then the ventilation factor is taken as the sum of the individual ventilation factors.

The rate of burning is independent of the type of combustibles which are burning. The fire duration, until room burnout, is the total heat value (heat of combustion times quantity) of all the combustibles in the room divided by the heat release rate of the fire.

For the purpose of this analysis, the ventilation rates were based on the available air flow through openings into the room such as doorways. Fixed ventilation systems were assumed not to contribute to the ventilation rate, since installed fire dampers will actuate.

B. Fuel Controlled Fires

When excess air is available for combustion, the heat output of the fire will be dependent on the free burning characteristics of the exposed combustibles. The fixed combustibles that can pose a threat of damage to the structural steel in the areas where they are located consist of grouped electrical cables (cable trays) and combustible liquids such as lubricating oils.

1. Cable Tray Burning Characteristics

The best available data on free burning cable trays containing hypalon and neoprene jacketed cables appear in the FMRC/EPRI (2) test reports. For these cables, a mass burning rate of 6.7 Kg/min was measured for an array of 12 cable trays, each 8' long and 18" wide. This reduces to a surface controlled burning rate of 0.1 (lb/min)/ft^2 of cable tray or a heat release rate of 1000 (BTU/min)/ft^2 (190 KW/m^2).

Another parameter vital to cable tray fire assessment is flame spread rate. Full scale tests conducted by FMRC/EPRI demonstrate a lateral spread rate of six to seven feet per hour in horizontal tray stacks. This figure agrees with observations of fire spread rates in similar tray arrays in the Reactor Building at the Browns Ferry fire. For this analysis a more conservative figure of 10 ft/hr has been assumed.

An important parameter that is developed for plant areas where cable fires are to be analyzed is the average combustible loading in the cable trays. This figure is expressed as pounds of insulation and jacketing per square foot of cable tray surface area. It should not be confused with the combustible loading per square foot of floor area which is not used in this analysis. The combustible loading figure for the trays can be divided by the mass burning rate of 0.1 (lbs/min)/ft^2 to determine the time it takes for a tray to burn to completion.

These parameters were applied to determine the worst case fire involving cable trays that can occur in an area. The fire is assumed to originate at the point in the room intersected by the maximum number of cable trays. The fire is assumed to spread out along horizontal trays at a rate of 10 feet per hour and instantaneously up any vertical trays encountered. The area of cable tray which has become involved when the original point of the fire burns itself out defines the steady state fire size. This quantity is multiplied by 1000 (Btu/min.)/ft^2 (190 kw/m^2) to determine the maximum heat release rate possible from a spreading cable fire in the area.

The duration of the spreading cable fire is taken to be the time required to consume all of the cabling in the area or 3 hours, whichever comes first. The maximum heat release rate is assumed to be the heat output of the fire through its entire duration. This is a very conservative assumption since the quantity of cabling involved will be less as the fire spreads out of the area of origin. The assumptions governing spreading cable fire scenarios hold as long as the room gas temperature remains below the ignition temperature of the cabling. The ignition temperature of the type of cabling installed at Limerick is approximately 1100°F. If the area temperature exceeds 1100°F, it must be assumed that all cables are burning simultaneously unless the fire becomes ventilation controlled.

2. Lubricating Oil Burning Characteristics

Free burning fires involving combustible liquids have been evaluated as pool fires. Although it is possible to have a spray fire if the oil escapes through a small orifice under pressure, it would be necessary to have a high spill rate to produce a significant heat output. In this case the mass of the oil will fall to floor level and form a pool.

Pool fires of varying sizes have been studied extensively for many years. Hydrocarbon liquids have been found to burn such that the depth of a pool will be reduced at a rate of approximately 5 mm/min(3). An equilibrium pool size can be calculated where the spill rate into the pool equals the mass burning rate of the fire. The consequent heat output can be determined by multiplying the mass burning rate times the heat of combustion of the liquid.

The normal quantity of combustible liquids in an area is that amount contained within equipment. To accomodate the possibility that a fire could occur where the lubricants are being changed, all lubricating oil quantities have been doubled in the calculations. Under free burning conditions a variety of oil leakage rates and consequent fire durations and heat outputs are possible.

IV. FIRE MODELING TECHNIQUES

The methodology for analyzing the fire resistance of structural steel in a given plant area requires that assessments be made of fire duration and heat output for the fire scenarios to be evaluated using the considerations discussed previously. This information is used along with data on the materials and geometry for the compartment under consideration as input for a simple and conservatively realistic fire model which predicts a gas temperature for the area.

This model should not be confused with sophisticated models which attempt to predict temperature profiles and/or gas concentrations throughout the room from ignition of the fire through its decay period. Since the heat output of the fire has been assumed constant throughout its duration and the only parameter of interest is room area temperature, the modeling has been greatly simplified.

Heat Balance Method

Writing a heat balance for the compartment is one of the most straightforward methods of determining the area temperature of a fire, especially when the heat output of the fire is assumed constant. A simplification of the method proposed by Babrauskas and Williamson (4) as modified by Berry (5) is used. Two conservative assumptions are made which allow this simplification:

1. Radiative and convective heat losses through openings in the enclosure are negligible (see Berry 5).
2. Heat loss through the walls will be dominated by the thermal inertia of the barriers, $\rho C_p K$ (assumption of semi-infinite slab approximation).

The massive reinforced concrete and concrete block construction prevalent throughout nuclear power plants plays a very important role in determining the time-temperature history of compartment fires. The thermal penetration time of a wall or ceiling/floor slab is defined as the period of time required for a temperature rise on one side to be transferred through to the back side. The thermal penetration time is a material property and can be determined if the thermal diffusivity of the wall material and its thickness are known.

The thermal penetration time for 12-inch thick concrete walls will exceed 7 hours and for 8 inch thick concrete block walls will be approximately 4 hours. Both of these times exceed the maximum 3-hour duration for the fire scenarios analyzed in this study. These results have an important implication. For all of the fire scenarios analyzed, the barriers will be absorbing heat without transferring it out the back face. This permits the use of the semi-infinite slab approximation for heat transfer through the walls.

The heat balance equation can be described as follows:

Q = heat release rate (kw) of fire ($Q = 1580\, A_o \sqrt{H}$ for ventilation controlled fires)

$Q = \sigma A_{t\eta} \quad (T_g^4 - T_w^4)$ = radiant heat transferred to boundary

$$Q = \frac{(\pi \rho C_p\, k)^{\frac{1}{2}} A_t\, (T_w - T_o)}{2\sqrt{t}}$$ = conductive heat loss through boundary

To get T_g as a function of t these equations can be solved to yield the following expression:

$$T_g = \left\{ \frac{Q}{\sigma A_{t\eta}} + \left(T_o + \frac{Q\sqrt{t}}{A_t K} \right)^4 \right\}^{\frac{1}{4}}$$

where Q = heat release rate (kW) of fire

$K = 1/2\ (\pi k \rho\, C_p)^{\frac{1}{2}}$

η = function of emissivity of fire gases and boundary walls

A_t = total heat loss surface area of boundary

This relationship is similar in form to that developed by Harmathy (6) except the heat release rate is defined by either the ventilation factors or the fuel surface controlled fire. This is not an iterative process. The formula can be used to determine the gas temperature at any time during the course of the fire.

A conservative assumption that has been made in the application of the model is that no heat will be lost through the floor.

V. LOCAL HEATING EFFECTS

The fire models just discussed are used to determine generalized conditions in the enclosure where the fire is occurring. However, plumes of heated gases will rise above burning objects and create localized hot zones that can effect the steel members located above. In these analyses, the results of heating of structural members due to engulfment in fire plumes has been referred to as localized heating effects.

The problems of localized heating can best be quantified by applying fire plume models to predict gas temperature profiles. This same approach can be applied to the evaluation of the impact of transient combustibles on structural steel and on cable ignition.

A. Plume Modeling:

Alpert and Ward (8) present empirical relationships for temperature increase, ΔT, with respect to height above fuel package, H, and size of fire, Q. This general relationship is as follows:

$$\Delta T = 300\ (kQ)^{.667}\ H^{-1.67}$$

Using this relationship, "safe" separation distances from fuel packages can be evaluated for localized heating of steel. If these relations predict a plume temperature at the level of the bottom flange of the steel higher than the critical temperature of the steel, the heating of the steel is assessed.

1. Cable Tray Fires

Cable tray fire test data was examined to establish temperature profiles above burning cable trays. Tests performed by Sandia Laboratories (7) and FMRC/EPRI (2) show that temperatures in the vicinity of 1500°F are reached in the flame region immediately above the surface of a burning cable tray. This temperature drops rapidly with increasing distance above the surface of the cable tray.

The plume of a cable fire is dependent on the number of trays in a stack and the separation between trays. To evaluate the effects of cable trays on localized heating of steel, the heat release rate from a stack of trays must be estimated and used to calculate plume temperature profiles. During FMRC/EPRI (2) large scale tests on hypalon cable, the temperature measured by thermocouples 6'5" above the top tray of the 12 tray array (2 stacks of 6) was 840°F. Using this data and applying the plume relationship described above, a temperature profile can be estimated as follows:

T = 1100°F	H = 5.41 ft
1300°F	4.87 ft
1500°F	4.45 ft

Applying the plume relationships to other cable arrays is necessary to estimate the plume effects of other stacks of trays on overhead structured steel. This was done by using the ratio of heat release rates which are directly proportioned to the width and number of trays in a stack. Estimated separation distance from stacks of 24" wide cable trays to reach plume temperatures of 1300°F and 1100°F are shown below:

No. of Trays	Distance above top tray for T_g	
	T_g= 1300°F	T_g = 1100°F
1	2.0 ft	2.21 ft.
2	2.7 ft	2.98 ft.
3	3.1 ft	3.40 ft.
4	3.5 ft	3.86 ft.
5	3.8 ft	4.20 ft.
6	4.1 ft	4.50 ft.

For evaluation of local effects of cable fire plume the data were rounded off and applied as separation requirements:

No. of Trays	Distance from top tray to bottom of beam
1	2 ft
2	3 ft
3-5	4 ft
>5	5 ft

These criteria were used to identify areas where stacks of cable trays were located less than these "safe" separation distances from structural steel. These areas were then evaluated regarding the cable loading, size of steel member, and number of trays to determine the potential effects on the structured steel.

Cable trays located within one foot of the bottom of steel beams were assumed to subject the beam to a constant temperature of 1500°F for the period of time it takes the tray to burn to completion (cable tray combustible loading divided by mass burning rate for tray fires). Trays closer than the separation distances previously identified but greater than 1 foot were assumed to subject the beam to a constant temperature of 1300°F for the period of time it takes for the tray to burn to completion.

2. <u>Pool Fires</u>

Realistic relations for determining temperature distributions for fire plumes have been developed by Heskested of FMRC (9). These relationships are based on large scale fire tests involving a variety of liquid fuels.

Fire plumes are considered to have a virtual origin (point source) from which the plume can be considered to emanate. A virtual origin has no physical meaning for fires involving most types of solid and liquid fuels. For liquid pool fires the virtual origin height, H_0, (relative to floor level) can be theoretically predicted using the following relation:

$$H_0 = -1.02D + 0.083\ Q^{.4}$$

Where D = pool diameter (m)

Heskested gives a relation which can be used to determine the temperature rise in the plume (above ambient) at any height in the plume. This equation is used to determine the temperature to which the structural steel located above the pool will be subjected.

$$\Delta T_o = 9.1 \, [T_\infty/(gc_p^2 \, \rho_\infty^2)]^{.333} \, Q_c^{.667} \, (H-H_o)^{-1.67}$$

Where ΔT_o = temperature rise in plume (°K)

T_∞ = ambient temperature (°K)

g = acceleration of gravity (m/s^2)

C_p = specific heat of air ($Kj/K_g°K$)

ρ_∞ = ambient density of air (Kg/m^3)

Q_c = convective heat flux in plume, $Q_c = .65Q$, (KW)

H = height above pool surface

VI. TRANSIENT COMBUSTIBLES

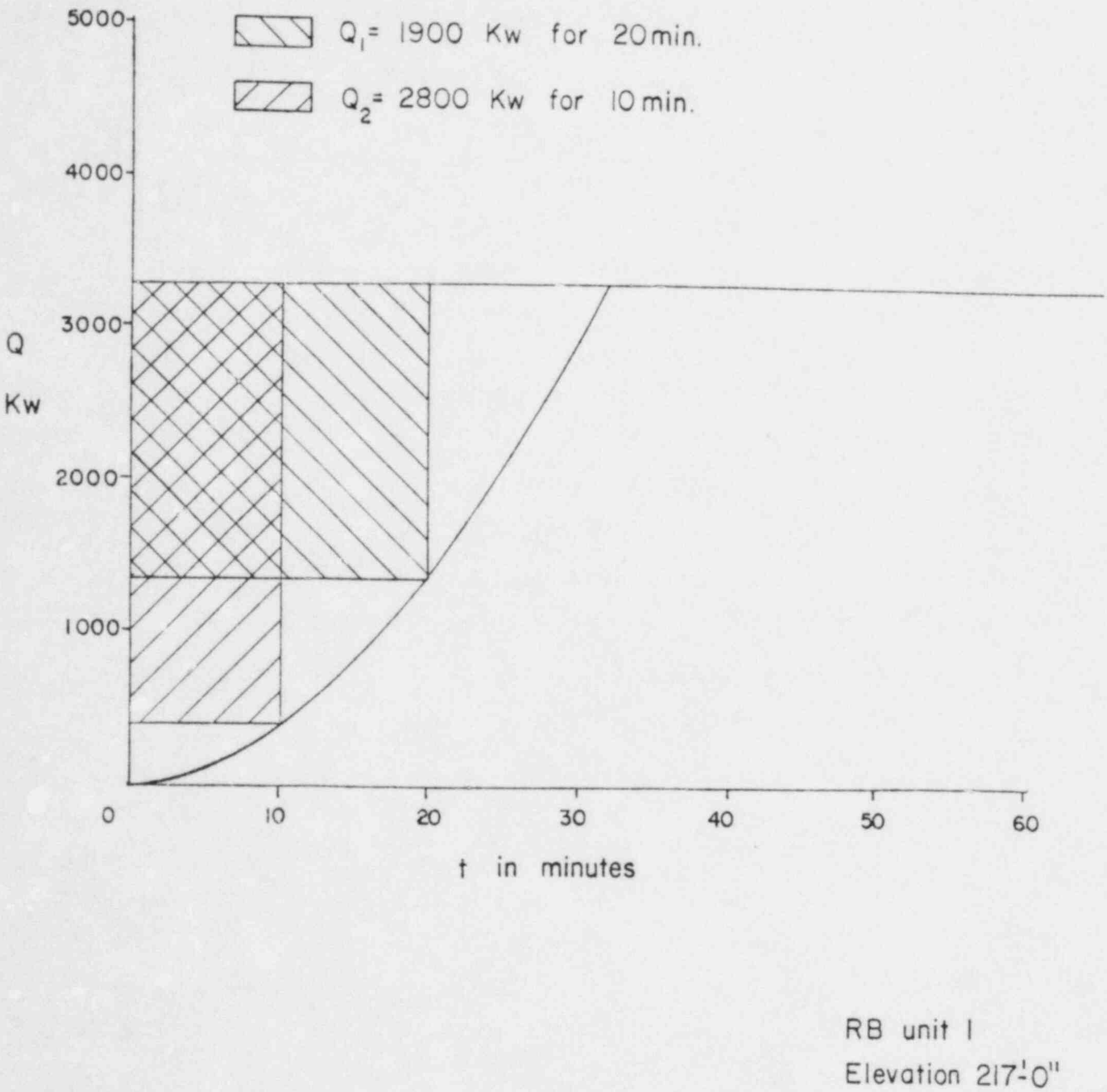
The effect of transient combustibles on the fire exposure to structural steel was also evaluated. This evaluation included both the effects on area calculations using the heat balance method and on localized heating from plumes. Since it is difficult and subjective to quantify the type and amount of transient combustibles which could be in an area, the approach taken was to quantify the size of fire which would cause the acceptance criteria outlined in Section VII to be exceeded.

A. Area Effects

The evaluation of transient combustibles using the heat balance method falls into three (3) categories. The first is fires controlled by ventilation openings (see Section III). For this case, transients could affect the duration of the fire but would not effect the heat release rate. The heat value in Btu's of the total quantity of transients can be calculated by determining the extended duration necessary to exceed the acceptance criteria and multiplying this extended duration by the ventilation limited heat release rate.

The second category is those transients accounted for in the early stages of a cable fire by assuming a constant heat release rate at the maximum value. This quantity can be estimated assuming a geometric growth of the fire. An example is shown graphically in Figure 1.

The third category is the additive effects of transient combustibles on in-situ combustibles. These effects were analyzed by applying the heat balance method for different unitized heat release rates (heat release rate from fire divided by the heat loss area, Q/A_t) to calculate the duration of fires required to exceed the area temperature acceptance criteria of 1100°F. These results are plotted in Figure 2. This figure is used to determine the maximum fires that did not exceed the acceptance criteria. As can be seen, this does not provide a unique solution since fire size and duration provides an infinite number of combinations. For analysis purposes, only the maximum size fire for the duration calculated in the area calculation was listed.



Q_1 = 1900 Kw for 20 min.
Q_2 = 2800 Kw for 10 min.
5000
4000
3000
2000
1000
Q
Kw
0
10
20
30
40
50
60
t in minutes
RB unit I
Elevation 217'-0"

Figure 1

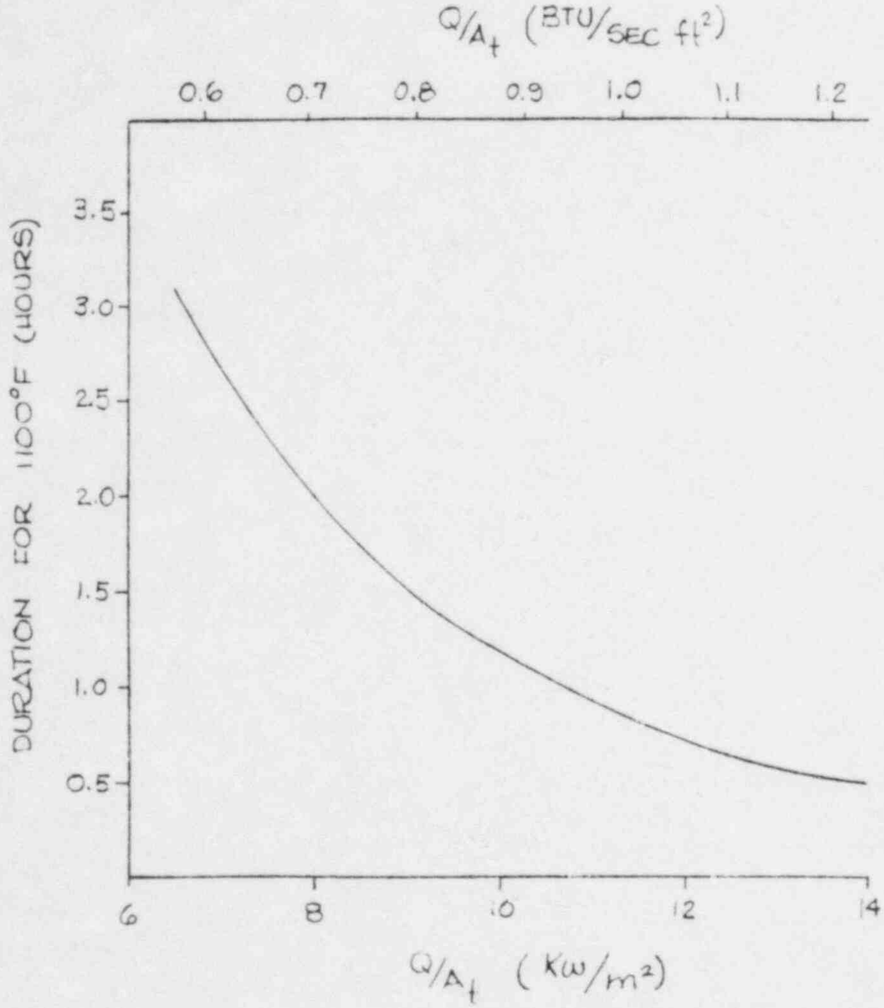

Q/A_t (BTU/SEC ft²)
0.6
0.7
0.8
0.9
1.0
1.1
1.2
DURATION FOR 1100°F (HOURS)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
6
8
10
12
14
Q/A_t (KW/m²)

FIGURE 2

B. Localized Effects

The hazards of transient combustibles may be either that of an ignition source for insitu combustibles (i.e. cables) or as a direct exposure to structural steel. To evaluate the potential effects of transient combustibles, the plume correlation relationships previously outlined were used to develop plots of height above fuel packages vs. fire size for three different temperatures; 1) 1100°F 2) 1300°F and 3) 1500°F.

Figure 3 shows the relationship of fire size to height above fuel array for these temperature criteria.

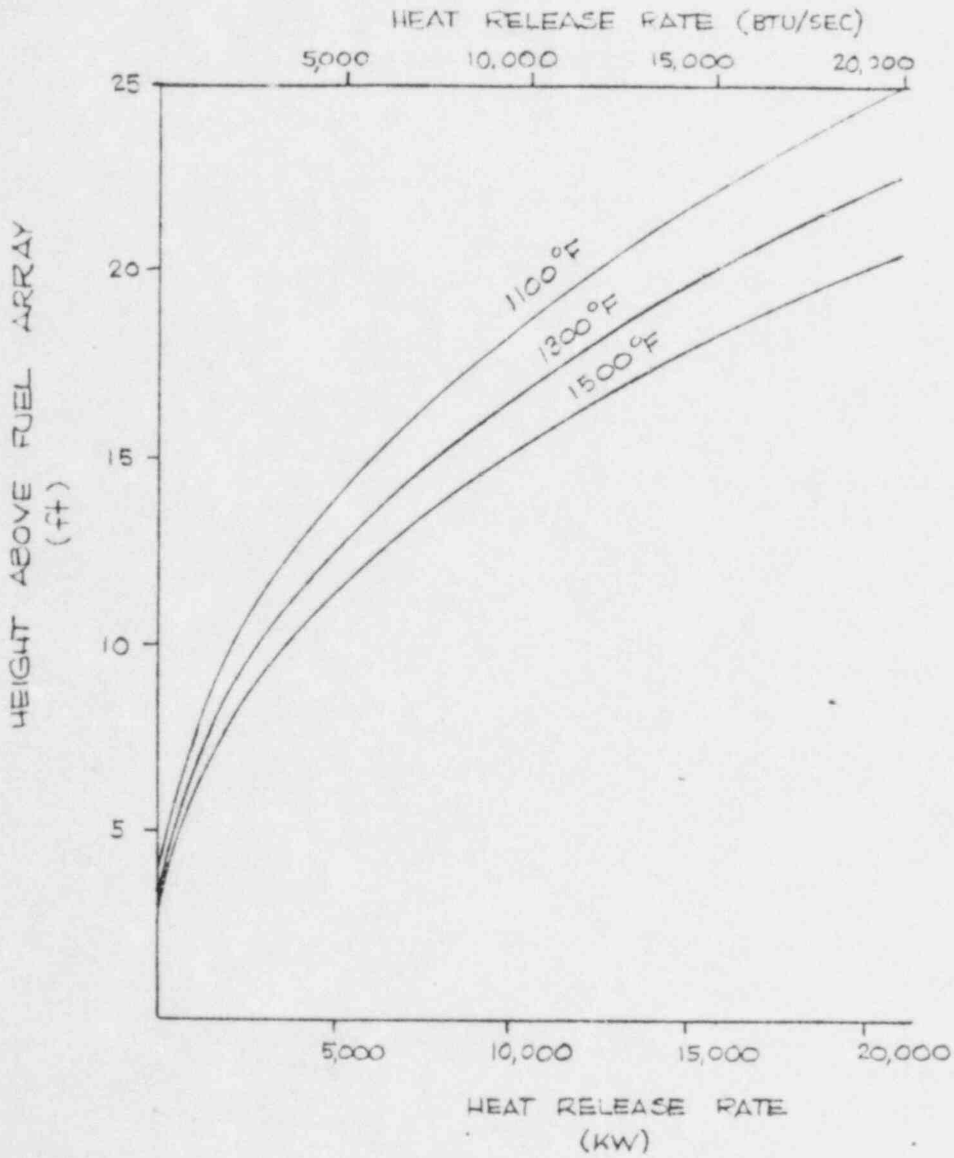


FIGURE 3

Fire Plume Effects

The approach taken in this analysis was to quantify the size fire in Btu/sec necessary to reach plume temperatures at the bottom flange of the steel of 1100°F, 1300°F, and 1500°F using Figure 3. For plume temperatures of 1300°F and 1500°F, the time required to heat the steel exposed to the plume to 1100°F is calculated. The heat release rate and duration yield the total BTUs which can be related to the total amount of transient combustible material.

It is important to remember that the heat release rate is the driving force and not the total heat of combustion of the materials. Alpert and Ward (8) provide some data on heat release rates for various materials such as wooden pallets, flammable liquids and storage related commodities. Limited data exists on "trash" or health physics supplies. To develop some guidance for these commodities, Sandia Laboratories tests for ignition source fire characterization (12) were evaluated. The temperature profiles recorded during these tests were used to estimate maximum heat release rates for Tests 3, 4, 5 and 10. These results are contained in Table 1.

Table 1

Characterization of Transient Combustible Fires

Test #	Test Description	Estimated Peak Heat Release Rate
3	20 lb of computer paper in two plastic trash bags	570 Btu/sec
4	25 lb of rags, 17 lb of paper towels, 13 lb of plastics (gloves and tape), 2 gal methanol placed in two plastic trash bags	600 Btu/sec
5	30 lb of computer paper in two 50 gal plastic trash cans (16.5 lb each)	700 Btu/sec
10	Same as 5	750 Btu/sec

Based on the heat release rates for solid fuel (transients) as compared to those of flammable liquids, all transients were quantified in terms of size and duration of spill fires.

VII STRUCTURAL STEEL RESPONSE

Once the area and localized exposure temperatures have been determined for the various fires that could occur in an area, an assessment is made of the effects of these temperatures on the structural steel members. An 1100°F cross-sectional average temperature of the steel member has been established as the temperature below which no protection of the steel beams is required and the member is capable of supporting the fire barrier. This is a conservative criteria because it neglects the added fire endurance provided by end restraints and composite construction.

The following measures are used in verifying compliance with this 1100°F temperature criteria:

1. If the area and localized peak temperatures are less than 1100°F, then the unprotected structural steel member is acceptable.
2. If the area or localized peak temperature is greater than 1100°F, the temperature of the steel will be calculated as described in the following sections.
   a. If the calculated steel temperature is less than 1100°F, then the unprotected structural member is acceptable.
   b. If the calculated steel temperature is greater than 1100°F, then either the member will be coated to provide the required fire resistance or measures will be taken to reduce the fire exposure to the beam to a level such that the member temperature will be less than 1100°F.

A 1100°F cross sectional average temperature of the steel member has been established for columns with similar verification steps.

Heating of Structural Steel Members

The temperature of the structural steel member is determined using the unsteady state heat transfer calculation outlined by Stanzak (10).

$$\Delta T = 231 \frac{U}{G} (T_a - T_i) \Delta t$$

Where ΔT = temperature rise in steel member during interval t (°C)

U = surface of steel member exposed to fire (m^2/m)

G = weight of steel member (Kg/m)

T_a = average fire temperature during interval (°C)

T_i = temperature of steel member at beginning of interval (°C)

Δt = time interval in minutes

Since the steel temperature rise is calculated over a time interval, a simple iterative process is set up where the steel temperature rise is added to the previous steel temperature for the next iteration. In all cases the peak fire temperatures have been used as a constant input to the steel temperature calculations.

This approach for evaluating effects of localized plumes incorporates a major conservatism in that only a portion of the beam's length would be heated rather than the entire length of the beam. Even though this is the case, no credit has been taken for conductive heat losses along the beam.

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SECTION 2

CONSERVATISMS

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CONSERVATISMS

The following conservative assumptions were used in this evaluation.

1. No convective heat losses through openings: although combustion air is allowed in, no heat losses via combustion gas leaving the compartment are allowed.

2. No radiation heat losses through openings.

3. No heat losses through the floor: in calculating heat loss area, the floor area is ignored.

4. High cable jacket heat of combustion: The heat of combustion of 10,000 Btu/lb was used for the hypalon jacketed cable and was applied to mass burning rates developed from large scale tests.

5. High heat release rates for fuel controlled cable fires: The heat release rate from a spreading cable fire is conservatively high based on the high fire spread rate of 10 ft/hr, the high heat release rate per unit area of tray (from 4), the selection of the origin in the area where trays are most dense, and using the maximum heat release rate throughout the fire duration.

6. Localized heat of steel: Localized heating of the steel assumes exposure of the entire exposed surface area to the plume and temperature at the bottom flange, regardless of the beam depth and ignores conductive heat losses down the length of the beam.

SECTION 3

SUMMARY

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CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERATURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
01	UNIT 1 REACTOR BUILDING EL. 177' RHR HX & PUMP ROOM 102	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	85	841	NO	STEEL DOES NOT REQUIRE FIREPROOFING. CASE 2 IS VERY CONSERVATIVE BECAUSE DOORS ARE MONITORED WATER-TIGHT DOORS. IT IS EXTREMELY UNLIKELY THAT BOTH DOORS WOULD BE OPEN. 72 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
01		2	VENTILATION CONTROLLED FIRE, 2 DOORS OPEN	44	1118 T(S)=1094	NO	
02	UNIT 1 REACTOR BUILDING EL. 177' RHR HX AND PUMP ROOM 103	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	85	770	NO	STEEL DOES NOT REQUIRE FIREPROOFING. CASE 2 IS VERY CONSERVATIVE BECAUSE DOORS ARE MONITORED WATER-TIGHT DOORS AND IT IS EXTREMELY UNLIKELY THAT BOTH DOORS WOULD BE OPEN. 72 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS
02		2	VENTILATION CONTROLLED FIRE, TWO DOORS OPEN	44	1020	NO	
03	UNIT 1 REACTOR BUILDING EL. 177' RCIC PUMP ROOM 108	1	VENTILATION CONTROLLED FIRE, ONE 3' X 5'10' DOOR OPEN	125	1291	NO	PREACTION SPRINKLER SYSTEM INSTALLED IN THIS AREA. STEEL WILL NOT BE FIREPROOFED. 80 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
03		2	VENTILATION CONTROLLED FIRE, TWO 3' X 5'10" DOORS OPEN	31	1373	NO	
04	UNIT 1 REACTOR BUILDING EL. 177' HPCI PUMP & TURBINE ROOM 109	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	180	1237	NO	PREACTION SPRINKLER SYSTEM INSTALLED IN THIS AREA. STEEL WILL NOT BE FIREPROOFED. 155 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
05	UNIT 1 REACTOR BUILDING EL. 177' CORE SPRAY PUMP ROOM 110	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	37	1128 T(S)=1070	NO	STEEL DOES NOT REQUIRE FIREPROOFING. 24 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
06	UNIT 1 REACTOR BUILDING EL. 177' CORRIDOR ROOM 111		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERATURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
07	UNIT 1 REACTOR BUILDING EL. 177' CORE SPRAY PUMP ROOM 113	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	37	1072	NO	STEEL DOES NOT REQUIRE FIREPROOFING. 24 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
08	UNIT 1 REACTOR BUILDING EL. 177' CORE SPRAY PUMP ROOM 114	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN	37	1118 T(S)=940	NO	STEEL DOES NOT REQUIRE FIREPROOFING. 24 GALLONS OF TRANSIENT LUBE OIL INCLUDED IN CALCULATIONS.
09	UNIT 1 REACTOR BUILDING EL. 177' SUMP ROOM, ROOM 115	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING SIMULTANEOUSLY	15	713	NO	STEEL DOES NOT REQUIRE FIREPROOFING. CONSERVATIVE BECAUSE CABLES WILL NOT BURN SIMULTANEOUSLY.
10	UNIT 1 REACTOR BUILDING EL. 177' CORRIDOR ROOM 118		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
11	UNIT 1 REACTOR BUILDING EL. 198' PIPE TUNNEL ROOM 202		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
12	UNIT 1 REACTOR BUILDING EL. 201' SAFEGUARD SYSTEM ACCESS AREA ROOM 200	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURNING	95	814	CABLE TRAY T(S)=1100 AT 16 MIN	PREACTION SPRINKLER SYSTEM WILL BE INSTALLED BECAUSE THE AREA IS A LIKELY PATH FOR TRANSIENTS.
12		2	VENTILATION CONTROLLED FIRE, TWO DOORS OPEN, ALL CABLES BURNING	46	1065		
12		3	VENTILATION CONTROLLED FIRE, THREE DOORS OPEN, ALL CABLES BURNING	35	1203		
13	UNIT 1 REACTOR BUILDING EL. 201' COOLING WATER HX AREA ROOM 207	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURNING	90	781	CABLE TRAY T(S)=1100 AT 16 MIN	PREACTION SPRINKLER SYSTEM WILL BE INSTALLED BECAUSE THE AREA IS A LIKELY PATH FOR TRANSIENTS.
13		2	VENTILATION CONTROLLED FIRE, TWO DOORS OPEN, ALL CABLES BURNING	45	1028		
14	UNIT 1 REACTOR BUILDING EL. 253' MAIN STEAM & FEEDWATER PIPE TUNNEL		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.

SUMMARY OF STRUCTURAL STEEL EVALUATIONS

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
15	UNIT 1 REACTOR BUILDING EL. 217' SAFEGUARD SYSTEM ACCESS AREA ROOM 309	1	VENTILATION CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURING SIMULTANEOUSLY	120	643	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
15		2	FUEL CONTROLLED FIRE, TWO DOORS OPEN, ALL CABLES BURNING SIMULTANEOUSLY	65	808	NONE	
16	UNIT 1 REACTOR BUILDING EL. 217' GENERAL FLOOR AREA NE CORNER	1	FUEL CONTROLLED FIRE, SPREADING CABLE FIRE	180	650	CABLE TRAY T(S)=700 AT 32 MIN	PREACTION SPRINKLER SYSTEM INSTALLED FOR SAFE SHUTDOWN CONSIDERATIONS. MEMBERS.
17	UNIT 1 REACTOR BUILDING EL. 217' GENERAL FLOOR AREA SE CORNER	1	FUEL CONTROLLED FIRE, SPREADING CABLE FIRE	180	550	CABLE TRAY T(S)=1100 AT 25 MIN	AFFECTED BEAMS WILL BE COATED.
18	UNIT 1 REACTOR BUILDING EL. 217' GENERAL FLOOR AREA NW CORNER	1	FUEL CONTROLLED FIRE, SPREADING CABLE FIRE	180	629	CABLE TRAY T(S)=1100 AT 24 MIN	W 27 X 94 WILL BE FIREPROOFED. W 14 X 87 COLUMN IS NOT REQUIRED STRUCTURALLY AND WILL NOT BE FIREPROOFED.
19	UNIT 1 REACTOR BUILDING EL. 253' GENERAL FLOOR AREA	1	FUEL CONTROLLED FIRE, SPREADING CABLE FIRE	180	1045	NO	PREACTION SPRINKLER SYSTEM INSTALLED IN NE CORNER FOR SAFE SHUTDOWN CONSIDERATIONS.
20	UNIT 1 REACTOR BUILDING EL. 283' GENERAL FLOOR AREA	1	FUEL CONTROLLED FIRE, SPREADING CABLE FIRE	180	854	CABLE TRAY T(S)=1100 AT 19 MIN	PREACTION SPRINKLER SYSTEM WILL BE INSTALLED IN AFFECTED AREA (NW CORNER) IN LIEU OF FIREPROOFING STRUCTURAL MEMBERS. W 14 X 87 COLUMN NOT REQUIRED STRUCTURALLY AND WILL NOT BE FIREPROOFED.
21	UNIT 1 REACTOR BUILDING EL. 295'-3" PIPE CHASE SERVICE ROOM	1	FUEL CONTROLLED FIRE, ONE DOOR OPEN, SPREADING CABLE FIRE	40	1035	CABLE TRAY T(S)=1100 AT 19 MIN	STRUCTURAL MEMBERS NOT REQUIRED. SLAB IS SELF SUPPORTING. NO ACTION TO BE TAKEN.
22	UNIT 1 REACTOR BUILDING EL. 313' LAYDOWN AREA ROOM 601	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING	40	543	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
23	UNIT 1 REACTOR BUILDING EL. 313' LAYDOWN AREA ROOM 602	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING	35	404	NO	STEEL DOES NOT REQUIRE FIREPROOFING. W 14 X 87 COLUMN NOT REQUIRED STRUCTURALLY AND WILL NOT BE FIREPROOFED.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
24	UNIT 1 REACTOR BUILDING EL. 313' CORRIDOR ROOM 605	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING	35	813	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
25	UNIT 1 REACTOR BUILDING EL. 313' REACTOR VENT SUPPLY FAN ROOM, ROOM 607	1	FUEL CONTROLLED FIRE, LOUVERS OPEN, ALL CABLES BURNING	35	438	NO	STEEL DOES NOT REQUIRE FIREFPROOFING.
26	UNIT 1 REACTOR BUILDING EL. 331' EXHAUST FAN [illegible], ROOM 615		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
27	UNIT 1 REACTOR BUILDING EL. 331' EQUIPMENT COMPARTMENT EXHAUST FILTER ROOM 616 & 617		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
28	UNIT 1 REACTOR BUILDING EL. 331' RECIRC FILTER COMPARTMENTS ROOM 618		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
29	UNIT 1 REACTOR BUILDING EL. 352' REFUELING FLOOR		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
30	CONTROL STRUCTURE EL. 180' BACKWASH PUMP ROOMS 161, 162 & 165	1	FUEL CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURNING SIMULTANEOUSLY	26	791	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
31	CONTROL STRUCTURE EL. 180' BACKWASH RECEIVING TANK ROOM 163	1	FUEL CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURNING SIMULTANEOUSLY	35	1002	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
32	CONTROL STRUCTURE EL. 180' CORRIDOR 164		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
33	CONTROL STRUCTURE EL. 180' CORRIDOR 166	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING SIMULTANEOUSLY	30	511	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
34	CONTROL STRUCTURE EL. 200' WEST CHILLER EQUIPMENT ROOM, ROOM 258	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING SIMULTANEOUSLY	20	689	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
35	CONTROL STRUCTURE EL. 200' RECOMBINER ACCESS AREA ROOM 259		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
36	CONTROL STRUCTURE EL. 200' EAST CHILLER EQUIPMENT ROOM, ROOM 263	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING SIMULTANEOUSLY	20	689	NO	STEEL DOES NOT REQUIRE FIREPROOFING.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
37	CONTROL STRUCTURE EL. 217' SWITCHGEAR AREA	1	FUEL CONTROLLED FIRE, ONE DOOR OPEN, SPREADING CABLE FIRE	180	395	CABLE TRAY T(S)=1100 AT 24 MIN	AFFECTED BEAMS WILL BE FIREPROOFED.
37		2	FUEL CONTROLLED FIRE, ONE DOOR OPEN, ALL CABLES BURNING SIMULTANEOUSLY	150	1188		
38	CONTROL STRUCTURE EL. 304' FAN ROOM, ROOM 619	1	VENTILATION CONTROLLED, ALL CABLES BURNING SIMULTANEOUSLY, ONE DOOR OPEN	105	557	NO	STEEL DOES NOT REQUIRE FIREPROOFING.
38		2	VENTILATION CONTROLLED, ALL CABLES BURNING SIMULTANEOUSLY, TWO DOORS OPEN	54	735	NO	
38		3	FUEL CONTROLLED, ALL CABLES BURNING SIMULTANEOUSLY, THREE DOORS OPEN	36	849	NO	
39	CONTROL STRUCTURE EL. 332' STANDBY GAS TREATMENT SYSTEM FILTER COMPARTMENT ROOM 624		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
40	CONTROL STRUCTURE EL. 332' STANDBY GAS TREATMENT SYSTEM ACCESS AREA ROOM 625		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
41	CONTROL STRUCTURE EL. 200' RADWASTE PIPE TUNNEL		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
42	UNIT 1 DIESEL GENERATOR ENCLOSURE EL. 217' DIESEL GENERATOR CELL 1A	1	VENTILATION CONTROLLED FIRE, TWO LOUVERS OPEN	180	3520		PREACTION SPRINKLER SYSTEM IS INSTALLED.
43	SPRAY POND PUMP STRUCTURE EL. 237' RHRSW PIPEWAY		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
44	SPRAY POND PUMP STRUCTURE EL. 268' ESW & RHRSW PUMP AREA		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
45	SPRAY POND PUMP STRUCTURE EL. 237' WET PIT		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
46	SPRAY POND PUMP STRUCTURE EL. 251'ESW & RHRSW PUMP AREA		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
47	SPRAY POND PUMP STRUCTURE EL. 268' ACCESS HATCH AREA		NO EXPOSED COMBUSTIBLES				STEEL DOES NOT REQUIRE FIREPROOFING.
48	SPRAY POND PUMP STRUCTURE EL. 251' RHRSW VALVE COMPARTMENT	1	FUEL CONTROLLED FIRE, ALL CABLES BURNING	30	729	NO	STEEL DOES NOT REQUIRE FIREPROOFING.

(1) T(S) - TEMPERATURE OF STEEL CROSS-SECTION

SECTION 4

CALCULATIONS

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Conversion Factors

Fires have been quantified in either Kw or Btu/sec. The following conversion factors can be applied to convert the results to other units.

1 Btu/sec = 1.0551 Kw

1 Btu/sec ft^2 = 11.349 Kw/m^2

1 Btu/lb = 2337 $J/_{kg}$ = 2.337 $KJ/_{kg}$

1 Btu = 1060 joules = 1.06 KJ

For estimating purposes, it is within 6% to use Btu/sec and Kw or Btu and KJ interchangably.

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 1

Unit 1 Reactor Building El. 177'

RHR Heat Exchanger and Pump Room - Room 102

Fire Area 32

Prepared by: W. F. Wahl　　　Date: February 7, 1984

Reviewed by: [signature]　　　Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the RHR Heat Exchanger and Pump Room, Room 102, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 32) (see Attachment A for sketch of area). The bounding walls of the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 7848 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

   Combustible loading in the area consists of 72 gallons of lubricating oil contained in the RHR pump motors. For the analysis this quantity was doubled to account for possible maintenace activities in the area. There are two cable trays in the room - one located along the east wall, the other along the west wall. The total surface area of the cable trays is 52 ft^2 with an average combustible loading of 1.5 lbs/ft^2 of cable tray surface.

3. VENTILATION PARAMETERS

   There are four doors which enter the area. Two watertight doors measuring 3' wide by 5'10" high enter the area on the 177' elevation and two steamtight doors measuring 3' wide by 7' high enter the area on the 201' elevation.

4. CASES EXAMINED

   Two cases were examined, each assuming a lube oil fire involving 144 gallons of lubricating oil. Case number one assumed the lube oil fire with one steamtight door open and case number two assumed both steamtight doors open.

5. RESULTS

   Case number one considered only one 3' x 7' door open which corresponds to a ventilation controlled heat output of 4504 kW. At this heat output the fire would consume the 144 gallons of lube oil in 85 minutes. The gas temperature at this time would be 841°F, which is below the critical temperature of the structural steel (see Attachment B).

The ventilation controlled burning rate of 4504 kW is equivalent to the heat output from a pool fire with an area of 14 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel supporting the intermediate grating at the 201' elevation, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.09$ m

Plume te ierature at bottom of structural steel supporting the 217' elevation floor slab.

$\Delta T_0 = 9.1[T_\infty/(gc_p{}^2 \rho_\infty{}^2)]^{.333}\ Q_c{}^{.667}\ (Z - Z_0)^{-1.67}$

T_0 = 103°K temperature rise

T = 253°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

Case number two considered both 3' x 7' doors open which corresponds to a ventilation controlled burning rate of 9008 kW. At this heat output the fire would consume the 144 gallons of lube oil in 44 minutes. The gas temperature at this time would be 1118°F which is above the critical temperature of the structural steel (see Attachment B). The W24X68 beam reaches 1094°F after 44 minutes. (See Attachment C).

The ventilation controlled burning rate of 9008 kW is equivalent to the heat output from a pool fire with an area of 28 ft^2 (pool diameter of approximately 6 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel supporting the intermediate grating at the 201' elevation, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{4} = 1.32$ m

Plume temperature at bottom of structural steel supporting the 217' elevation floor slab.

$$\Delta T_0 = 9.1[T_\infty/(gc_p^2 \rho_\infty^2)]^{.333} Q_c^{.667} (Z - Z_0)^{-1.67}$$

ΔT_0 = 169°K temperature rise

T = 372°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

The cable trays in this area were positioned such that they did not present a localized heating exposure to the structural steel.

Columns in this area are W14X730. When exposed to a plume temperature of 1500°F for 44 minutes, the steel temperature does not exceed 590°F.

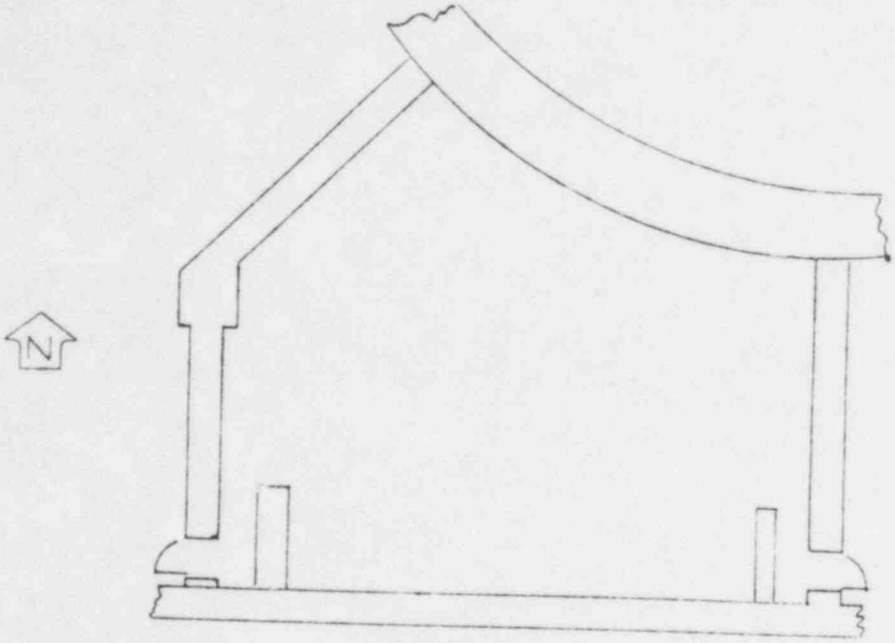
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled and had a duration of 44 minutes. The temperature at this time exceeded 1100°F, therefore, no transient materials were quantified.

The ceiling height in the area is 20'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W24X68.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,654	
1300	16,134	21 min
1500	20,457	15 min



Unit 1 Reactor Building El. 177'
RHR Heat Exchanger and Pump Room 102

Surface Area Calculation

<u>Walls</u>		
North wall	(32' x 40')	$1280\ ft^2$
South wall	(52' x 40')	$2080\ ft^2$
East wall	(29' x 40')	$1160\ ft^2$
West wall	(52' x 40')	$2080\ ft^2$
		$6600\ ft^2$

Ceiling for area is at elevation 217'

<u>Ceiling</u>	(24' x 52')	$1248\ ft^2$
Total Surface Area for Heat Transfer		$7848\ ft^2$

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RHR HX & PUMP ROOM 102
CASE DESCRIPTION: ONE 3'x 7' DOOR OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	7848	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	643
10	658
15	672
20	686
25	698
30	711
35	724
40	736
45	748
50	760
55	772
60	784
65	795
70	807
75	818
80	830
85	841

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RHR HX & PUMP ROOM 102
CASE DESCRIPTION: TWO 3'x 7' DOORS OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	42.0	7.0	7848	9008

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
4	849
8	876
12	903
16	930
20	958
24	985
28	1012
32	1039
36	1066
40	1092
44	1118

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: EL.177'
CASE DESCRIPTION: W24x68

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1118
WEIGHT OF STEEL MEMBER (lbs./ft): 68
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.06

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	438
10.00	677
15.00	832
20.00	933
25.00	998
30.00	1040
35.00	1068
40.00	1085
45.00	1097
50.00	1104
55.00	1109
60.00	1112
65.00	1114

ATTACHMENT C

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 2

Unit 1 Reactor Building El. 177'

RHR Heat Exchanger and Pump Room - Room 103

Fire Area 31

Prepared by: W. F. Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the RHR Heat Exchanger and Pump Room, Room 103, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 31) (see Attachment A for sketch of area). The bounding walls of the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 9068 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of 72 gallons of lubricating oil contained in the RHR pump motors. For the analysis this quantity was doubled to account for possible maintenace activities in the area. There are two cable trays in the room - one located along the east wall, the other along the west wall. The total surface area of the cable trays is 58 ft^2 with an average combustible loading of 1.5 lbs/ft^2 of cable tray surface.

3. VENTILATION PARAMETERS

There are four doors which enter the area. Two watertight doors measuring 3' wide by 5'10" high enter the area on the 177' elevation and two steamtight doors measuring 3' wide by 7' high enter the area on the 201' elevation.

4. CASES EXAMINED

Two cases were examined, each assuming a lube oil fire involving 144 gallons of lubricating oil. Case number one assumed the lube oil fire with one steamtight door open and case number two assumed both steamtight doors open.

5. RESULTS

Case number one considered only one 3' x 7' door open which corresponds to a ventilation controlled heat output of 4504 kW. At this heat output the fire would consume the 144 gallons of lube oil in 85 minutes. The gas temperature at this time would be 770°F, which is below the critical temperature of the structural steel (see Attachment B).

The ventilation controlled burning rate of 4504 kW is equivalent to the heat output from a pool fire with an area of 14 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel supporting the intermediate grating at the 201' elevation, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.09$ m

Plume temperature at bottom of structural steel supporting the 217' elevation floor slab.

$\Delta T_0 = 9.1[T_\infty/(gc_p^2\ \rho_\infty^2)]^{.333}\ Q_c^{.667}\ (Z - Z_0)^{-1.67}$

ΔT_0 = 103°K temperature rise

T = 253°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

Case number two considered both 3' x 7' doors open which corresponds to a ventilation controlled burning rate of 9008 kW. At this heat output the fire would consume the 144 gallons of lube oil in 44 minutes. The gas temperature at this time would be 1020°F which is below the critical temperature of the structural steel (see Attachment B).

The ventilation controlled burning rate of 9008 kW is equivalent to the heat output from a pool fire with an area of 28 ft^2 (pool diameter of approximately 6 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel supporting the intermediate grating at the 201' elevation, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.32$ m

Plume temperature at bottom of structural steel supporting the 217' elevation floor slab.

$\Delta T_o = 9.1[T\infty/(gc_p^2 \rho\infty^2)]^{.333} Q_c^{.667} (Z - Z_o)^{-1.67}$

ΔT_o = 169°K temperature rise

T = 372°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

The cable trays in this area were positioned such that they did not present a localized heating exposure to the structural steel.

Columns in this area are W14X730. When exposed to a plume temperature of 1500°F for 44 minutes, the steel temperature does not exceed 590°F.

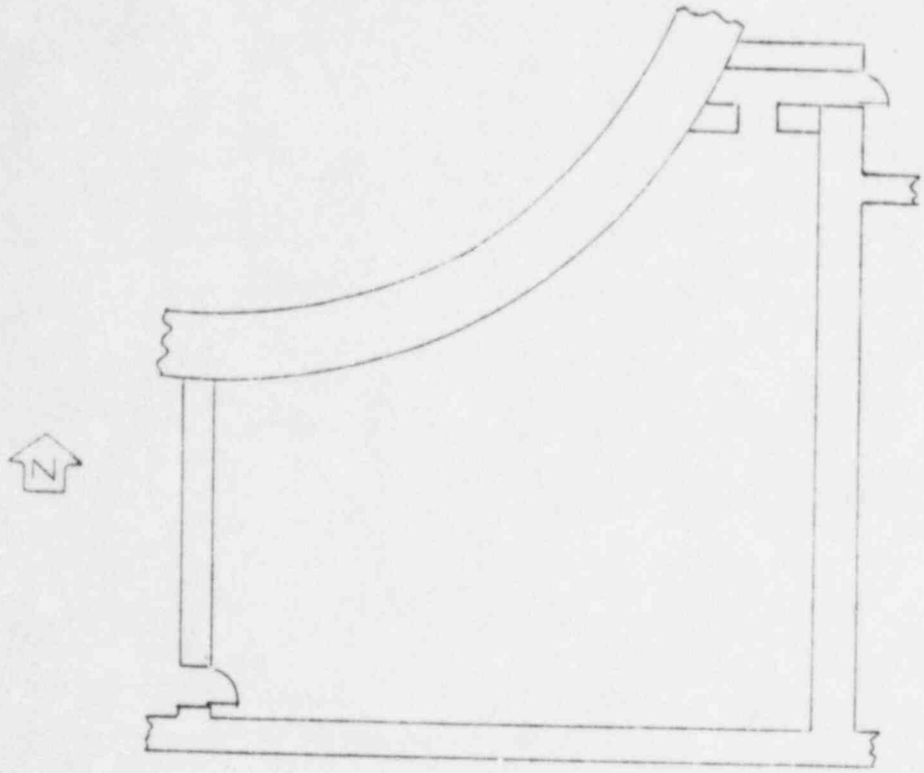
6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled with a duration of 44 minutes. The temperature at this time was 1020°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 20'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X68.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,654	
1300	16,134	21 min
1500	20,457	15 min



Unit 1 Reactor Building El. 177'
RHR Heat Exchanger and Pump Room 103

Surface Area Calculation

Walls		
North wall	(52' x 40')	2080 ft^2
South wall	(52' x 40')	2080 ft^2
East wall	(56' x 40')	2240 ft^2
West wall	(29' x 40')	1160 ft^2
		7560 ft^2

Ceiling for area is at elevation 217'

Ceiling	(29' x 52')	1508 ft^2
Total Surface Area for Heat Transfer		9068 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RHR HX & PUMP ROOM 103
CASE DESCRIPTION: ONE 3'x7' DOOR OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	9068	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	605
10	618
15	630
20	641
25	652
30	663
35	673
40	683
45	693
50	703
55	713
60	723
65	732
70	742
75	751
80	761
85	770

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RHR HX & PUMP ROOM 103
CASE DESCRIPTION: TWO 3'x7' DOORS OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	42.0	7.0	9068	9008

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
4	801
8	824
12	846
16	868
20	890
24	912
28	934
32	955
36	977
40	998
44	1020

ATTACHMENT B

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 3

Unit 1 Reactor Building El. 177'

RCIC Pump Room 108

Fire Area 33

Prepared by: W. F. Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the RCIC Pump Room, Room 108, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 33) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 3820 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

   Combustible loading in the area consists 80 gallons of lubricating oil contained in the RCIC turbine. For the analysis this quantity was doubled to account for possible maintenance activities in the area. A single cable tray having 38 ft^2 of surface area with an average combustible loading of 3.6 lbs/ft^2 of cable tray surface area is located along the west wall of the room.

3. VENTILATION PARAMETERS

   There are two doors which enter this area. Two watertight doors, each measuring 3' wide by 5'10" high, one door is located in the north wall, the other in the south wall.

4. CASES EXAMINED

   Two cases were examined each assuming a lube oil fire involving 160 gallons of lubricating oil. Case number one assumed one 3' x 5'10" door open, and case number two assumed two 3' x 5'10" doors open. All cases assumed that the pre-action sprinkler system does not operate and that no actions are taken by plant personnel to extinguish the fire.

5. RESULTS

   Case number one considered only one 3' x 5'10" door open, which corresponds to a ventilation controlled heat output of 3417 kW. At this heat output

the fire would consume the 160 gallons of lube oil in approximately 125 minutes. The gas temperature at this time would be 1291°F which is above the critical temperature of the structural steel (see Attachment B).

The ventilation controlled burning rate of 3417 kW is equivalent to the heat output from a pool fire with an area of 11 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated gases above the pool fire in the structural steel supporting the ceiling, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.01$ m

Plume temperature at bottom of structural steel supporting the ceiling.

$\Delta T_0 = 9.1[T_\infty/(gc_p^2 \rho_\infty^2)]^{.333}\ Q_c^{.667}\ (Z - Z_0)^{-1.67}$

$\Delta T_0 = 214°K$ temperature rise

$T = 453°F$ temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

Case number 2 considered two 3' x 5'10" doors open which corresponds to a ventilation controlled heat output of 6833 kW. At this heat output the fire would consume the 160 gallons of lube oil in approximately 31 minutes. The gas temperature at this time would be 1373°F which is above the critical temperature for the structural steel (see Attachment B).

The ventilation controlled burning rate of 6833 kW is equivalent to the heat output from a pool fire with an area of 21 ft^2 (pool diameter of approximately 5 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel supporting the ceiling, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.23$ m

Plume temperature at bottom of structural steel supporting ceiling:

$\Delta T_o = 9.1[T_\infty/(gc_p^2 \rho_\infty^2)]^{.333} Q_c^{.667} (Z - Z_o)^{-1.67}$

ΔT_o = 482°K temperature rise

T = 935°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel.

The plume temperature for both cases examined is below the critical temperature of the structural steel. It is concluded that there is no problem due to localized heating of the structural steel as a result of the maximum pool fire that can be supported by the available air flow into the room.

The cable trays in this area were positioned such that they did not present a localized heating exposure to the structural steel.

Even though there are no localized heating problems, all of the cases examined did result in an overall gas temperaure which was above the critical temperature of the structural steel.

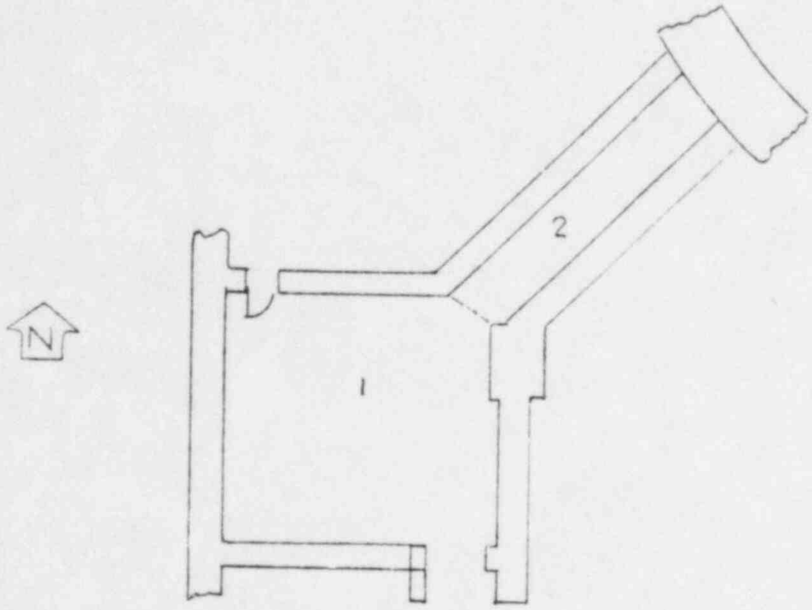
6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled with a duration of 31 minutes. The temperature at this time exceeded 1100°F, therefore no transient materials were quantified.

The ceiling height in the area is 20 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W27X84.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,232	
1300	15,712	24 min
1500	19,613	17 min



Unit 1 Reactor Building El 177'
RCIC Pump Room - Room 108

Surface Area Calculation

Walls		
North wall	(48' x 23')	1104 ft^2
South wall	(50' x 23')	1150 ft^2
East wall	(20' x 23')	460 ft^2
West wall	(21' x 23')	483 ft^2
		3197 ft^2
Ceiling		
Area 1	(23' x 21')	483 ft^2
Area 2	(5' x 28')	140 ft^2
Total Surface Area for Heat Transfer		3820 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RCIC PUMP ROOM 108
CASE DESCRIPTION: ONE 3'x5'10 DOOR OPEN LUBE OIL FIRE

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	17.5	5.8	3820	3417

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	773
10	797
15	821
20	845
25	869
30	892
35	915
40	938
45	961
50	983
55	1006
60	1028
65	1049
70	1071
75	1092
80	1113
85	1134
90	1154
95	1174
100	1194
105	1214
110	1234
115	1253
120	1272
125	1291

ATTACHMENT B

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' RCIC PUMP ROOM 108
CASE DESCRIPTION: TWO 3'x5'10 DOORS OPEN LUBE OIL FIRE

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	35.0	5.8	3820	6833

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	976
2	989
3	1001
4	1014
5	1027
6	1039
7	1052
8	1066
9	1079
10	1092
11	1105
12	1119
13	1132
14	1146
15	1159
16	1173
17	1187
18	1200
19	1214
20	1227
21	1241
22	1254
23	1268
24	1281
25	1294
26	1308
27	1321
28	1334
29	1347
30	1360
31	1373

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 4

UNIT 1 Reactor Building El. 177'

HPCI Pump & Turbine Room Room 109

Fire Area 34

Prepared by: W. F. Wahl

Reviewed by: [illegible signature]

Date: February 7, 1984

Revision: 1

P. O. [illegible] 46 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the High Pressure Coolant Injection (HPCI) Pump and Turbine Room, Room 109 on the 177' elevation of the Unit 1 Reactor Building (Fire Area 34). Bounding walls in the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 4760 ft^2 (see Attachment A for sketch and calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the ar onsists of 155 gallons of lubricating oil contained in the HPCI turbine. For the analysis this quantity was doubled to account for possible maintenance activities in the area. A single cable tray having 18 ft^2 of surface area and an average combustible loading of 1.5 lbs/ft^2 of cable tray surface is located near the east wall of the room.

3. VENTILATION PARAMETERS

Two watertight doors each measuring 3' wide by 5'10" high enter the room. One door is located in the north wall, the other in the south wall.

4. CASES EXAMINED

A lube oil fire was assumed in the area involving 310 gallons of lubricating oil. One door entering the area was assumed to be open. This is an opening area of 17.5 ft^2 which results in a ventilation controlled maximum heat output of 3417 kW.

5. RESULTS

With one door open, the resulting ventilation controlled heat output of 3417 kW will consume the 310 gallons of fuel in 238 minutes. Due to the excessive fuel quantity, the fire duration was taken to 180 minutes which resulted in a gas temperature of 1237°F (see Attachment B) which is above the critical temperature of the structural steel.

The ventilation controlled burning rate of 3417 kW is equivalent to the output from a pool fire with an area of 11 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel located above the fire, Heskestad's relations will be used:

Virtual point source determination:

$Z_o = -1.02D + .083\ Q^{4} = 1.01$ m

Plume temperature at bottom of steel supporting the room ceiling:

$T_o = 9.1\ (T\ /(gc_p^{2}\ \ ^{2}))^{333}\ Q_c^{667}\ (Z - Z_o)^{1\ 67}$

T_o = 282°K temperature rise

T = 576°F temperature of fire plume

The plume temperature is below the critical temperature for the structural steel. It can be concluded that there is no problem due to localized heating as a result of the maximum pool fire that can be supported by the available air flow into the room through a single door. The cable tray in this area is positioned such that it does not present a localized heating exposure to structural steel. Columns in the area are W14X730. When exposed to a plume temperature of 1500°F, the steel will reach 757°F after 65 minutes if the fire is permitted to burn.

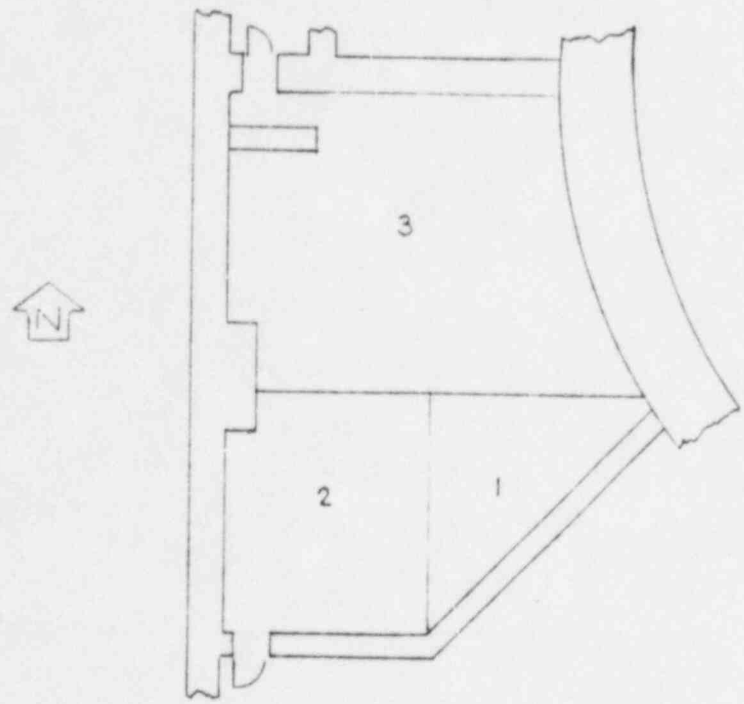
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled and had a duration of 180 minutes. The temperature at this time exceeded 1100°F, therefore, no transient materials were quantified.

The ceiling height in the area is 19'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W36X194.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater tnan 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	11,178	
1300	14,236	46 min
1500	17,926	32 min



UNIT 1 Reactor Building El. 177'
HPCI Pump & Turbine Room 109

Surface Area Calculation

Walls		
North wall	(30' x 23')	690 ft^2
East wall	(28' x 23')	644 ft^2
South wall		1058 ft^2
West wall	(46' x 23')	1058 ft^2
		3450 ft^2
Ceiling		
Area 1	1/2(20' x 20')	200 ft^2
Area 2	(20' x 18') - 160 ft^2 (Hatch)	200 ft^2
Area 3	(35' x 26')	910 ft^2
		1310 ft^2
Total Surface Area for Heat Transfer		4760 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' HPCI PUMP AND TURBINE ROOM
CASE DESCRIPTION: ONE DOOR OPEN LUBE OIL FIRE

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CL[illegible]TE	17.5	5.8	4760	3417

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	725
20	761
30	795
40	829
50	862
60	894
70	926
80	957
90	987
100	1017
110	1047
120	1075
130	1103
140	1131
150	1158
160	1185
170	1211
180	1237

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 5

Unit 1 Reactor Building El. 177'

Core Spray Pump Room 110

Fire Area 35

Prepared by: W F Wahl

Reviewed by: Kenneth W Dungan

Date: February 7, 1984

Revision: 1

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Core Spray Pump Room, Room 110, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 35) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 2749 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of 24 gallons of lubricating oil contained in the core spray pump. For the analysis this quantity was doubled to account for possible maintenance activities in the area. A single cable tray having 37 ft^2 of surface area with an average combustible loading of .5 lbs/ft^2 of tray surface area.

3. VENTILATION PARAMETERS

A single watertight door measuring 3' wide by 5'10" high is located in the west wall of the room.

4. CASES EXAMINED

A lube oil fire was assumed in the area involving 48 gallons of lubricating oil. The door entering the area was assumed to be open. This is an opening area of 17.5 ft^2 which results in a ventilation controlled maximum heat output of 3417 kW.

5. RESULTS

With one door open, the resulting ventilation controlled heat output of 3417 kW will consume the 48 gallons of lube oil in 37 minutes. The gas temperature at this time would be 1128°F which is above the critical temperature of the structural steel (see Attachment B). The W27X84 beam will be heated to 1070°F in 37 minutes if exposed to a constant temperature of 1128°F. (See Attachment C).

The ventilation controlled burning rate of 3417 kW is equivalent to the heat output from a pool fire with an area of 11 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated

gases above the pool fire on the structural steel located above the fire, Hesketad's relation will be used:

Virtual point source determination:
$Z_0 = -1.02D + .083\ Q^{.4} = 1.01$ m

Plume temperature at bottom of steel supporting the room ceiling:
$\Delta T_0 = 9.1[T_\infty/(g c_p{}^2 \rho_\infty{}^2)]^{.333}\ Q_c{}^{.667}\ (Z - Z_0)^{-1.67}$
ΔT_0 = 282°K temperature rise
T = 576°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel. It is concluded that there is no problem due to localized heating of the structural steel as a result of the maximum pool fire that can be supported by the available air flow into the room.

The cable tray in the area was positioned such that it did not present a localized heating exposure to the structural steel.

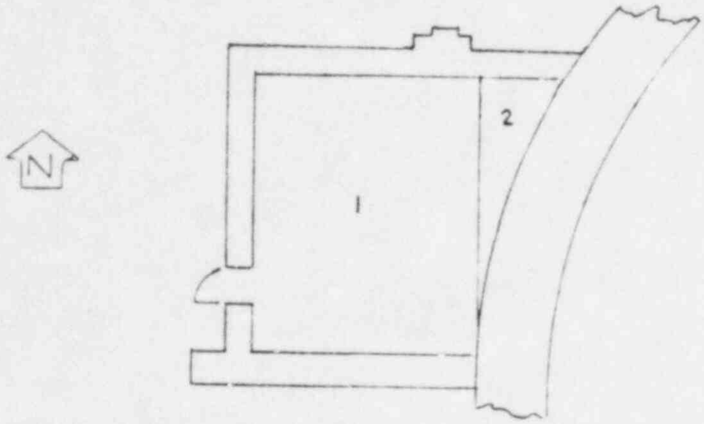
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled and had a duration of 37 minutes. The temperature at this time exceeded 1100°F, therefore, no transient materials were quantified.

The ceiling height in the area is 20 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W27X84.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,232	
1300	15,712	24 min
1500	19,613	17 min



Unit 1 Reactor Building
Core Spray Pump Room 110

Surface Area Calculation

Walls		
North wall	(27' x 23')	621 ft^2
South wall	(20' x 23')	460 ft^2
East wall	(24' x 23')	552 ft^2
West wall	(24' x 23')	552 ft^2
		2185 ft^2
Ceiling		
Area 1	(20' x 24')	480 ft^2
Area 2	1/2(24' x 7')	84 ft^2
Total Surface Area for Heat Transfer		2749 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' CORE SPRAY ROOM 110
CASE DESCRIPTION: ONE DOOR OPEN LUBE OIL FIRE

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	17.5	5.8	2749	3417

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	852
2	860
3	868
4	876
5	884
6	891
7	899
8	907
9	914
10	922
11	929
12	937
13	945
14	952
15	960
16	968
17	975
18	983
19	991
20	998
21	1006
22	1014
23	1021
24	1029
25	1037
26	1044
27	1052
28	1060
29	1067
30	1075
31	1082
32	1090
33	1098
34	1105
35	1113
36	1120
37	1128

ATTACHMENT B

CASE NO.: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' CORE SPRAY ROOM 110
CASE DESCRIPTION: W 27X84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (DEF. F): 1128
WEIGHT OF STEEL MEMBER (LBS./FT.): 84
SURFACE OF STEEL MEMBER HEATED (SQ. FT./FT): 6.78

TIME (MIN.)	STEEL TEMPERATURE (DEG. F)
5	406.240502
10	636.550214
15	793.36929
20	900.148213
25	972.854535
30	1022.360648
35	1056.069615
40	1079.022227

ATTACHMENT C

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 6

UNIT 1

Unit 1 Reactor Building El. 177'

Corridor - Room 111

Fire Area 40

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box [illegible] • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Corridor (Room 111) on the 177' elevation of the Unit 1 Reactor Building (Fire Area 40) and contains the safety related HPCI pump discharge flow transmitters. The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 3953 ft^2. (See Attachment A for sketch and calculations of the area.)

2. COMBUSTIBLE LOADING

There are no cable trays or combustible liquids located in this area.

3. VENTILATION PARAMETERS

Access doors connect to the stairwell, elevator shaft, and core pump spray rooms.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the corridor, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail since there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

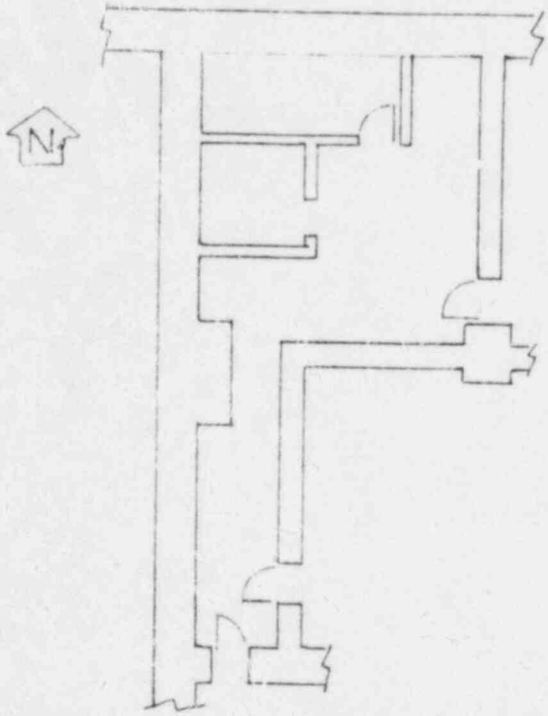
This area contains no exposed fixed combustibles. The table below lists the maximum heat release rate for transient combustibles for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	3857
2 hours	7.5	2755
3 hours	6.5	2387

The ceiling height in the area is 20'9". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W18X40.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	13,392	
1300	17,188	16 min
1500	>21,089	12 min



Unit 1 Reactor Building El. 177'
Corridor - Room 111

Surface Area Calculation

<u>Walls</u>		
North wall	(24' x 23')	552 ft^2
East wall	(51' x 23')	1173 ft^2
South wall	(24' x 23')	552 ft^2
West wall	(51' x 23')	1173 ft^2
		3450 ft^2
<u>Ceiling</u>	(33' x 7') + (16' x 14') + (8' x 6')	503 ft^2
Total Surface Area for Heat Transfer		3953 ft^2

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 7

Unit 1 Reactor Building El. 177'

Core Spray Pump Room 113

Fire Area 36

Prepared by: W F Wahl

Date: February 7, 1984

Reviewed by: [signature]

Revision: 1

P. O. Box • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Core Spray Pump Room, Room 113, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 36) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 2976 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of 24 gallons of lubricating oil contained in the core spray pump. For the analysis this quantity was doubled to account for possible maintenance activities in the area. A single cable tray having 34 ft^2 of surface area with an average combustible loading of .5 lbs/ft^2 of tray surface area is located along the north wall.

3. VENTILATION PARAMETERS

A single watertight door measuring 3' wide by 5'10" high is located in the west wall of the room.

4. CASES EXAMINED

A lube oil fire was assumed in the area involving 48 gallons of lubricating oil. The door entering the area was assumed to be open. This is an opening area of 17.5 ft^2 which results in a ventilation controlled maximum heat output of 3417 kW.

5. RESULTS

With one door open, the resulting ventilation controlled heat output of 3417 kW will consume the 48 gallons of lube oil in 37 minutes. The gas temperature at this time would 1072°F which is below the critical temperature of the structural steel (see Attachment B).

The ventilation controlled burning rate of 3417 kW is equivalent to the heat output from a pool fire with an area of 11 ft^2 (pool diameter of approximately 4 ft). In order to assess the effect of the plume of heated

gases above the pool fire on the structural steel located above the fire, Hesketad's relation will be used:

Virtual point source determination:

$Z_o = -1.02D + .083\ Q^{.4} = 1.01$ m

Plume temperature at bottom of steel supporting the room ceiling:

$\Delta T_o = 9.1[T_\infty/(gc_p{}^2\rho_\infty{}^2)]^{.333}\ Q_c{}^{.667}\ (Z - Z_o)^{-1.67}$

ΔT_o = 282°K temperature rise

T = 576°F temperature of fire plume

The plume temperature is below the critical temperature of the structural steel. It is concluded that there is no problem due to localized heating of the structural steel as a result of the maximum pool fire that can be supported by the available air flow into the room.

The cable tray in the area was positioned such that it did not present a localized heating exposure to the structural steel.

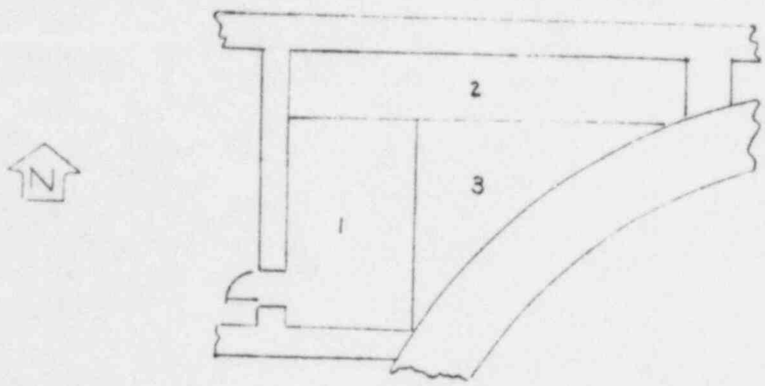
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled and had a duration of 37 minutes. The temperature at this time was 1072°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 20 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W27X145.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,232	
1300	15,712	38 min
1500	19,613	27 min



Unit 1 Reactor Building
Core Spray Pump Room 113

Surface Area Calculation

<u>Walls</u>		
North wall	(34 x 23')	782 ft^2
South wall	(40' x 23')	920 ft^2
East wall	(5' x 23')	115 ft^2
West wall	(24' x 23')	552 ft^2
		2369 ft^2
<u>Ceiling</u>		
Area 1	(11' x 19')	209 ft^2
Area 2	(34' x 5')	170 ft^2
Area 3	1/2(24' x 19')	228 ft^2
Total Surface Area for Heat Transfer		2976 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' CORE SPRAY ROOM 113
CASE DESCRIPTION: ONE DOOR OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	17.5	5.8	2976	3417

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	826
2	834
3	841
4	849
5	856
6	862
7	869
8	876
9	883
10	890
11	897
12	903
13	910
14	917
15	924
16	931
17	937
18	944
19	951
20	958
21	965
22	971
23	978
24	985
25	992
26	999
27	1005
28	1012
29	1019
30	1026
31	1032
32	1039
33	1046
34	1052
35	1059
36	1066
37	1072

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 8

Unit 1 Reactor Building El. 177'

Core Spray Pump Room 114

Fire Area 37

Prepared by: W. F. Wall

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box [illegible] • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Core Spray Pump Room, Room 114, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 37) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 2784 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of 24 gallons of lubricating oil contained in the core spray pump. For the analysis this quantity was doubled to account for possible maintenance activities in the area. A single cable tray having 37 ft^2 of surface area with an average combustible loading of .5 lbs/ft^2 of tray surface area is located along the east wall.

3. VENTILATION PARAMETERS

A single watertight door measuring 3' wide by 5'10" high is located in the east wall of the room.

4. CASES EXAMINED

A lube oil fire was assumed in the area involving 48 gallons of lubricating oil. The door entering the area was assumed to be open. This is an opening area of 17.5 ft^2 which results in a ventilation controlled maximum heat output of 3417 kW.

5. RESULTS

With one door open, the resulting ventilation controlled heat output of 3417 kW will consume the 48 gallons of lube oil in 37 minutes. The gas temperature at this time would be 1118°F which is above the critical temperature of the structural steel (see Attachment B).

When exposed to gases at 1118°F for 37 minutes, the W27X145 beam will reach 940°F which is below 1100°F acceptance criteria. (See Attachment C).

The ventilation controlled burning rate of 3417 kW is equivalent to the heat output from a pool fire with an area of 11 ft2 (pool diameter of

approximately 4 ft). In order to assess the effect of the plume of heated gases above the pool fire on the structural steel located above the fire, Hesketad's relations will be used:

Virtual point source determination:

$Z_0 = -1.02D + .083\ Q^{.4} = 1.01$ m

Plume temperature at bottom of steel supporting the room ceiling:

$\Delta T_0 = 9.1[T_\infty/(gc_p{}^2\rho_\infty{}^2)]^{.333}\ Q_c{}^{.667}\ (Z - Z_0)^{1.67}$

$\Delta T_0 = 282°K$ temperature rise

$T = 576°F$ temperature of fire plume

The plume temperature is below the critical temperature of the structural steel. It is concluded that there is no problem due to localized heating of the structural steel as a result of the maximum pool fire that can be supported by the available air flow into the room.

The cable tray in the area was positioned such that it did not present a localized heating exposure to the structural steel.

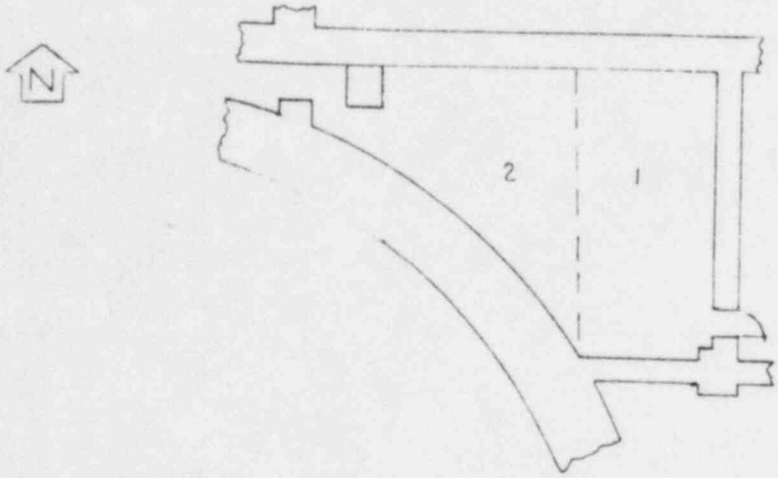
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled and had a duration of 37 minutes. The temperature at this time exceeded 1100°F, therefore, no transient materials were quantified.

The ceiling height in the area is 20 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W27X145.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,232	
1300	15,712	38 min
1500	19,613	27 min



Unit 1 Reactor Building
Core Spray Pump Room 114

Surface Area Calculation

Walls		
North wall	(29' x 23')	667 ft^2
South wall	(12' x 23')	276 ft^2
East wall	(25' x 23')	575 ft^2
West wall	(30' x 23')	690 ft^2
		2208 ft^2
Ceiling		
Area 1	(10' x 24')	240 ft^2
Area 2	1/2(24' x 28')	336 ft^2
Total Surface Area for Heat Transfer		2784 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' CORE SPRAY PUMP ROOM 114
CASE DESCRIPTION: ONE DOOR OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	17.5	5.8	2784	3417

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	847
2	856
3	864
4	872
5	879
6	887
7	894
8	902
9	909
10	917
11	924
12	932
13	939
14	947
15	954
16	962
17	969
18	977
19	984
20	992
21	999
22	1007
23	1014
24	1022
25	1029
26	1037
27	1044
28	1052
29	1059
30	1067
31	1074
32	1082
33	1089
34	1096
35	1104
36	1111
37	1118

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: EL.177'
CASE DESCRIPTION: W27x145

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1118
WEIGHT OF STEEL MEMBER (lbs./ft): 145
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	293
10.00	470
15.00	609
20.00	718
25.00	804
30.00	871
35.00	924
40.00	966
45.00	998
50.00	1024
55.00	1044
60.00	1060
65.00	1072

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 9

Unit 1 Reactor Building El. 177'

Sump Room, Room 115

Fire Area 39

Prepared by: W F Wahl | Date: February 7, 1984

Reviewed by: [illegible] | Revision: 1

P. O. Box • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Sump Room, Room 115, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 39). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 2595 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

The combustible loading in this area consists of cable insulation in cable trays. The total surface area of the cable trays is 96 ft^2 with an average combustible loading of 1.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in the area.

3. VENTILATION PARAMETERS

This room is open to the Corridor Passageway, Room 118. There are two doors which enter into the Sump Room. One door measuring 3' wide by 5'10" high is located in the east wall, and one door measuring 3' wide by 7' high is located at the entrance to the stairwell.

4. CASES EXAMINED

With the light combustible loading in this area, the assumption that all cables are burning simultaneously would present the worst case. With all cables burning simultaneously, a surface area of 96 ft^2 would be involved. This corresponds to a heat output of approximately 1700 kW. With all combustibles assumed to be burning simultaneously, the duration of the fire would be $1.5\ lbs/ft^2 \div \frac{.1\ lb}{min/ft^2} = 15$ minutes.

5. RESULTS

With all the cable trays in the area assumed to be burning simultaneously and a 3' wide by 5'10" door open, the resulting fire was fuel controlled. A gas temperature of 713°F was achieved after 15 minutes, which is below the critical temperature for the structural steel (see Attachment B).

The location of the cable trays relative to structural steel members was examined in the area. No cable trays were positioned so as to present a localized heating exposure to the structural steel.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

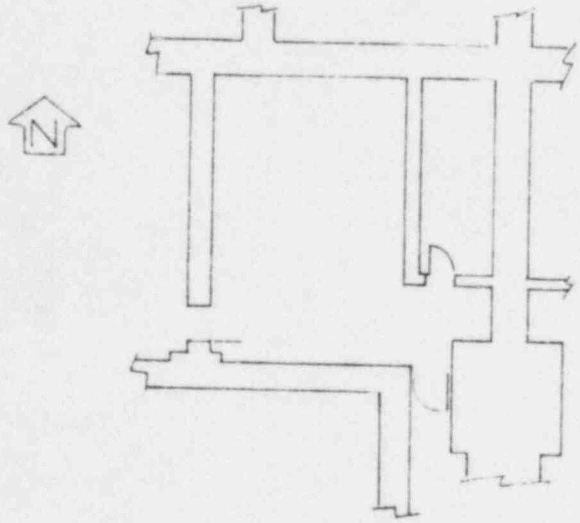
The fire examined was fuel controlled with a duration of 15 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
15 min	17	2400

The ceiling height in the area is 20'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X55.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,654	
1300	16,134	19 min
1500	20,457	13 min



Unit 1 Reactor Building El. 177'
Sump Room 115

Surface Area Calculation

<u>Walls</u>		
North wall	(24' x 23')	552 ft^2
East wall	(24' x 23')	552 ft^2
South wall	(21' x 23')	483 ft^2
West wall	(24' x 23')	552 ft^2
		2139 ft^2
Ceiling	(24' x 25') - (18' x 8')	456 ft^2
Total Surface Area for Heat Transfer		2595 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 177' SUMP ROOM FIRE ZONE 39
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	17.5	5.8	2595	1700

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	662
2	667
3	672
4	676
5	680
6	683
7	687
8	690
9	694
10	697
11	700
12	704
13	707
14	710
15	713

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 10

Unit 1 Reactor Building El. 177'

Corridor Room 118

Fire Area 39

Prepared by: W. F. Wahl

Reviewed by: [signature]

Date: February 7, 1984

Revision: 1

P. O. Box 146 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Corridor and Passageway, Room 118, on the 177' elevation of the Unit 1 Reactor Building (Fire Area 39). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 4976 ft^2 (see Attachment A for sketch and surface area calculations).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

This room is open to the Sump Room, Room 115. There are also two doors, each measuring 3' wide by 5'10" high, located in the west wall of the area.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in the area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

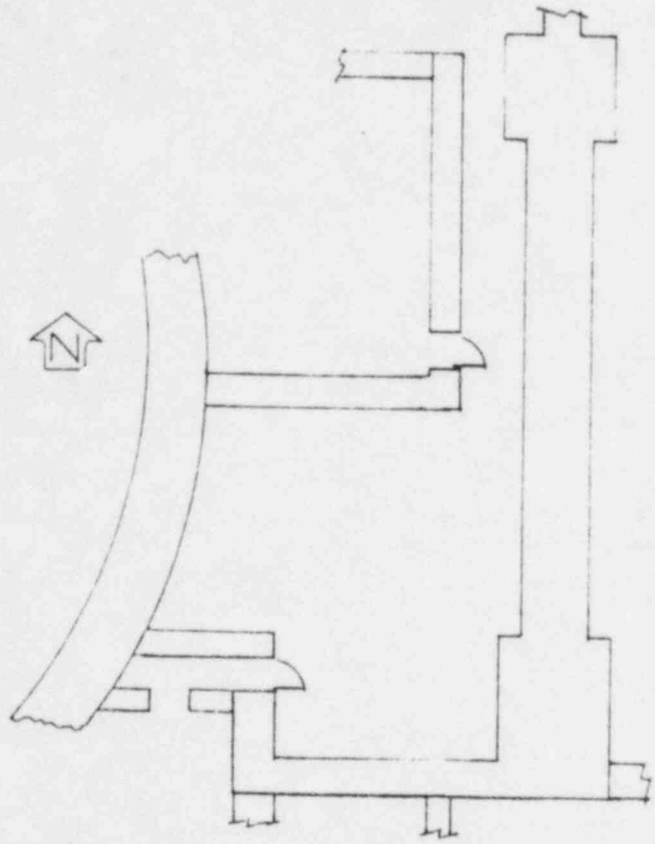
This area has no eposed combustibles. The table below lists the maximum heat release rates for transient combustibles for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	4855
2 hours	7.5	3468
3 hours	6.5	3005

The ceiling height in the area is 20 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W27X84.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	12,232	
1300	15,712	24 min
1500	19,613	17 min



Unit 1 Reactor Building El. 177'
Corridor & Passageway Room 118

Surface Area Calculation

Area 1 (Corridor)

Walls			
East wall	(29' x 23')	667 ft^2	
West wall	(29' x 23')	667 ft^2	
			1334 ft^2
Ceiling	(29' x 6')		174 ft^2

Area 2 (Room 118)

Walls			
North wall	(22' x 23')	506 ft^2	
East wall	(31' x 23')	713 ft^2	
South wall	(32' x 23')	736 ft^2	
West wall	(31' x 23')	713 ft^2	
			2668 ft^2
Ceiling			800 ft^2

Total Surface Area for Heat Transfer 4976 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 11

Reactor Building El. 198'

Pipe Tunnel Room 202

Fire Area 76

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Pipe Tunnel Room 202 on the 198' elevation of the Reactor Building (Fire Area 76). Bounding walls and ceiling are of concrete construction with an average thickness of 3 ft. The total surface area of the bounding walls and ceiling is 14368 ft^2. (See Attachment A for sketch and calculation of areas.)

2. COMBUSTIBLE LOADING

There are no cable trays or combustible oils located in this area.

3. VENTILATION PARAMETERS

There are two doors into the tunnel. Both doors are in the north wall near the east and west walls of the tunnel. Each door is part of an air lock into the tunnel.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the tunnel, there is no fuel in the area to support combustion.

5. RESULTS

The structural steel in this area will not fail since there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

This area has no exposed combustibles. Access to the area is through air locks, so transient materials are unlikely.

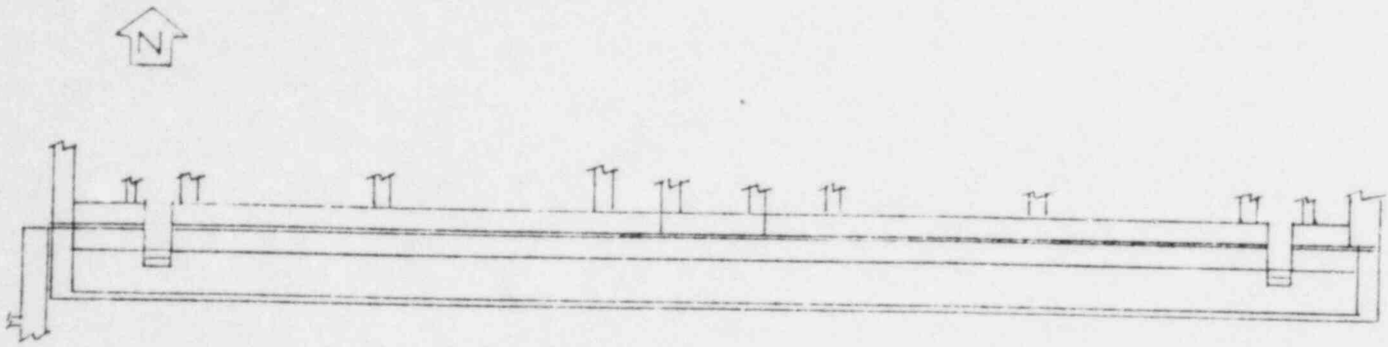
The maximum heat release rates from transient combustibles in the area which would result in an area temperature less than 1100°F are listed below:

Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	14,370
2 hours	8.0	10,630
3 hours	6.5	8,620

The ceiling height in the area is 15'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W24X94.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6116	
1300	7381	30 min
1500	10,018	21 min



Reactor Building El. 198'
Pipe Tunnel Room 202

Surface Area Calculation

Walls		
North wall	(320' x 18')	5760 ft^2
East wall	(8' x 18')	144 ft^2
South wall	(8' x 18')	144 ft^2
West wall	(320' x 18')	5760 ft^2
		11,808 ft^2

[Wall height = 217' el - 198' el - (1' floor slab) = 18']

Ceiling	(320' x 8')	2560 ft^2
Total Surface Area for Heat Transfer		14,368 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 12

Unit 1 Reactor Building El. 201'

Safeguard System Access Area Room 200

Fire Area 42A

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P.O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Safeguard System Access Area, Room 200, on the 201' elevation of the Unit 1 Reactor Building (Fire Area 42A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 8611 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of the cable insulation located in cable trays. The total surface area of the cable trays is 684 ft^2 with an average combustible loading of 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in the area.

3. VENTILATION PARAMETERS

There are four doors which enter the area. All doors measure 3' wide by 7' high. Two doors are located on the south wall, one door on the east wall and one door on the north wall.

4. CASES EXAMINED

Three cases were examined. Case number one considered all cables in the area burning simultaneously with one door open. Case number two considered all cables burning simultaneously with two doors open. Case number three considered all cables burning simultaneously with three doors open.

5. RESULTS

Case number one considered all cables burning simultaneously with a 3' x 7' door open. This resulted in a ventilation controlled fire with a heat output of 4504 kW, and a duration of 95 minutes. The gas temperature at this time would be 814°F which is below the critical temperature of the structural steel (see Attachment B).

Case number two considered all cables burning simultaneously with two 3' x 7' doors open. This resulted in a ventilation controlled fire with a heat output of 9008 kW and a duration of 46 minutes. The gas temperature at this

time would be 1065°F which is below the critical temperature of the structural steel (see Attachment B).

Case number three considered all cables burning simultaneously with three 3' x 7' doors open. This resulted in a fuel controlled fire with a heat output of 12,078 kW and a duration of $3.5\ lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2} = 35$ minutes.

The gas temperature at this time would be 1203°F which is above the critical temperature of the structural steel (see Attachment B).

The position of cable trays relative to structural steel members were examined throughout the area in order to assess the potential for localized heating. Cable tray ICCTA is located within 12 inches of member types W30X99, W33X152, W27X84, W24X76, W24X68, W27X114, W21X44, and W21X55.

Attachment C contains the results of calculations performed to determine the response of the structural steel members to localized heating. These calculations are conservative because they assume that the entire length of the structural steel member is subjected to 1300°F when, in actuality, only a small section of the steel would be subjected to localized heating. As can be seen from the results, member types W30X99, W27X84, W24X76, W24X68, W27X114, W21X44 and W21X55 exceeded the localized failure temperature of 1100°F during the 35 minute exposure period (time required for tray to burn to completion).

Columns in the area are W14X730. When exposed to plume temperatures of 1500°F for 35 minutes, the steel temperature does not exceed 500°F.

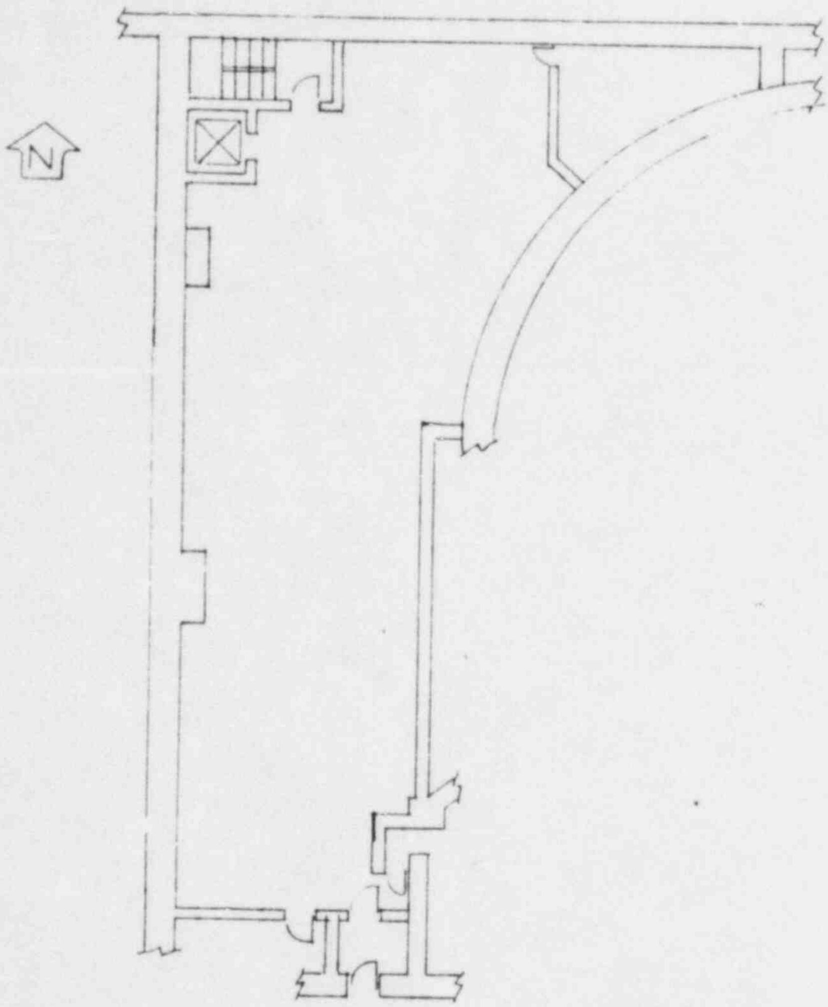
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 35 minutes. The temperature at this time exceeded 1100°F, therefore, no transient materials were quantified.

The ceiling height in the area is 12 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W33X141.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	2,952	
1300	4,007	35 min
1500	5,062	24 min



Unit 1 Reactor Building El. 201'
Safeguard System Access Area Room 200

Surface Area Calculation

Walls		
North wall	(61' x 15')	894 ft^2
East wall	[(71' + 59') x 15']	1929 ft^2
South wall	(29' x 15')	393 ft^2
West wall	(123' x 15')	1765 ft^2
Ceiling		3630 ft^2
Total Surface Area for Heat Transfer		8611 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	21.0	7.0	8611	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	618
10	632
15	645
20	657
25	668
30	680
35	691
40	702
45	712
50	723
55	733
60	744
65	754
70	764
75	774
80	784
85	794
90	804
95	814

ATTACHMENT B

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: TWO DOORS OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	42.0	7.0	8611	9008

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	804
4	818
6	830
8	842
10	854
12	866
14	878
16	890
18	902
20	913
22	925
24	937
26	949
28	961
30	972
32	984
34	996
36	1007
38	1019
40	1030
42	1042
44	1053
46	1065

CASE NUMBER: 3
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: THREE DOORS OPEN ALL CABLES BURNING

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	63.0	7.0	8611	12078

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	928
10	974
15	1020
20	1066
25	1112
30	1158
35	1203

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x44

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 44
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.94

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	614
10.00	918
15.00	1088
20.00	1182
25.00	1234
30.00	1263
35.00	1280

ATTACHMENT C

CASE NUMBER: 2
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x55

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 55
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.01

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	511
10.00	795
15.00	977
20.00	1093
25.00	1167
30.00	1215
35.00	1246

ATTACHMENT C

CASE NUMBER: 3
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x68

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 68
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.06

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	502
10.00	783
15.00	965
20.00	1083
25.00	1159
30.00	1209
35.00	1241

ATTACHMENT C

CASE NUMBER: 4
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x76

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 76
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.09

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	458
10.00	724
15.00	907
20.00	1031
25.00	1116
30.00	1174
35.00	1214

CASE NUMBER: 5
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 84
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	461
10.00	728
15.00	911
20.00	1035
25.00	1119
30.00	1177
35.00	1216

ATTACHMENT C

CASE NUMBER: 6
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x114

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 114
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.89

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	362
10.00	586
15.00	756
20.00	886
25.00	985
30.00	1060
35.00	1117

CASE NUMBER: 7
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x99

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 99
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATI (deg.F)
5.00	430
10.00	686
15.00	866
20.00	994
25.00	1084
30.00	1147
35.00	1192

ATTACHMENT C

CASE NUMBER: 8
BUILDING: UNIT 1 REACOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARD SYSTEM ACCESS AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x152

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 152
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.27

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	333
10.00	541
15.00	704
20.00	832
25.00	932
30.00	1011
35.00	1073

ATTACHMENT C

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 13

Unit 1 Reactor Building El. 201'

Cooling Water HX Area Room 207

Fire Area 41

Prepared by: W F Wahl

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Cooling Water Heat Exchanger Area Room 207 on the 201' elevation of the Unit 1 Reactor Building (Fire Area 41). The bounding walls of the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 8985 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of cable insulation located in cable trays. The total surface area of cable trays is 702 ft^2 with an average combustible loading of 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There are two doors which enter this area. Both measure 3' wide by 7' high. One door is located in the east wall and the other is located in the west wall and enters stair No. 2.

4. CASES EXAMINED

Two cases were examined, each assuming that all the cable trays in the area were burning simultaneously. Case number one assumed one door open while case number two assumed both doors open.

5. RESULTS

Case number one assumed all cables burning simultaneously with one 3' x 7' door open. This resulted in a ventilation controlled fire with a burning rate of 4504 kW and a duration of 90 minutes. The gas temperature at this time would be 781°F which is below the critical temperature of the structural steel (see Attachment B).

Case number two assumed all cables burning simultaneously with both 3' x 7' doors open. This resulted in a ventilation controlled fire with a burning rate of 9008 kW and a duration of 45 minutes. The gas temperature at this time would be 1028°F which is below the critical temperature of the structural steel (see Attachment B).

The position of cable trays relative to structural members were examined throughout the area in order to assess the potential for localized heating. Cable tray 1DCQA is located within 12 inches of member types W27X84, W21X44, W18X40 and W27X102.

Attachment C contains the results of calculations performed to determine the response of the structural steel members to localized heating. These calculations are conservative because they assume that the entire length of the structural steel member is subjected to a temperature of 1300°F when, in actuality, only a small section of the steel would be subjected to localized heating. As can be seen from the results, member types W18X40, W21X44, W27X84 and W27X102 exceeded the single point failure temperature of 1100°F during the 35 minute exposure period (time required for tray to burn to completion).

Columns in this area are W14X342 and W14X550. When exposed to a plume temperature of 1500°F, the steel temperature of the W14X342 reaches 1000°F in 55 minutes and the steel temperature of the W14X550 reaches 876°F in 65 minutes.

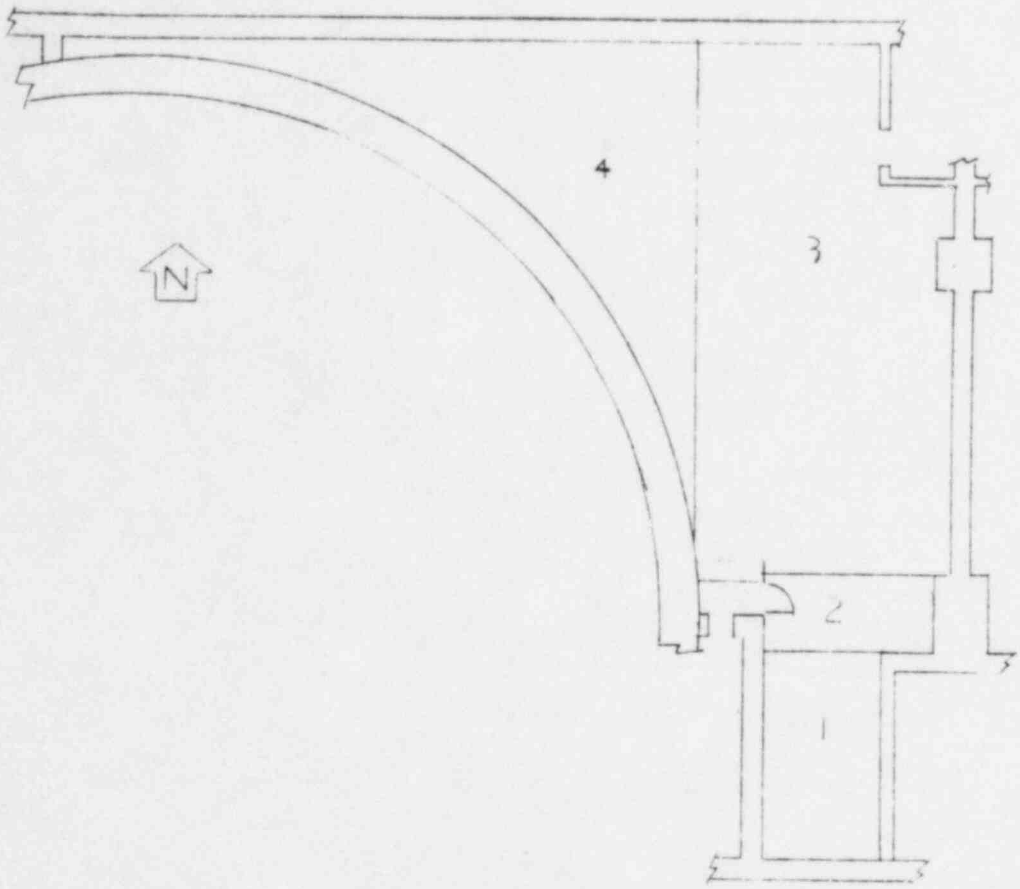
6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled with a duration of 45 minutes. The temperature at this time was 1028°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 12 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W33X141.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	2,952	
1300	4,007	35 min
1500	5,062	24 min



Unit 1 Reactor Building El. 201'
Cooling Water Heat Exchanger Area Room 207

Surface Area Calculation

Walls

North wall	(95' x 15')	1425 ft^2
East wall	(132' x 15')	1980 ft^2
South wall	(33' x 15')	495 ft^2
West wall	(105' x 15')	1575 ft^2
		5475 ft^2

Ceiling

Area 1	(12' x 48')	576 ft^2
Area 2	(19' x 11')	209 ft^2
Area 3	(29' x 74') - (18' x 8')	2002 ft^2
Area 4	1/2(48')(32')	768 ft^2
		3555 ft^2

Total Surface Area for Heat Transfer 9030 ft^2

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA RM 207
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	9030	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	606
10	619
15	631
20	643
25	654
30	664
35	675
40	685
45	695
50	705
55	715
60	725
65	734
70	744
75	753
80	763
85	772
90	781

ATTACHMENT B

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA RM 207
CASE DESCRIPTION: TWO DOORS OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	42.0	7.0	9030	9008

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	808
10	836
15	864
20	892
25	919
30	947
35	974
40	1001
45	1028

ATTACHMENT B

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA ROOM 207
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x40

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 40
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.38

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	601
10.00	903
15.00	1075
20.00	1172
25.00	1227
30.00	1259
35.00	1277

ATTACHMENT C

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA ROOM 207
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x44

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 44
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.94

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	614
10.00	918
15.00	1088
20.00	1182
25.00	1234
30.00	1263
35.00	1280

ATTACHMENT C

CASE NUMBER: 3
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA ROOM 207
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 84
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	461
10.00	728
15.00	911
20.00	1035
25.00	1119
30.00	1177
35.00	1216

ATTACHMENT C

CASE NUMBER: 4
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' COOLING WATER HX AREA ROOM 207
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x102

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 102
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.85

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	395
10.00	635
15.00	811
20.00	941
25.00	1036
30.00	1106
35.00	1158

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 14

UNIT 1 Reactor Building El. 253'

Main Steam & Feedwater Pipe Tunnel

Fire Zone 46

Prepared by: W. F. Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Main Steam and Feedwater Pipe Tunnel on the 253' elevation of the Unit 1 Reactor Building (Fire Area 46). The bounding walls in the area are of reinforced concrete with an average thickness of 3.5 feet. The total surface area for heat transfer is approximately 5858 ft^2. (See Attachment A for a sketch of the area under consideration and a calculation of areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There is one 3' wide by 5'10" high door serving this area.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

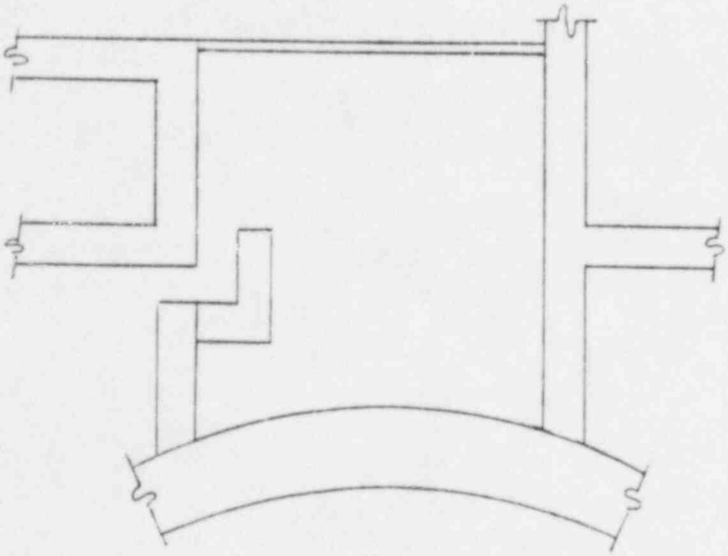
5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

This area has no fixed combustibles. There is one door measuring 3' wide by 5'10" high entering this area. This corresponds to a ventilation controlled heat output of 3417 kW. A fire of this heat rate could burn for a maximum of 200 minutes without reaching a temperature of 1100°F.

Plume effects from floor level transients are negligible because of the high ceiling.



Unit 1 Reactor Building El. 253'
Main Steam and Feedwater Pipe Tunnel Fire Zone 46

Surface Area Calculation

Walls		
North wall	(40' x 29')	1160 ft^2
East wall	(40' x 33')	1320 ft^2
South wall	(40' x 30')	1200 ft^2
West wall	(40' x 33')	1320 ft^2
		5000 ft^2

Ceiling

Area 1 (30' x 30') - [(3.5' x 3.5') + (10' x 3')] 857.75 ft^2

Total Surface Area for Heat Transfer 5857.75 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 15

Unit 1 Reactor Building El. 217'

Safeguard System Area Room 309

Fire Area 43

Prepared by: W F Wohl　　Date: February 7, 1984

Reviewed by: [signature]　　Revision: 1

P. O. Bo[illegible] • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Safeguard System Area, Room 309, on the 217' elevation of the Unit 1 Reactor Building (Fire Area 43). Bounding walls to the north, south, and east are of reinforced concrete construction while the west wall is of concrete masonry unit construction. The average wall thickness is 2 ft. The total surface area for heat transfer is 13,777 ft^2 (see Attachment A for sketch and surface area calculations).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of two cable trays, 10CRA and 10IWA, which are located along the south wall of the area. The total surface area of the cable trays is 460 ft^2 with an average combustible loading of 6.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Two steam tight doors each measuring 3' wide by 7' high enter this area. One door is located in the east wall while the other door is located in the west wall.

4. CASES EXAMINED

Two cases were examined for this area. The first case assumed all cable trays in the area to be burning simultaneously with one door open. The second case assumed all cable trays burning simultaneously with two doors open.

5. RESULTS

Case number one assumed one 3' x 7' door open with all cables burning simultaneously. This resulted in a ventilation controlled fire with a heat output of 4504 kW and a duration of 120 minutes. The gas temperature at this time would be 643°F which is below the critical temperature of the structural steel (see Attachment B).

Case number two assumed both 3' x 7' doors open with all cables burning simultaneously. This resulted in a fuel controlled fire with a heat output

of 8123 kW. The fire duration would be $6.5 \text{ lbs/ft}^2 \div \frac{.1 \text{ lbs}}{\text{min/ft}^2} = 65$ minutes.

The gas temperature at this time would be 808°F, which is below the critical temperature of the structural steel (see Attachment B).

The location of the cable trays relative to structural steel members was examined in the area. No cable trays were positioned so as to present a localized heating exposure to structural steel.

Columns in the area are W14X730, W14X550, and W14X287. When exposed to a plume temperature of 1500°F, the temperatures of the steel columns are as follows:

W14X730	757°F after 65 minutes
W14X550	876°F after 65 minutes
W14X287	1000°F after 47 minutes

6. EFFECTS OF TRANSIENT COMBUSTIBLES

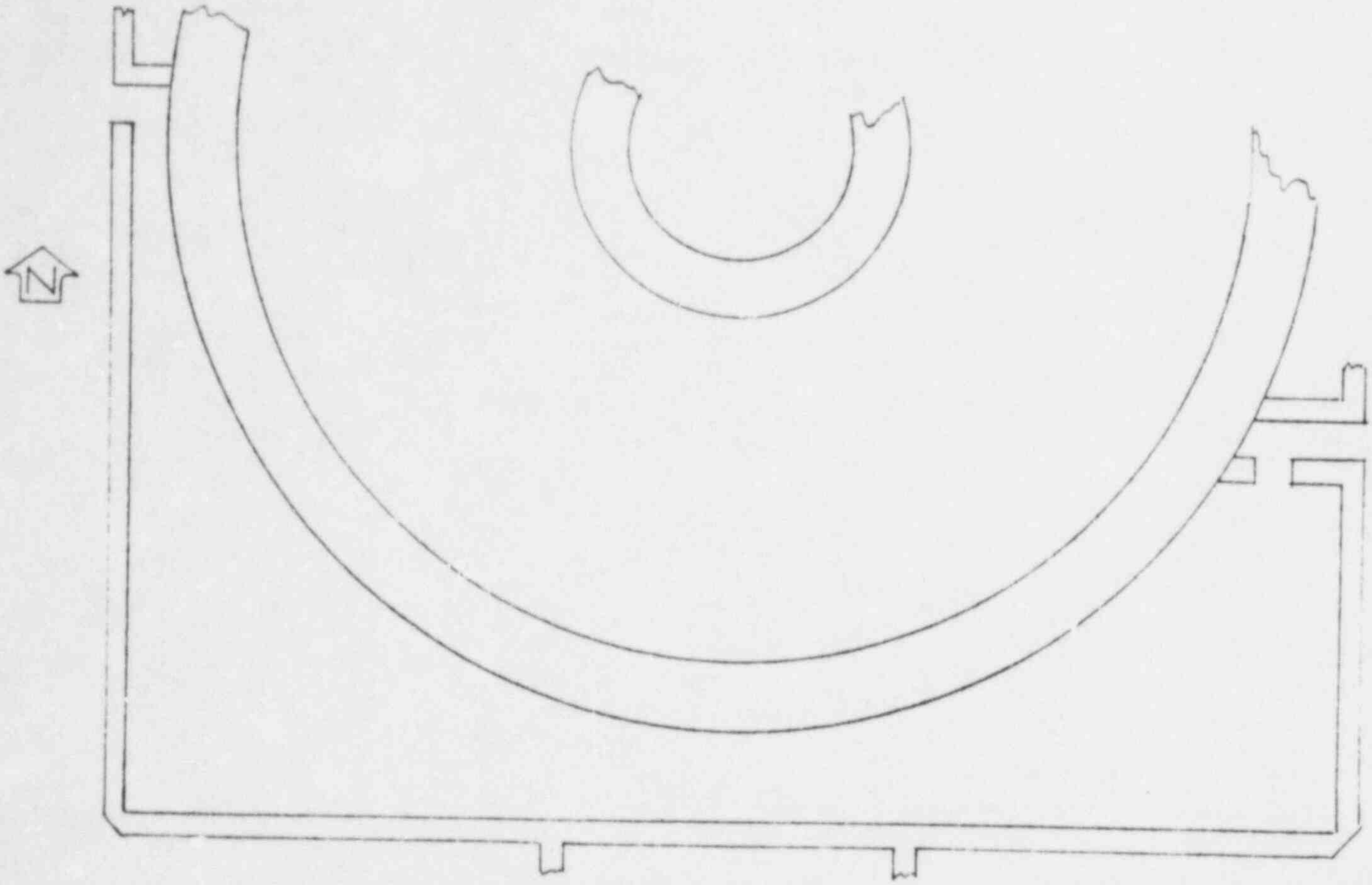
The fire examined was fuel controlled with a duration of 65 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m²)	Q (kW)
65 min	10	4630

The ceiling height in the area is 18'6". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W18X50.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	10,123	
1300	13,076	19 min
1500	16,450	13 min



Unit 1 Reactor Building El 217'
Safeguard System Area Room 309

Surface Area Calculation

Walls		
North wall	(140' x 35')	4900 ft^2
South wall	(107' x 35')	3745 ft^2
East wall	(31' x 35')	1085 ft^2
West wall	(62' x 35')	2170 ft^2
		11,900 ft^2
Ceiling		
Area 1	(7' x 107')	749 ft^2
Area 2	1/2(32' x 36')	576 ft^2
Area 3	1/2(48' x 23')	552 ft^2
Total Surface Area for Heat Transfer		13,777 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' SAFEGUARD SYSTEM AREA ROOM 309
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	21.0	7.0	13777	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	514
20	530
30	543
40	556
50	568
60	579
70	590
80	601
90	612
100	623
110	633
120	643

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' SAFEGUARD SYSTEM AREA ROOM 309
CASE DESCRIPTION: TWO DOORS OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	42.0	7.0	13777	8123

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	650
10	666
15	680
20	694
25	708
30	721
35	734
40	746
45	759
50	771
55	784
60	796
65	808

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 16

Unit 1 Reactor Building El. 217'

General Floor Area Northeast Corner

Fire Area 44

Prepared by: W. F. Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the general floor area on the 217' elevation of the Unit 1 Reactor Building (Fire Area 44). The heaviest combustible loading encountered on this elevation is found in the northeast corner. The area of heaviest combustible loading is bounded by column lines 19.4 & 23 and J & Fb (see Attachment A for a sketch of the area under consideration). The bounding walls in the area are of reinforced concrete with an average thickness of 3 ft. The total surface area for heat transfer is 11,309 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

   The heaviest concentration of cabling found within this area was centered along column line 21.5. The average combustible loading of the cable trays in this area is 3.2 lb/ft^2 of tray surface area. There are no combustible liquids in this area. Enclosed combustibles are not included in the combustible loading.

3. VENTILATION PARAMETERS

   The area under consideration is open to the remainder of this elevation on its south side. This opening is approximately 13 ft. wide by 35 ft. high.

4. CASES EXAMINED

   A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 ft per hour. The fire will spread along all of the horizontal cable trays intersecting the point source for a distance of 5 feet in each direction before the original point source dies out after 32 minutes. A maximum surface area of 186 ft^2 of cable trays (see Attachment B for a list of trays) will be involved at any one time, which corresponds to a heat output of 3284 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less since the quantity of cabling that would be involved at any one time would be less.

5. RESULTS

The fire duration was taken to be 180 minutes and the fire temperature reached after 3 hours was 650°F which is below the critical temperature for the structural steel (see Attachment C for results of analysis). Since the fire was assumed to occur in the area of heaviest combustible loading, the results are considered to be representative for the entire general floor area on the 217' elevation of the Reactor Building.

The location of cable trays relative to structural steel members were examined throughout the 217' elevation of the Reactor Building in order to assess the potential for localized heating. A stack of 4 cable trays were positioned 2'6" below a G7 girder so as to present a localized heating exposure to structural steel. When exposed to the 1300°F plume temperature for 32 minutes the girder will be heated to 700°F.

Columns in the area are W14X550 and W14X287. When exposed to a plume temperature of 1500°F, the steel temperatures of the columns are as follows:

W14X550	876°F after 65 minutes
W14X287	1000°F after 47 minutes

C. EFFECTS OF TRANSIENT COMBUSTIBLES

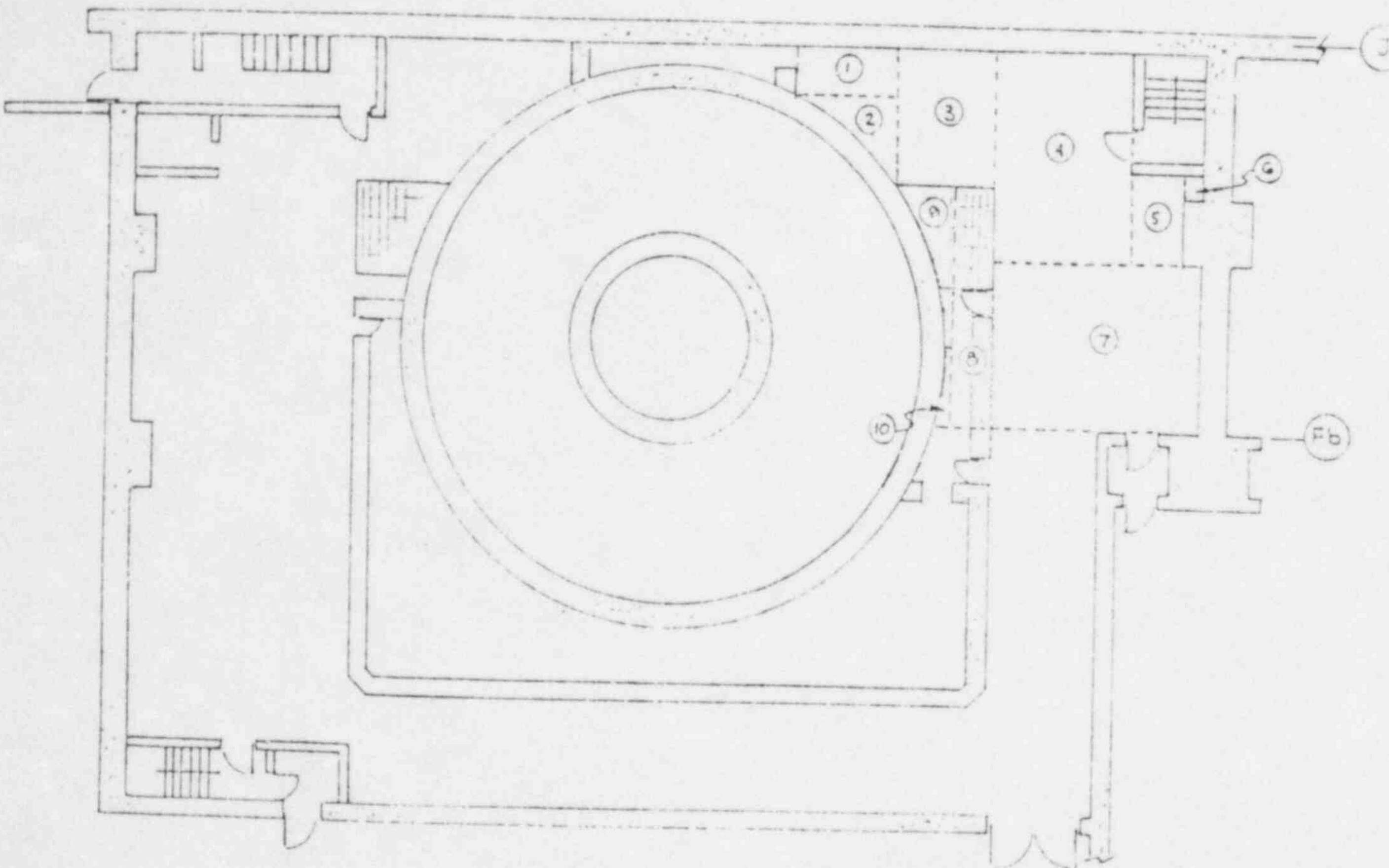
The fire examined was fuel controlled with a duration of 180 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
3 hours	6.5	3547

The ceiling height in the area is 30 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a G7 48".

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	>21,089	
1300	>21,089	
1500	>21,089	



Unit 1 Safeguard Systems El. 217' Northeast Corner

Surface Area Calculation

Walls		
North wall	(51' x 34.5')	1759.5 ft^2
North wall stairway	(8' x 34.5')	276 ft^2
East wall stairway	(18' x 34.5') - (3' x 7' door)	600 ft^2
West wall (H to Fb)	(51' x 24')	1224 ft^2
East wall (stairway to Fb)	(55' + 2' x 3') x 34.5'	2104.5 ft^2
South wall at H	(13' x 24')	312 ft^2
South wall at Fb	(10.5' x 34.5') - (3' x 7' door)	341 ft^2
Drywell to Fb	(30.5' x 34.5') + (51' x 24')	2276 ft^2
		8893 ft^2

ATTACHMENT A

Ceiling

Area 1	(5' x 24')	120 ft^2
Area 2	1/2 (24' x 19') - 42 ft^2	186 ft^2
Area 3	(24' x 13')	312 ft^2
Area 4	(31' x 16')	496 ft^2
Area 5	(13' x 5')	65 ft^2
Area 6	(4' x 3')	12 ft^2
Area 7	(21' x 42')	882 ft^2
Area 8	(49' x 5')	245 ft^2
Area 9	1/2(28' x 8') - 42 ft^2	70 ft^2
Area 10	1/2(21' x 4') - 14 ft^2	28 ft^2
		2416 ft^2

Total Surface Area for Heat Transfer 11,309 ft^2

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in)	Length (ft)	Surface Area (ft^2)
1BCTA70	24"	17'	34
1BCVA70	24"	17'	34
1BCVA70	24"	17'	34
1BCWA70	24"	10'	20
1OCRA63	24"	6'	12
1OCRA62	24"	4'	8
1OIWA63	24"	8'	16
)IXA62	24"	2'	4
1OIWA62	24"	2'	4
1OIXA70	24"	10'	20
			186 ft^2

Average Combustible Loading per Tray Surface Area = 3.2 lb/ft^2

Fire Duration for Free Burning Tray Fires =

$$3.2\ lb/ft^2 \div \frac{0.1\ lb}{ft^2/min} = 32 \text{ minutes}$$

Heat output with all trays in source fire area (above) burning simultaneously:

$$\frac{186\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 3284\ kW$$

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in)	Length (ft)	Surface Area (ft^2)
1BCTA70	24"	17'	34
1BCVA70	24"	17'	34
1BCVA70	24"	17'	34
1BCWA70	24"	10'	20
10CRA63	24"	6'	12
10CRA62	24"	4'	8
10IWA63	24"	8'	16
10IXA62	24"	2'	4
10IWA62	24"	2'	4
10IXA70	24"	10'	20
			186 ft^2

Average Combustible Loading per Tray Surface Area = 3.2 lb/ft^2

Fire Duration for Free Burning Tray Fires =

$$3.2\ lb/ft^2 \div \frac{0.1\ lb}{ft^2/min} = 32 \text{ minutes}$$

Heat output with all trays in source fire area (above) burning simultaneously:

$$\frac{186\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 3284\ kW$$

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' GENERAL FLOOR AREA
CASE DESCRIPTION: SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	452.0	35.0	11309	3284

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	488
20	501
30	513
40	524
50	535
60	545
70	555
80	564
90	574
100	583
110	592
120	600
130	609
140	617
150	626
160	634
170	642
180	650

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 17

Unit 1 Reactor Building El. 217'

General Floor Area Southeast Corner

Fire Area 44

Prepared by: W. F. Mahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Southeast Corner of the General Floor Area on the 217' elevation of the Unit 1 Reactor Building (Fire Area 44). Bounding walls are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 7722 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

The heaviest concentration of cabling found within this area is along the east wall which borders the railroad bay where cable trays are stacked four high. The average combustible loading of the cable trays in this area is 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

The area under consideration is open to the remainder of the 217' elevation of the Reactor Building.

4. CASES EXAMINED

A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread along all of the horizontal cable trays intersecting the point source for a distance of 6 feet in each direction before the original point source dies out after 35 minutes. A maximum surface area of 96 ft^2 of cable trays (see Attachment B for a list of trays) will be involved at any one time, which corresponds to a heat output of 1700 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less since the quantity of cabling that would be involved at any one time would be less.

5. RESULTS

The fire duration was taken to be 180 minutes and the gas temperature reached after 3 hours would be 550°F which is below the critical temperature for the structural steel (see Attachment C).

The location of cable trays relative to structural steel members were examined throughout the area in order to assess the potential for localized heating. A stack of 4 cable trays were positioned 2' below the W27X84 beams so as to present a localized heating exposure to the structural steel.

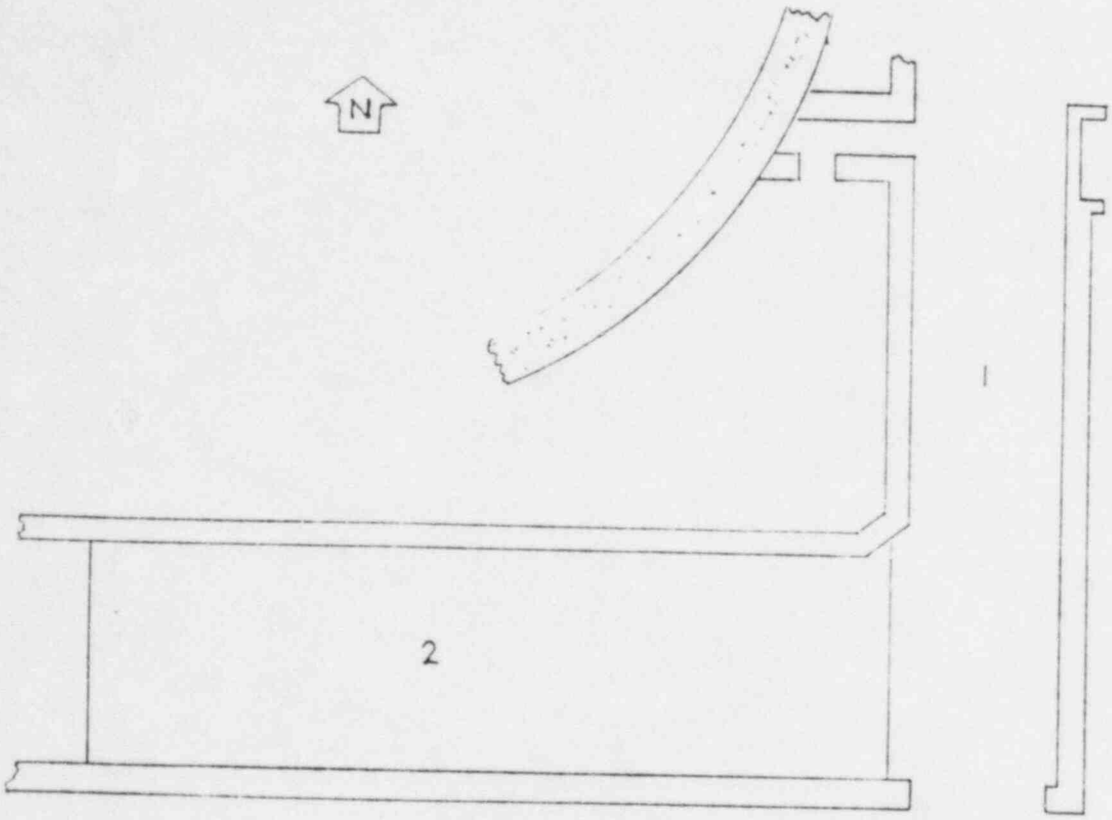
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 180 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
3 hours	6.5	2964

The ceiling height in the area is 32'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W27X84.

Plume effects from floor level transients are negligible.



Unit 1 Reactor Building El. 217'
Southeast Corner

Surface Area Calculation

Area 1		
South wall	(14' x 34')	476 ft^2
East wall	(58' x 34')	1972 ft^2
West wall	(34' x 34')	1156 ft^2
Area 2		
North wall	(38' x 34')	1292 ft^2
South wall	(38' x 34')	1292 ft^2
Ceiling	(58' x 14') + (38' x 19')	1534 ft^2
Total Surface Area for Heat Transfer		7722 ft^2

ATTACHMENT A

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in.)	Length (ft.)	Surface Area (ft^2)
1BCTA56	24	6	12
1BCTA58	24	6	12
1BCVA56	24	6	12
1BCVA57	24	6	12
1BCUA56	24	6	12
1BCUA57	24	6	12
1BCWA56	24	6	12
1BCWA57	24	6	12
			96 ft^2

Average combustible loading pe. ›y surface area = 3.5 lbs/ft^2

Heat output with all trays listed above burning simultaneously:

$$\frac{96\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 1700\ kW$$

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' SOUTH EAST
CASE DESCRIPTION: SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	432.0	24.0	7722	1700

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	430
20	441
30	450
40	458
50	466
60	474
70	481
80	488
90	495
100	501
110	508
120	514
130	520
140	526
150	532
160	538
170	544
180	550

ATTACHMENT C

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 18

Unit 1 Reactor Building El. 217'

General Floor Area Northwest Corner

Fire Area 44

Prepared by: W F Mahl

Date: February 7, 1984

Reviewed by: [signature]

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Northwest Corner of the General Floor Area on the 217' elevation of the Unit 1 Reactor Building (Fire Area 44). Bounding walls are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 7706 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

The heaviest concentration of cabling found within this area is along the west wall in the southwest corner of the area. The average combustible loading of the cable trays in this area is 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

The area under consideration is open to the remainder of the 217' elevation of the Reactor Building.

4. CASES EXAMINED

A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread along all of the horizontal cable trays intersecting the point source for a distance of 6 feet in each direction before the original point source dies out after 35 minutes. A maximum surface area of 120 ft^2 of cable trays (see Attachment B for a list of trays) will be involved at any one time, which corresponds to a heat output of 2119 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less since the quantity of cabling that would be involved at any one time would be less.

5. RESULTS

The fire duration was taken to be 180 minutes and the gas temperature reached after 3 hours was 629°F which is below the critical temperature for the structural steel (see Attachment C for results of analysis). Since the fire was assumed to occur in the area of heaviest combustible loading, the results are considered to be representative for the entire area on the 217' elevation of the Reactor Building.

The location of cable trays relative to structural steel members were examined throughout the area in order to assess the potential for localized heating. Two cable trays were positioned 2' below a W27X94 beam so as to present a localized heating exposure to the structural steel.

Columns in this area are W14X730 and W14X87. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X730	757°F after 65 minutes
W14X87	1000°F after 14 minutes

6. EFFECT OF TRANSIENT COMBUSTIBLES

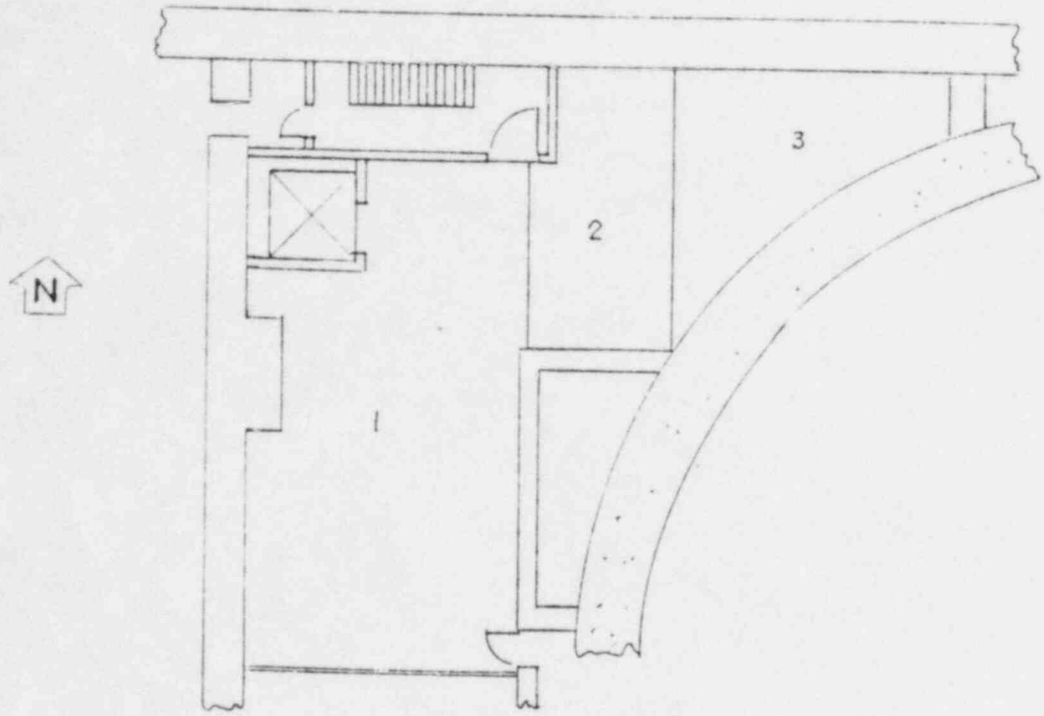
The fire examined was fuel controlled with a duration of 180 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which would result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
3 hours	6.5	2536

The ceiling height in the area is 30 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a G7 48".

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	>21,089	
1300	>21,089	
1500	>21,089	



Unit 1 Reactor Building El. 217'
Northwest Corner Fire Area 44

Surface Area Calculation

Walls

Area 1		
North wall	(24' x 34')	816 ft^2
East wall	(28' x 34')	952 ft^2
West wall	(44' x 34')	1496 ft^2
Area 2		
North wall	(10' x 34')	340 ft^2
South wall	(10' x 34')	340 ft^2
West wall	(8' x 34')	272 ft^2
Area 3		
North wall	(24' x 34')	816 ft^2
South wall	(30' x 34')	1020 ft^2
East wall	(5' x 34')	170 ft^2
		6222 ft^2
Ceiling		
Area 1	(44' x 24') - (10' x 10')	956 ft^2
Area 2	(24' x 10')	240 ft^2
Area 3	1/2 (24' x 24')	288 ft^2
		1484 ft^2
Total Surface Area for Heat Transfer		7706 ft^2

ATTACHMENT A

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in.)	Length (ft.)	Surface Area (ft^2)
1ACWA19	24	6	12
1ACVA19	24	6	12
1ACYA19	24	6	12
1ACXA19	24	6	12
1OCUA19	24	6	12
1ACWA20	24	6	12
1ACVA20	24	6	12
1ACYA20	24	6	12
1ACXA20	24	6	12
1OCUA20	24	6	12
			120 ft^2

Average combustible loading per tray surface area = 3.5 lbs/ft^2

Fire duration for free burning tray fires =

$$3.5\ lbs/ft^2 \div \frac{.1\ lbs}{ft^2/min} = 35\ minutes$$

Heat output with all trays in source fire area (above) burning simultaneously:

$$\frac{120\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 2119\ kW$$

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' NORTH WEST
CASE DESCRIPTION: SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	432.0	34.0	7706	2119

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	476
20	489
30	500
40	511
50	521
60	530
70	539
80	548
90	557
100	565
110	574
120	582
130	590
140	598
150	606
160	614
170	621
180	629

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK ATOMIC GENERATING STATION

Calculation No. 19

Unit 1 Reactor Building, El. 253'

General Floor Area

Fire Area 45A

Prepared by: W F Wall Date: February 7, 1984

Reviewed by: [signature] Revision: 1

P. O. Box 446 • [illegible]k Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the general floor area on the 253' elevation of the Unit 1 Reactor Building (Fire Area 45A). The heaviest combustible loading encountered on this elevation is found in the CRD Hydraulic Equipment Area and Neutron Monitoring System Area. The area of heaviest combustible loading is bounded by column lines 19.4 & 23 and J & Fa (see Attachment A for a sketch of the area under consideration). The total surface area for heat transfer is approximately 11,774 ft^2. The bounding walls are constructed of reinforced concrete with an average thickness of 1.5 ft.

2. COMBUSTIBLE LOADING

The heaviest concentration of cabling found within this area was along the east wall. The average combustible loading of the cable trays in this area is 4.7 lbs/ft^2 of tray surface area. There are no combustible liquids in this area. Enclosed combustibles are not included in the combustible loading.

3. VENTILATION PARAMETERS

The area under consideration is open to the remainder of this elevation on its south side. This opening is approximately 28.5 ft. wide and 29 ft. high.

4. CASES EXAMINED

A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread north and south along the east wall and westward a distance of 8 feet in each direction along the cable trays before the original point source dies out after 47 minutes. A maximum surface area of 386 ft^2 of cable trays (see Attachment B for a list of trays) will be involved at any one time, which corresponds to a heat output of 6816 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less since the quantity of cabling involved at any one time would be less.

5. RESULTS

The fire duration was taken to be 180 minutes and the fire temperature reached after 3 hours was 1045°F which is below the critical temperature for the structural steel (see Attachment C for results of analysis). Since the fire is assumed to occur in the area of heaviest combustible loading, the results are considered to be representative for the entire general floor area on the 253' elevation of the Reactor Building.

The positions of cable trays relative to structural steel members were examined throughout the 253' elevation of the Reactor Building in order to assess the potential for localized heating. Cable tray 1ACYC05 is located 12" below the bottom of a girder type G-52 (54WF366).

Attachment D contains the results of calculations performed to determine the response of the girder to localized heating. These calculations are conservative because they assume that the entire length of the girder is subjected to a temperature of 1300°F when in actuality only a small section of the steel would be subjected to localized heating. As can be seen from the results, the girder does not reach its single point failure temperature of 1100°F during the 50 minute exposure period (time required for a tray to burn to completion).

Columns in the area are W14X730, W14X665, W14X370, W14X550, W14X119, W14X342, and W14X87. When exposed to a plume temperature of 1500°F, the steel temperatures of the columns are as follows:

W14X730	757°F after 65 minutes
W14X665	795°F after 65 minutes
W14X370	1000°F after 58 minutes
W14X550	876°F after 65 minutes
W14X119	1000°F after 20 minutes
W14X342	1000°F after 55 minutes
W14X87	1000°F after 14 minutes

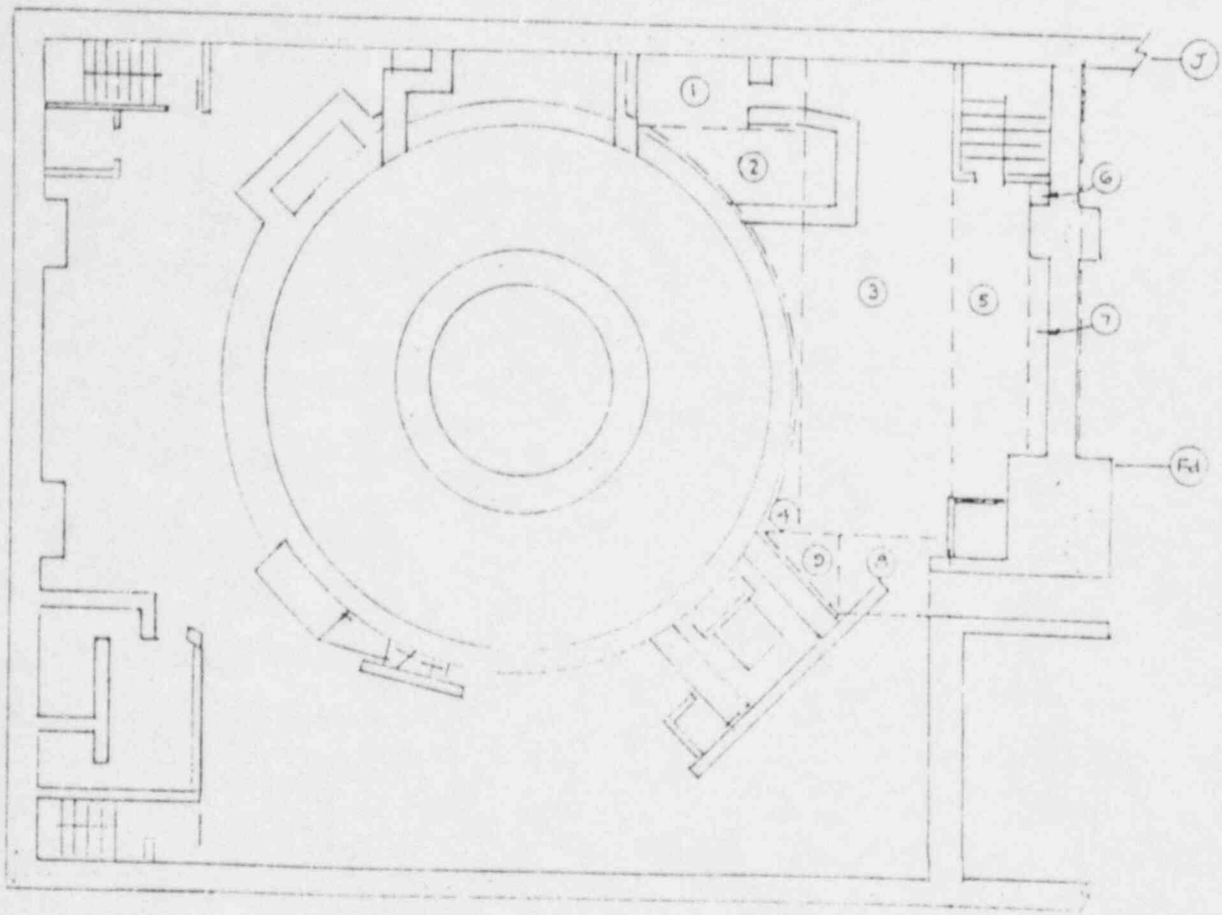
6. <u>EFFECTS OF TRANSIENT COMBUSTIBLES</u>

The fire examined was fuel controlled with a duration of 180 minutes. The temperature at this time was 1045°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 24 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a G52, 54".

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	19,192	
1300	>21,089	>50 min
1500	>21,089	42 min



Unit 1 Reactor Enclosure 253' El.

Surface Area Calculation

Walls

North wall above Neutron Mon.	(18' x 19')	342 ft^2
North wall Neut. Mon. to Stairway	(35' x 28.5')	997.5 ft^2
North wall stairwell	(8' x 28.5') - (3' x 7')	207 ft^2
East wall	(67' x 28.5')	1909.5 ft^2
Column North & South Faces East Wall	(16' x 28.5')	456 ft^2
Drywell Access Wall	(16' x 28.5')	456 ft^2
Drywell wall above Neutron Mon.	(22' x 19')	418 ft^2
Drywell wall from Neut. Mon. to Access	(49' x 28.5')	1396.5 ft^2
Neutron Monitoring Walls	(63' x 9.5') - (3' x 7')	577.5 ft^2
		6969 ft^2

ATTACHMENT A

Ceiling

Area 1	(27' x 11')	297 ft^2
Area 2	1/2(27' x 41') - 240 ft^2	313.5 ft^2
Area 3	(46' x 74')	3404 ft^2
Area 4	1/2([illegible] x 6') - 21 ft^2	45 ft^2
Area 5	(4' x 61')	244 ft^2
Area 6	(4' x 4')	16 ft^2
Area 7	(4' x 42')	168 ft^2
Area 8	(21' x 12')	252 ft^2
Area 9	1/2(11' x 12')	66 ft^2
		4805.5 ft^2

Total Surface Area for Heat Transfer = 11,774 ft^2

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in)	Length (ft)	Surface Area (ft^2)
1DCPA79	24"	2'	4
1OCAA74	24"	16'	32
1OCVA72	24"	5'	10
1OCBA72	24"	10'	20
1DCQA21	24"	12'	24
11CCA21	24"	16'	32
1OCZA21	24"	9.5'	19
1DCPA74	24"	7'	14
1CDPA75,76,78	24"	5'	10
1DCQA76	24"	11'	22
11CLA74	24"	11'	22
1OCDA74	24"	11'	22
1OIYA74	24"	11'	22
1OCZA74	24"	8'	16
11CCA74	24"	8'	16
1OCBA74	24"	8'	16
1OCDB13	24"	11.5'	23
1OIYB13	24"	15'	30
1OCDB12	24"	8'	16
1OIYB12	24"	8'	16
			386 ft^2

Average Combustible Loading per Tray Surface Area = 4.7 lb/ft^2

Fire Duration for Free Burning Cable Tray Fire =

$$4.7\ lb/ft^2 \div \frac{0.1\ lb}{ft^2/min} = 47\ minutes$$

Heat output with all trays in source fire area (above) burning simultaneously:

$$\frac{386\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 6816\ kW$$

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 253' NORTHEAST CORNER
CASE DESCRIPTION: SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
1.5	CONCRETE	826.0	29.0	11774	6816

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	661
20	688
30	714
40	739
50	764
60	788
70	811
80	834
90	857
100	879
110	901
120	923
130	944
140	965
150	985
160	1005
170	1025
180	1045

ATTACHMENT C

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 253' GENERAL FLOOR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G-52(54WF366)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 366
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 13.30

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	245
10.00	396
15.00	526
20.00	637
25.00	732
30.00	814
35.00	883
40.00	943
45.00	994
50.00	1038

ATTACHMENT D

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 20

Unit 1 Reactor Building El. 283'

General Floor Area

Fire Area 47A

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1983

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the general floor area on the 283' elevation of the Unit 1 Reactor Building (Fire Area 47A). The heaviest combustible loading encountered on this elevation is found in the northeast corner. The area of heaviest combustible loading is bounded by column lines 20 & 23 and J & H (see Attachment A for sketch of area). Bounding walls are of reinforced concrete construction with an average thickness of 3 ft. Total surface area for heat transfer is 6947 ft^2(645 m^2) (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

The heaviest concentration of cabling found within this area is located five feet to the west of column line 21.5. The average combustible loading of the cable trays in this area is 4 lbs/ft^2 of tray surface area. There are no combustible liquids in this area. Enclosed combustibles are not included in the combustible loading.

3. VENTILATION PARAMETERS

The area under consideration is open to the remainder of this elevation on its south side, however, there are several rooms at floor level that extend a height of 12 ft from the floor. This leaves a ventilation opening above these rooms approximately 54' wide by 17' high.

4. CASES EXAMINED

A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire is assumed to extend along the north wall and southwest, a distance of 7 feet before the original point source dies out after 40 minutes. A maximum surface area of 172 ft^2 of cable trays (see Attachment B for list of cable trays initially burning) will be involved at any one time, which corresponds to a heat output of approximately 3050 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less because concentrations of cabling that would be involved at any one time would be less.

5. RESULTS

The fire was assumed to last 3 hours with no action taken by plant personnel to extinguish the fire. The peak gas temperature reached was 854°F (see Attachment C) which is below the critical temperature for the structural steel. Since the fire was assumed to occur in the area of heaviest combustible loading, the results are considered to be representative for the entire general floor area on the 283' elevation of the Reactor Building.

The position of cable trays relative to structural steel members were examined throughout the 283' elevation of the Reactor Building in order to assess the potential for localized heating. Cable trays were encountered within 1 foot of type 36WF230 beams in numerous locations. Cable trays 1CCRA, 1CCTA, 1MIAB, and 1ACYA were positioned 12 inches below a 18WF45 beam located northeast of the drywell near column line 20.

Attachment D contains the results of calculations performed to determine the response of the structural members to localized heating.

These calculations are conservative because they assume that the entire length of the member is subjected to a temperature of 1300°F when in actuality only a small section of the steel would be subjected to localized heating. As can be seen from the results, member type 18WF45 exceeded the single point failure temperature of 1100°F during the 40 minute exposure period (time required for a tray to burn to completion). Attachment D includes a sketch showing the location of the structural member which will fail due to localized heating effects.

Columns in the area are W14X730, W14X665, and W14X87. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X730	757°F after 65 minutes
W14X665	795°F after 65 minutes
W14X87	1000°F after 14 minutes

6. <u>EFFECTS OF TRANSIENT COMBUSTIBLES</u>

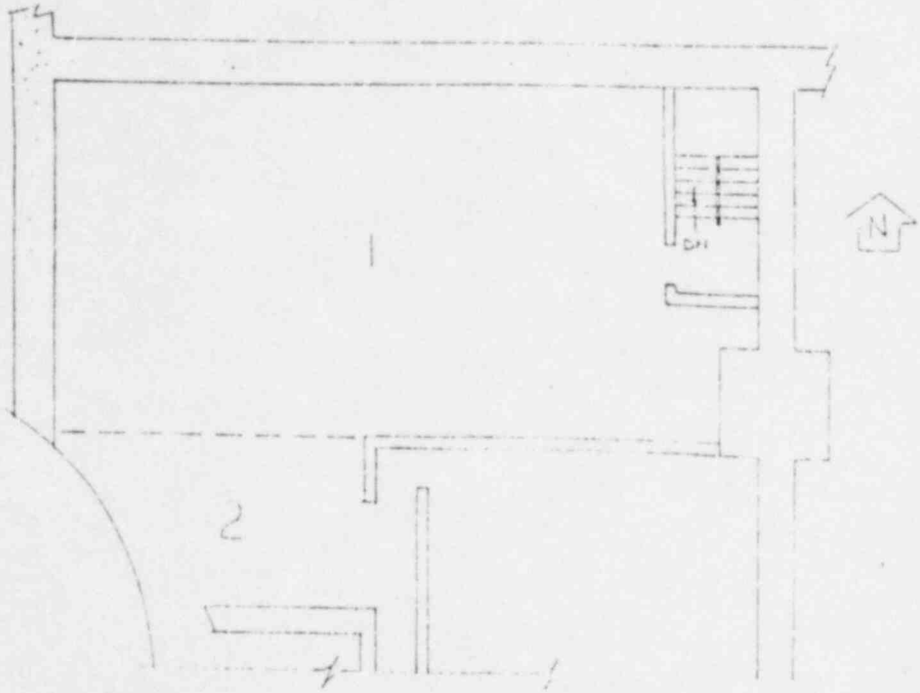
The fire examined was fuel controlled with a duration of 180 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
3 hours	6.5	1146

The ceiling height in the area is 24 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W36X300.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	19,192	
1300	>21,089	>50 min
1500	>21,089	45 min



Unit 1 Reactor Building El. 283'

Surface Area Calculation

Walls

North wall	(61' x 29')	1769 ft^2
South wall	(48' x 12')	576 ft^2
East wall	(44' x 29')	1276 ft^2
West wall	(46' x 29')	1334 ft^2
		4955 ft^2

Ceiling

Area 1	(30' x 60') - (18' x8' stairwell)	1656 ft^2
Area 2	(24' x 14')	336 ft^2
		1992 ft^2

Total Surface Area for Heat Transfer 6947 ft^2 (645 m^2)

ATTACHMENT A

Cable Trays

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to burn simultaneously.

Cable Tray No.	Tray Width (in)	Tray Length (ft)	Surface Area (ft^2)
1M1AC01-02	24	15	30
1M1AD01-02	24	15	30
1M1AE01-02	24	15	30
1OCVA18	24	15	30
1O1SA73	24	2	4
1BCWA91	24	7	14
1BCWA92	24	5	10
1BCWA80	24	7	14
1BCWA75	24	5	10
			172

$$\frac{172\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 3050\ kW$$

Average Combustible Loading per Tray Surface Area = 4.0 lb/ft^2

Fire Duration for Free Burning Tray Fires =

$$4.0\ lb/ft^2 \div \frac{0.1\ lb}{ft^2/min} = 40\ minutes$$

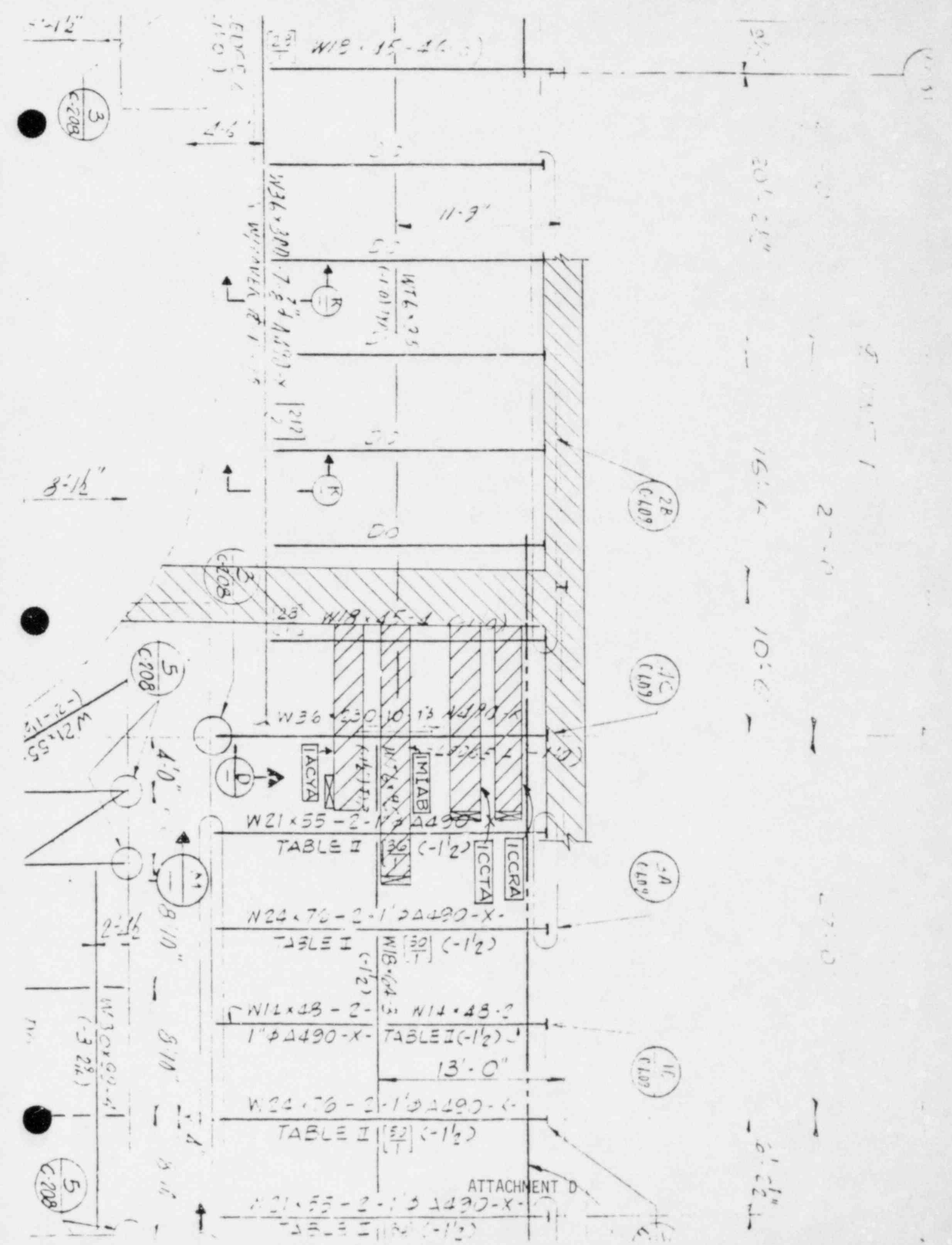
CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 283' NORTHEAST CORNER
CASE DESCRIPTION: ONE OPENING SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	918.0	17.0	6947	3050

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	586
20	606
30	625
40	642
50	659
60	676
70	692
80	708
90	724
100	739
110	754
120	769
130	784
140	798
150	812
160	826
170	840
180	854

ATTACHMENT C



ATTACHMENT D
W21×55-2-N♯Δ490-X
TABLE II (-1½)
W24×76-2-1"♯Δ490-X-
TABLE II (-1½)
W14×48-2-
W14×48-2
1"♯Δ490-X-
TABLE II (-1½)
13'-0"
W24×76-2-1"♯Δ490-X-
TABLE II (-1½)
W36×230-10-1⅜Δ490-X
W18×45-1
ICCRA
ICCTA
IMIAB
IACYA
W16×25
W36×300-7-⅞Δ490-X
DO
4'-0"
8'-10"
11'-9"
8'-1½"
16'-6"
10'-6"
2'-0"
W21×55

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 283' GENERAL FLOOR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE 18WF45

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 45
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.41

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	545
10.00	837
15.00	1016
20.00	1126
25.00	1193
30.00	1235
35.00	1268
40.00	1275

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 283' GENERAL FLOOR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE 36WF230

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 230
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.84

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	276
10.00	449
15.00	593
20.00	712
25.00	812
30.00	894
35.00	963
40.00	1020

ATTACHMENT D

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 21

Unit 1 Reactor Building El. 295'3"

Pipe Chase Service Room 523

Prepared by: W F [signature]

Reviewed by: [signature]

Date: February 7, 1984

Revision: 1

P. O. Box 4 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Pipe Chase Service Area, Room 523, on the 295'-3" elevation of the Unit 1 Reactor Building. Bounding walls are of reinforced concrete construction. The average wall thickness is 3.5 ft. The total surface area for heat transfer is 1742 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of cable insulation in cable trays. The total surface area of the cable trays is 104 ft^2 with an average combustible loading of 4.0 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

One door located in the west wall and measuring 3' wide by 7' high enters this area.

4. CASES EXAMINED

A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread along all of the horizontal cable trays intersecting the point source for a distance of 7 feet in each direction before the original point source dies out after 40 minutes. A maximum surface area of 104 ft^2 of cable trays (see Attachment B for a list of trays) will be involved at any one time, which corresponds to a heat output of 1836 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved would be less since the quantity of cabling that would be involved at any one time would be less.

5. RESULTS

The case examined assumed one 3' x 7' door open with a spreading cable fire. This resulted in a fuel controlled fire with a heat output of 1836

kW and a duration of 40 minutes. The gas temperature at this time would be 1035°F which is below the critical temperature of the structural steel (see Attachment C for results of analysis).

The location of cable trays relative to structural steel members was examined in the area to assess the potential for localized heating. Cable trays were positioned 16 inches below structural steel members of type W18X45.

Attachment D contains the result of the calculation performed to determine the response of the structural steel to localized heating. These calculations are conservative because they assume that the entire length of the structural steel member is subjected to 1300°F when, in actuality, only a small section of the steel would be subjected to localized heating. As can be seen from the results, member type W18X45 exceeded the single point failure temperature of 1100°F during the 40 minute exposure period (time required for tray to burn to completion).

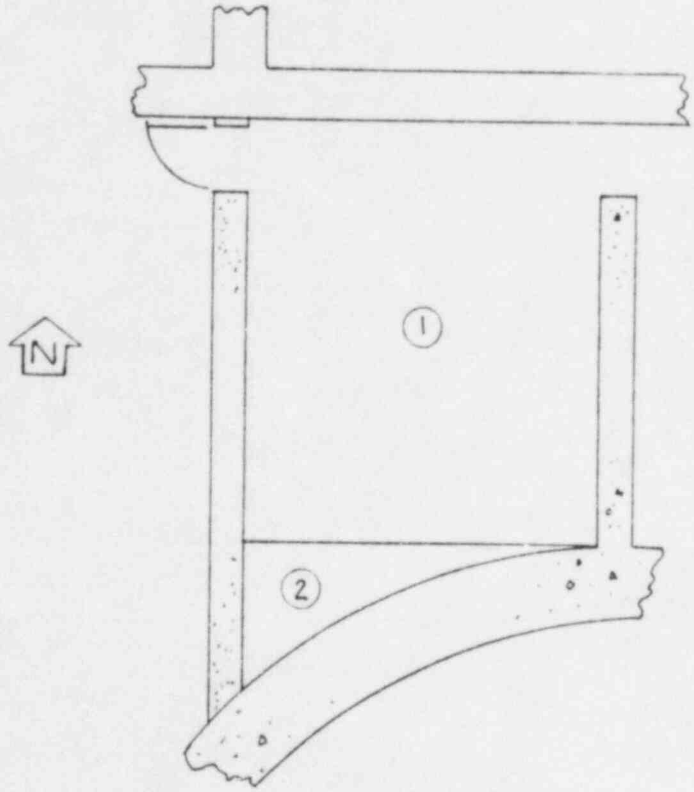
6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 40 minutes. The temperature at this time was 1035°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 14'9". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W18X45.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	5,800	
1300	8,436	19 min
1500	9,279	13 min



Unit 1 Reactor Building El. 295'-3"
Pipe Chase Service Room 523

Surface Area Calculation

Walls		
North wall	(16' x 17')	272 ft^2
South wall	(16' x 17')	272 ft^2
East wall	(21' x 17')	357 ft^2
West wall	(25' x 17')	425 ft^2
		1326 ft^2
Ceiling		
Area 1	(16' x 24')	384 ft^2
Area 2	1/2 (4' x 16')	32 ft^2
Total Surface Area for Heat Transfer		1742 ft^2

The following cable trays are present in the area defined for the source fire and all of the trays are assumed to be burning simultaneously:

Tray No.	Width (in.)	Length (ft.)	Surface Area (ft^2)
1ACXA95	24	5	10
1ACXA96	22	7	14
1ACYA95	24	5	10
1ACYA96	24	7	14
1MIAA01	24	14	28
1MIAB01	24	14	28
			104 ft^2

Average combustible loading per tray surface area = 4.0 lbs/ft^2

Fire duration for free burning tray fires =

$$4.0\ lb/ft^2 \div \frac{.1\ lb}{ft^2/min} = 40 \text{ minutes}$$

Heat output with all trays in source fire area (above) burning simultaneously:

$$\frac{104\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 1836\ kW$$

ATTACHMENT B

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 295.25' PIPE CHASE SERVICE AREA
CASE DESCRIPTION: ONE 3'x 7' DOOR OPEN SPREADING CABLE FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.5	CONCRETE	21.0	7.0	1742	1836

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	826
10	857
15	887
20	917
25	947
30	976
35	1006
40	1035

ATTACHMENT C

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOP BUILDING
ELEVATION AND AREA DESCRIPTION: 295'3 PIPE CHASE SERVICE ROOM
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x45

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 45
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.41

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	545
10.00	837
15.00	1016
20.00	1126
25.00	1193
30.00	1235
35.00	1260
40.00	1275

ATTACHMENT D

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 22

Unit 1 Reactor Building El. 313'

Laydown Area Room 601

Fire Area 48A

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Laydown Area, Room 601, on the 313' elevation of the Unit 1 Reactor Building (Fire Area 48A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 5136 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of the cable insulation in a single cable tray which runs north/south through the area. The total surface area of the cable tray is 90 ft^2 with an average combustible loading of 4 lbs/ft^2 of cable tray surface area. There are no combustible liquids in the area.

3. VENTILATION PARAMETERS

This area is open to the remainder of the 313' elevation of the Reactor Building.

4. CASES EXAMINED

With the light combustible loading in the area, the assumption that all cable trays are burning simultaneously would present the worst case. With all cables burning, a surface area of 90 ft^2 would be involved. This corresponds to a heat output of approximately 1600kW. With all combustibles burning simultaneously, the fire duration would be $4\ lbs/ft^2 \div \frac{.1\ lbs}{min\ ft^2} = 40$ minutes.

5. RESULTS

With all cable trays in the area burning simultaneously and the large ventilation opening, the resulting fire was fuel controlled. A gas temperature of 543°F was achieved after 40 minutes, which is below the critical temperature for the structural steel (see Attachment B).

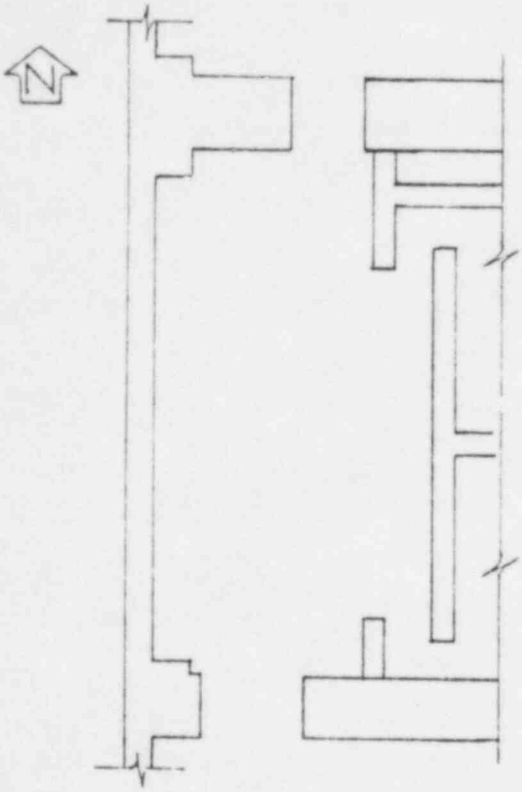
The position of the cable tray relative to structrual steel members was examined in the area. The cable tray was positioned so as not to present a localized heating exposure to the structural steel.

6. EFFECT OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 40 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
40 min	12	4127

Plume effects from floor level transients are negligible because of the high ceiling.



Unit 1 Reactor Building El. 313'
Laydown Area Room 601

Surface Area Calculation

Walls		
North wall	(12' x 38')	456 ft^2
South wall	(12' x 38')	456 ft^2
East wall	(48' x 38')	1824 ft^2
West wall	(48' x 38')	1824 ft^2
Ceiling		576 ft^2
Total Surface Area for Heat Transfer		5136 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 313' LAYDOWN AREA ROOM 601
CASE DESCRIPTION: ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	608.0	38.0	5136	1600

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	494
10	503
15	511
20	518
25	524
30	531
35	537
40	543

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 23

Unit 1 Reactor Building El. 313'

Laydown Area Room 602

Fire Area 48A

Prepared by: W F Wahl

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Laydown Area, Room 602, on the 313' elevation of the Unit 1 Reactor Building (Fire Area 48A). The bounding walls in the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 16,764 ft^2 (see Attachment A for sketch and surface area calculations).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of a single cable tray located along the north wall of the area. The total surface area of the cable tray is 164 ft^2 with an average combustible loading of 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

This area is open to the remainder of the 313' elevation by two large walkways in the south wall.

4. CASES EXAMINED

With the light combustible loading in this area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning a surface area of 164 ft^2 would be involved. This corresponds to a heat output of approximately 2900 kW. With all cables assumed to be burning simultaneously the duration of the fire would be

$$3.5\ lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2} = 35\ minutes.$$

5. RESULTS

With all cable trays in the area burning simultaneously, a gas temperature of 404°F was achieved after 35 minutes, which is below the critical temperature for the structural steel (see Attachment B). The cable tray in the area was positioned so as to not present a localized heating exposure to the structural steel.

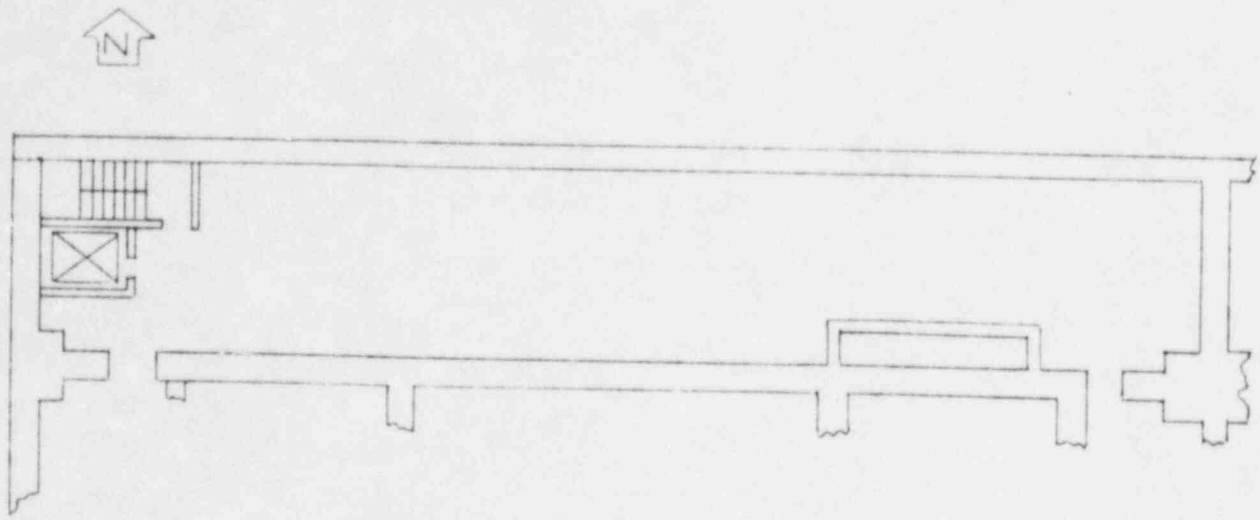
A W14X87 column is in the area. When exposed to a plume temperature of 1500°F, the steel temperature will reach 1000°F after 14 minutes.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 35 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
35 min	13	17,353

Plume effects from floor level transients are negligible.



Unit 1 Reactor Building El 313'
Laydown Area Room 602

Surface Area Calculation

Walls

North wall	(160' x 37')	5920 ft^2
South wall	(160' x 37')	5920 ft^2
East wall	(22' x 37')	814 ft^2
West wall	(22' x 37')	814 ft^2
		13,468 ft^2

Ceiling

160' x 22' - (18' x 8' + 10' x 8')
for stairwell elevation — 3296 ft^2

Total Surface Area for Heat Transfer — 16,764 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 313' LAYDOWN AREA ROOM 602
CASE DESCRIPTION: ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	222.0	37.0	16764	2900

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	378
10	384
15	389
20	393
25	397
30	401
35	404

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATICN

Calculation No. 24

Unit 1 Reactor Building El. 313'

Corridor Room 605

Fire Area 48A

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Corridor, Room 605, on the 313' elevation of the Unit 1 Reactor Building (Fire Area 48A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 12,460 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of the cable insulation located in cable trays. The total cable tray surface area is 508 ft^2 with an average combustible loadng of 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids in the area.

3. VENTILATION PARAMETERS

This area is open to the remainder of the 313' elevation of the Reactor Building.

4. CASES EXAMINED

All cables in the area were assumed to be burning simultaneously. With all cable trays burning a surface area of 508 ft^2 would be involved. This correspnds to a heat output of approximately 8970 kW. With all combustibles burning simultaneously, the fire duration would be $3.5\ lbs/ft^2 \div \frac{.1\ lbs}{min\ ft^2} =$ 35 minutes.

5. RESULTS

With all cable trays in the area burning simultaneously and the large ventilation opening, the resulting fire was fuel controlled. A gas temperature of 813°F would be achieved after 35 minutes, which is below the critical temperature for the structural steel (see Attachment B).

The position of the cable trays relative to structrual steel members were examined in the area. No cable trays were positioned so as to present a localized heating exposure to the structural steel.

6. EFFECT OF TRANSIENT COMBUSTIBLES

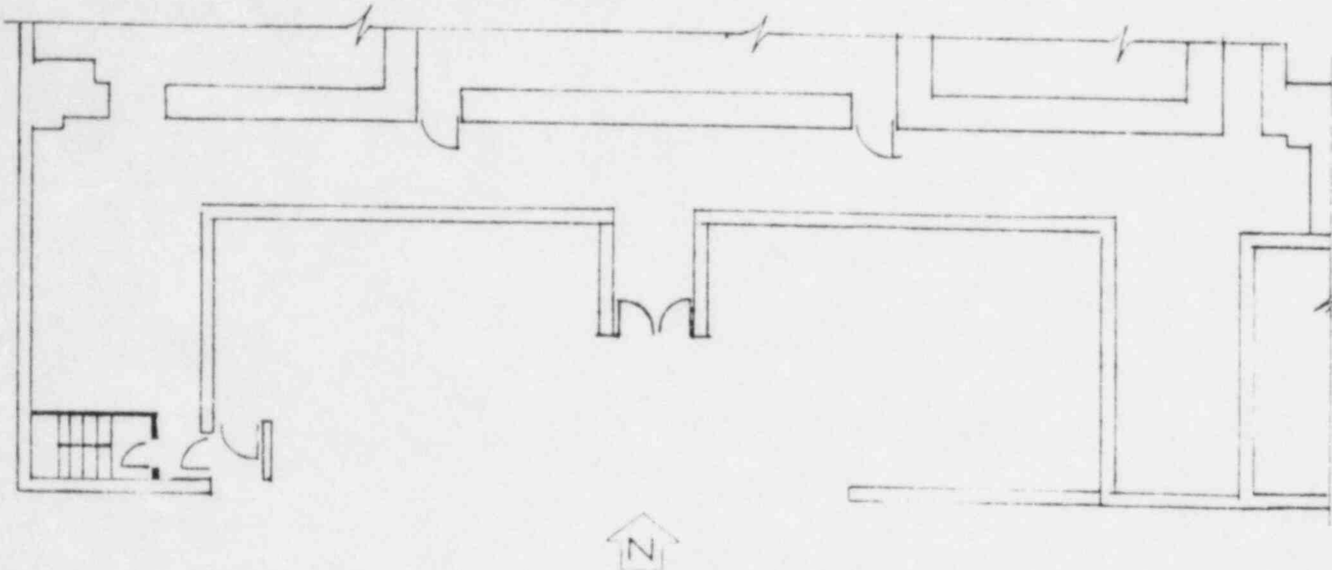
The fire examined was fuel controlled with a duration of 35 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
35 min	13	6083

The ceiling height in the area is 13'3". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W36X230.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4,323	
1300	5,000	49 min
1500	7,275	35 min



Unit 1 Reactor Building El. 313'
Corridor Room 605

Surface Area Calculation

Walls		
North wall	(160' x 38')	6080 ft^2
South wall	(112' x 38')	4256 ft^2
East wall	(9' x 38')	342 ft^2
West wall	(9' x 38')	342 ft^2
Ceiling	(160' x 9')	1440 ft^2
Total Surface Area for Heat Transfer		12,460 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 313' CORRIDOR ROOM 605
CASE DESCRIPTION: ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	304.0	38.0	12460	8970

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	707
10	726
15	744
20	762
25	779
30	796
35	813

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 25

Unit 1 Reactor Building El. 313'

Reactor Vent Supply Fan Room Room 607

Fire Area 49

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the Reactor Vent Supply Fan Room, Room 607, on the 313' elevation of the Unit 1 Reactor Building (Fire Area 49). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The majority of the south wall is louvers open to the outside. The total surface area for heat transfer is 7720 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

   Combustible loading in the area consists of the cable insulation located in cable trays. The total cable tray surface area is 89 ft^2 with an average combustible loading of 3.5 lbs/ft^2 of cable tray surface area. There are no combustible liquids i: the area.

3. VENTILATION PARAMETERS

   The south wall of the area contains louvers which measure 16' high by 75' wide and are open to the outside.

4. CASES EXAMINED

   With the light combustible loading in the area, the assumption that all cable trays were burning simultaneously would present the worst case. With all cables burning, a cable tray surface area of 89 ft^2 would be involved. This corresponds to a heat output of 1575 kW. With all combustibles burning simultaneously the fire duration would be 3.5 $lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2}$ = 35 minutes.

5. RESULTS

   With all cable trays in the area burning simultaneously and the large area of louvers, the resulting fire was fuel controlled. A gas temperature of 438°F would be achieved after 35 minutes, which is below the critical temperature for the structural steel (see Attachment B).

   The position of the cable trays relative to structrual steel members were examined in the area. No cable trays were positioned so as to present a localized heating exposure to the structural steel.

Columns in the area are W14X730 and W14X287. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X398	1000°F after 62 minutes
W14X287	1000°F after 48 minutes

6. EFFECT OF TRANSIENT COMBUSTIBLES

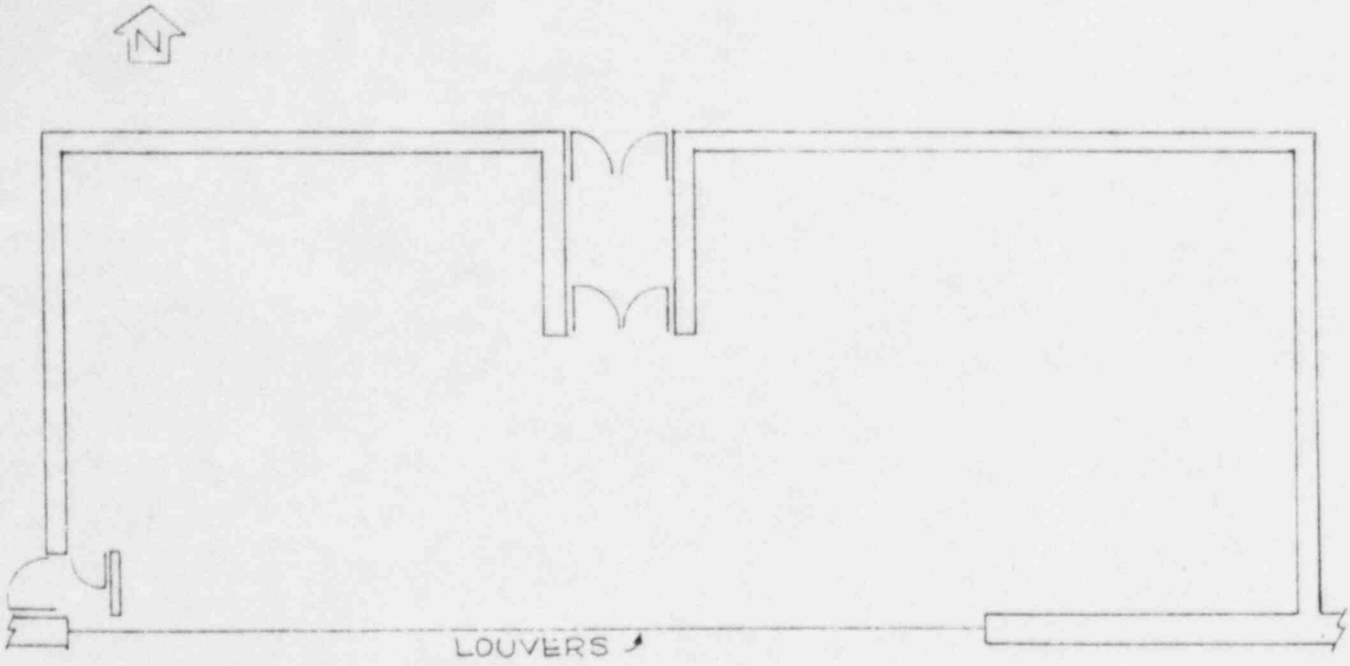
The fire examined was fuel controlled with a duration of 35 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rates due to transient materials in the area which result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
35 min	13	7752

The ceiling height in the area is 13 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W36X194.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4,218	
1300	5,377	46 min
1500	6,854	32 min



Unit 1 Reactor Building El. 313'
Reactor Vent Supply Fan Room Room 607

Surface Area Calculation

Walls		
North wall	(111' x 16')	1776 ft^2
South wall	(38' x 16')	608 ft^2
East wall	(40' x 16')	640 ft^2
West wall	(40' x 16')	640 ft^2
Ceiling	(111' x 40') - (12' x 16') airlock	4056 ft^2
Total Surface Area for Heat Transfer		7720 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 313' REACTOR VENT SUPPLY ROOM
CASE DESCRIPTION: LOUVERS OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	1200	16.0	7720	1575

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	408
10	415
15	420
20	425
25	430
30	434
35	438

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 26

Unit 1 Reactor Building El. 331'

Exhaust Fan Room Room 615

Fire Area 50A

Prepared by: M F Wahl

Reviewed by: [illegible signature]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak R[illegible] Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the Exhaust Fan Area, Room 615, on the 331' elevation of the Reactor Building (Fire Area 50A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 6376 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

   All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

   There is one door which measures 3' wide by 7' high located in the west wall of the area.

4. CASES EXAMINED

   With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

   The structural steel in this area will not fail due to a fire, as there are no fixed combustibles in the area to support a fire

6. EFFECT OF TRANSIENT COMBUSTIBLES

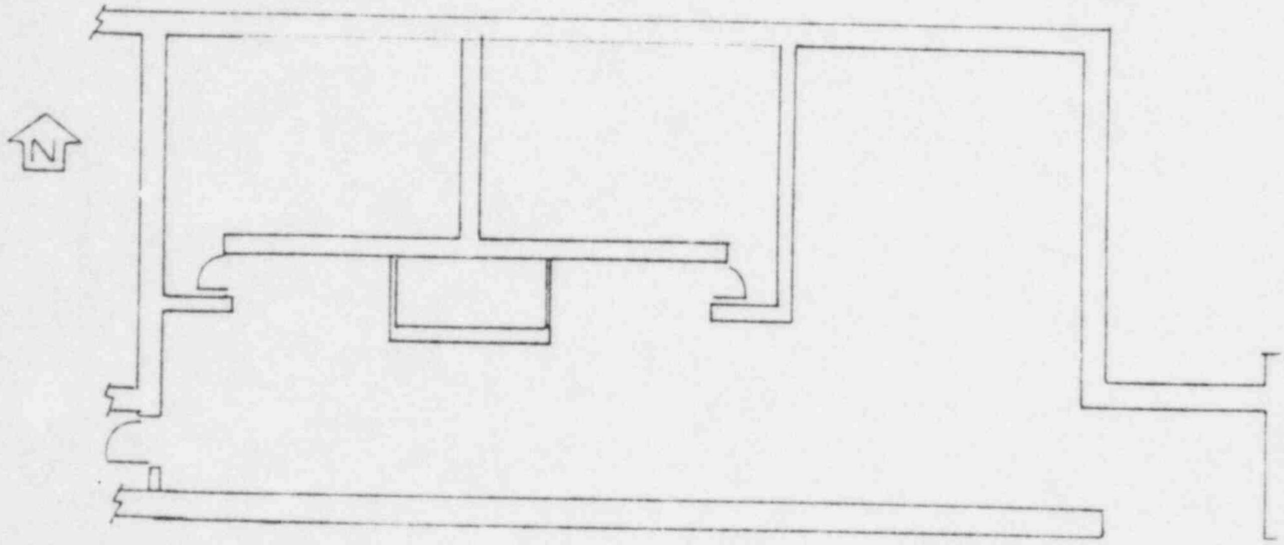
   This area has no fixed combustibles. There is one door measuring 3' wide by 7' high entering the area. This corresponds to a ventilation controlled heat release rate of 4504 kW. A fire of this heat release rate could burn for a maximum of 130 minutes before reaching an area temperature of 1100°F. The maximum heat release rate for a fire of 3 hour duration is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
3 hours	6.5	3851

The ceiling height in the area is 17 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W36X300.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	8,225	
1300	10,545	>50 min
1500	13,181	45 min



Unit 1 Reactor Building El. 331'
Exhaust Fan Area Room 615

Surface Area Calculation

Walls		
North wall	(74' x 18')	1332 ft^2
South wall	(96' x 18')	1728 ft^2
East wall	(38' x 18')	684 ft^2
West wall	(36' x 18')	648 ft^2
Ceiling		1984 ft^2
Total Surface Area for Heat Transfer		6376 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 27

Unit 1 Reactor Building El. 331'

Equipment Compartment Exhaust Filter Room 616 & 617

Fire Areas 50B & 50C

Prepared by: W F Mahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the Equipment Compartment Exhaust Filter Rooms, Rooms 616 & 617, on the 331' elevation of the Reactor Building (Fire Areas 50B & 50C). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 3856 ft^2, 1928 ft^2 in each filter compartment (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

   All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

   There are two doors entering this area, each measuring 3'6" wide by 7' high. One door enters each filter compartment.

4. CASES EXAMINED

   With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

   The structural steel in this area will not fail due to a fire, as there are no fixed combustibles in the area to support a fire

6. EFFECT OF TRANSIENT COMBUSTIBLES

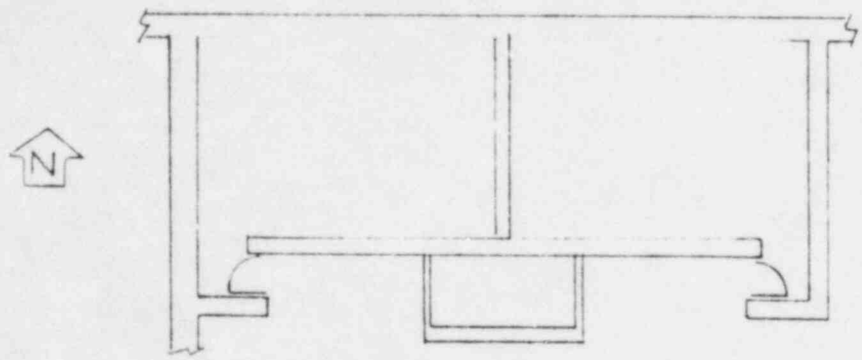
   This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	1881
2 hours	7.5	1343
3 hours	6.5	1164

The ceiling height in the area is 17 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W36X300.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	8,225	
1300	10,545	>50 min
1500	13,181	45 min



Unit 1 Reactor Building El. 331'
Equipment Compartment Exhaust Filter Rooms 616 & 617

Surface Area Calculation

Walls		
North wall	(26' x 18')	468 ft^2
South wall	(26' x 18')	468 ft^2
East wall	(16' x 18')	288 ft^2
West wall	(16' x 18')	288 ft^2
Ceiling	(26' x 16')	416 ft^2
Total Surface Area for Heat Transfer for Each Compartment		1928 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 28

Unit 1 Reactor Building El. 331'

Recirc Filter Compartments Room 618

Fire Areas 51A & 51B

Prepared by: W F Mall

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the Recirc Filter Compartments Room 618 on the 331' elevation of the Unit 1 Reactor Building (Fire Areas 51A & 51B). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 2664 ft^2 for the East compartment and 2644 ft^2 for the West compartment (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

   All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

   Two doors serve this area, each measuring 3' wide by 7' high. Each door enters a separate filter compartment.

4. CASES EXAMINED

   With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

   The structural steel in this area will not fail due to a fire, as there are no fixed combustibles in the area to support a fire

6. EFFECTS OF TRANSIENT COMBUSTIBLES

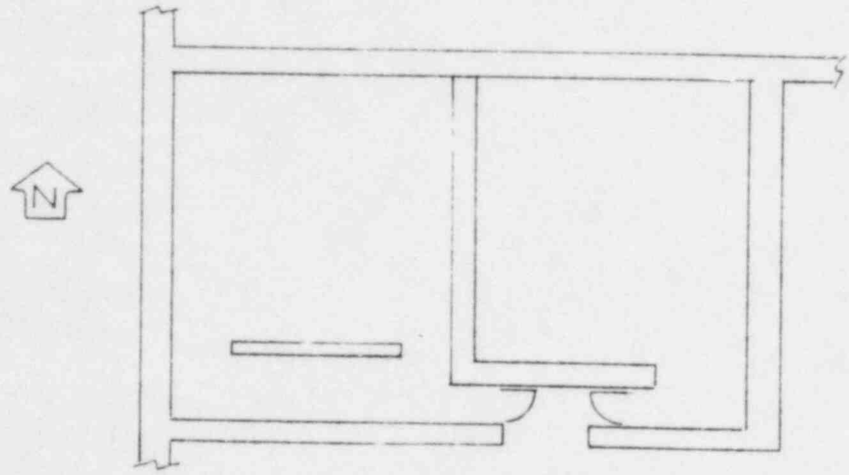
   This area has no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	2599
2 hours	7.5	1856
3 hours	6.5	1609

The ceiling height in the area is 17 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W36X300.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	8,225	
1300	10,545	>50 min
1500	13,181	45 min



Unit 1 Reactor Building El. 331'
Recirc Filter Compartments Room 618

Surface Area Calculations

East Room

Walls		
North wall	(24' x 18')	432 ft^2
South wall	(24' x 18')	432 ft^2
East wall	(30' x 18')	540 ft^2
West wall	(30' x 18')	540 ft^2
Ceiling	(24' x 30')	720 ft^2
Total Surface Area for Heat Transfer for East Room		2664 ft^2

West Room

Walls		
North wall	(24' x 18')	432 ft^2
South wall	(24' x 18')	432 ft^2
East wall	(30' x 18')	540 ft^2
West wall	(30' x 18')	540 ft^2
Ceiling	(24' x 30')	720 ft^2
Total Surface Area for Heat Transfer for West Room		

ATTACHMENT A

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 29

Unit 1 Reactor Building El. 352'

Refueling Floor

Fire Area 78A

Prepared by: W F Wall

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Refueling Floor on the 352' elevation of the Unit 1 Reactor Building (Fire Area 78A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 28,220 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

This area is open to the remainder of the 352' elevation of the Reactor Building.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

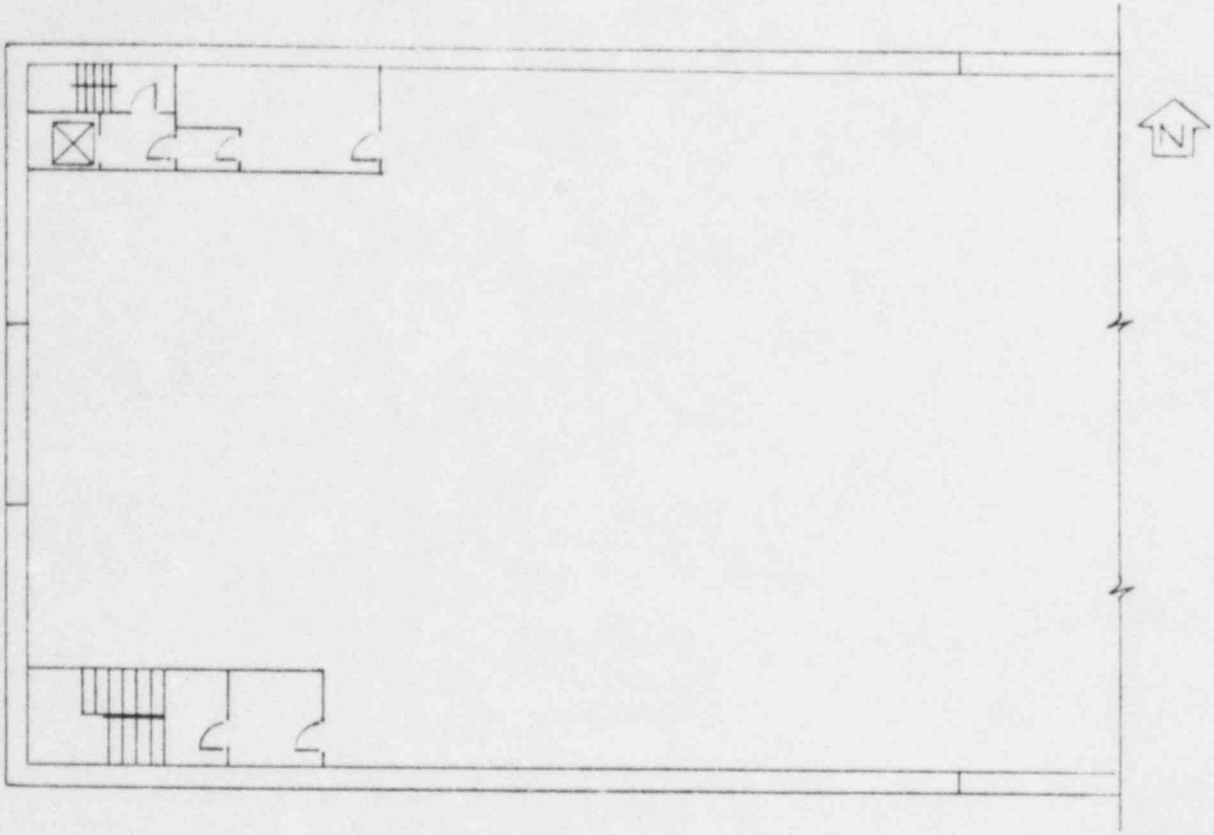
The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	27538
2 hours	7.5	19670
3 hours	6.5	17047

The roof slab is approximately 55 ft above the floor. Because of this high ceiling, plume effects of transients can be ignored.



Unit 1 Reactor Building El. 352'
Refueling Floor

Surface Area Calculation

Walls

North wall	(160' x 30')	4800 ft^2
South wall	(160' x 30')	4800 ft^2
West wall	(98' x 30')	2940 ft^2
		12,540 ft^2
Ceiling	(160' x 98')	15,680 ft^2
Total Surface Area for Heat Transfer		28,220 ft^2

ATTACHMENT A

PLC

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 30

Control Structure El. 180'

Backwash Pump Rooms

Rooms 161 162, & 165

Fire Area 1J

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Backwash Pump Rooms, Rooms 161, 162, and 165 on the 180' elevation of the Control Structure (Fire Area 1J) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 1684 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of two cable trays which run east-west across room 161. Total surface area of the cable trays is 70 ft^2. The average combustible loading of the trays is 2.6 lbs/ft^2 of tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

One door which measures 2'8" wide by 7' high serves the area. This door opens into Corridor 164.

4. CASES EXAMINED

With the light combustible loading in the area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 70 ft^2 would be involved. This corresponds to a heat output of approximately 1240 kW. With all cables assumed to be burning simultaneously the duration of the fire would be

$$2.6 \text{ lbs/ft}^2 \div \frac{.1 \text{ lbs}}{\text{min/ft}^2} = 26 \text{ minutes}$$

5. RESULTS

With all cable trays in the area burning simultaneously and the door entering the area open, a fire temperature of 791°F was achieved after 26 minutes, which is below the critical temperature for the structural steel (see Attachment B). The cable trays in the area were p[illegible]ned so as not to present a localized heating exposure to the structural [illegible].

6. EFFECTS OF TRANSIENT COMBUSTIBLES

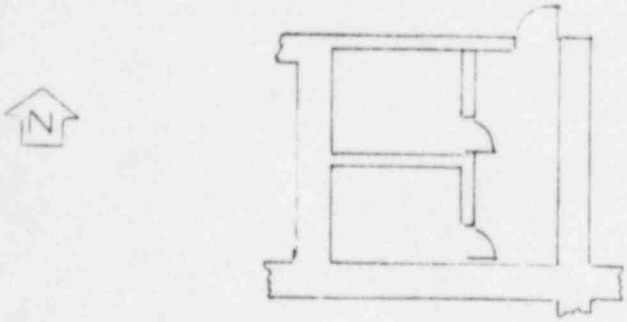
The fire examined was fuel controlled with a duration of 26 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
26 min	14.5	1029

The ceiling height in the area is 16 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X130.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6,960	
1300	9,069	38 min
1500	11,388	26 min



Control Structure El. 180'
Backwash Pump Rooms

Surface Area Calculation

Walls		
North wall	(20' x 18')	360 ft^2
South wall	(20' x 18')	360 ft^2
East wall	(19' x 18')	342 ft^2
West wall	(19' x 18')	342 ft^2
Ceiling	20' x 14'	280 ft^2
Total Surface Area for Heat Transfer		1684 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 180' BACKWASH PUMP ROOMS
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ac (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	19.0	7.0	1684	1240

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	6[illegible]4
2	700
3	705
4	709
5	713
6	717
7	722
8	725
9	729
10	733
11	737
12	741
13	744
14	748
15	752
16	755
17	759
18	763
19	766
20	770
21	774
22	777
23	781
24	784
25	788
26	791

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 31

Control Structure El. 180'

Backwash Receiving Tank Room 163

Fire Area 16

Prepared by: W F Wahl Date: February 7, 1984

Reviewed by: [illegible] Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Backwash Receiving Tank Room 163 on the 180' elevation of the Control Structure (Fire Area 1G) (see Attachment A for sketch of area). The bounding walls in the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is approximately 2772 ft^2 (257 m^2) (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of two cable trays which run east-west across the room. The total surface area of the trays is 164 ft^2. The average combustible loading of the trays is 3.5 lbs/ft^2 of tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There is one door leading into this area. The door measures 3' wide by 7' high and is located in the northwest corner of the room.

4. CASES EXAMINED

With the light combustible loading in the area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 164 ft^2 would be involved. This corresponds to a heat output of approximately 2900 kW. With all cables assumed to be burning simultaneously the duration of the fire would be

$$3.5\ lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2} = 35\ minutes$$

5. RESULTS

With all cable trays in the area burning simultaneously and the door entering the area open, a fire temperature of 1002°F was achieved after 35 minutes, which is below the critical temperature for the structural steel (see Attachment B). None of the cable trays in the area was positioned so as to present a localized heating exposure to the structural steel.

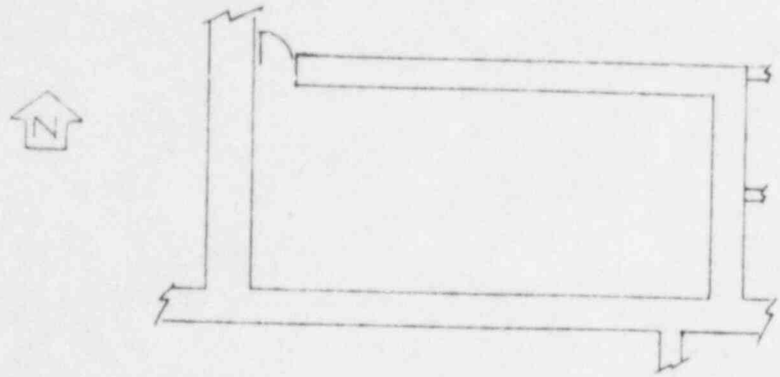
6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was fual controlled with a duration of 35 minutes. The temperature at this time was 1002°F. Since this temperature approaches the critical temperature of 1100°F, no transient materials were quantified.

The ceiling height in the area is 16 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X110.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6,960	
1300	9,069	31 min
1500	11,388	23 min



Control Structure El. 180'
Backwash Receiving Tank Room 163

Surface Area Calculation

Walls		
North wall	(40' x 18')	720 ft^2
South wall	(40' x 18')	720 ft^2
East wall	(17' x 18')	306 ft^2
West wall	(17' x 18')	306 ft^2
Ceiling	40' x 18'	720 ft^2
Total Surface Area for Heat Transfer		2772 ft^2

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 180' BACKWASH RECEIVING TANK AREA 163
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	2772	2900

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	824
10	854
15	884
20	913
25	943
30	972
35	1002

ATTACHMENT B

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 32

Control Structure El. 180'

Corridor 164

Fire Area 1A

Prepared by: W. F. Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is Corridor 164 on the 180' elevation of the Control Structure (Fire Area 1A) (see Attachment A for sketch of area). Bounding walls are of reinforced concrete construction with an average thickness of 3 feet. Total surface area for heat transfer is approximately 2200 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Both ends of the corridor are open. The east end opening measures 8' wide by 8' high. The west end of the corridor leads to an open stairwell serving the upper elevations.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail since there are no fixed combustibles in the area to support a fire.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

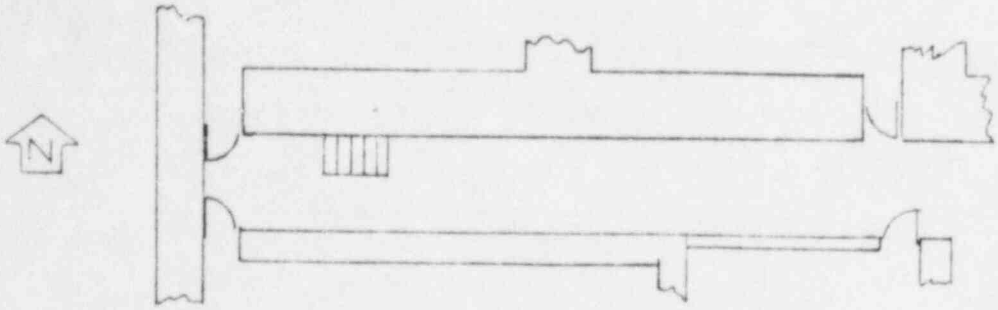
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	2146
2 hours	7.5	1533
3 hours	6.5	1328

The ceiling height in the area is 16 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X130.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6,960	
1300	9,069	38 min
1500	11,388	26 min



Control Structure El. 180'
Corridor 164

Surface Area Calculations

Walls		
North wall	(50' x 18')	900 ft^2
South wall	(50' x 18')	900 ft^2
Ceiling	(50' x 8')	400 ft^2
Total Surface Area for Heat Transfer		2200 ft^2

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 33

Control Structure El. 180'

Corridor 166

Fire Area 1B

Prepared by: M F Mall

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is Corridor 166 on the 180' elevation of the Control Structure (Fire Area 1B) (see Attachment A for sketch of area). Bounding walls are of reinforced concrete construction with an average thickness of 3 feet. Total surface area for heat transfer is approximately 1980 ft^2 (184 m^2) (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of two cable trays which run north-south across the corridor. The total surface area of the trays is 32 ft^2. The average combustible loading of the cable trays is 3 lbs/ft^2 of tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Both ends of the corridor are open. The west end opening measures 8' wide by 8' high. The east end of the corridor leads to an open stairwell serving the upper elevations.

4. CASES EXAMINED

With the light combustible loading in the area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 32 ft^2 would be involved. This corresponds to a heat output of approximately 570kW. With all cables assumed to be burning simultaneously, the duration of the fire would be

$$3\ lbs/ft^2 \div \frac{.1\ lb}{min\ ft^2} = 30\ minutes.$$

5. RESULTS

With all cable trays in the area burning simultaneously, a fire temperature of 511°F was reached after 30 minutes (see Attachment B). None of the cable trays in the area were positioned so as to present a localized heating exposure to structural steel.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

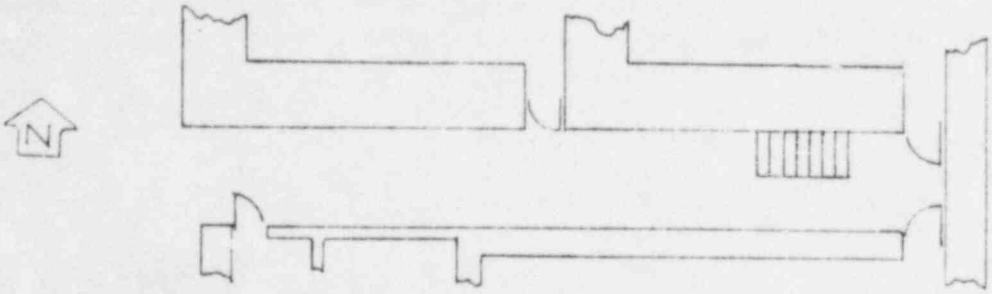
The fire examined was fuel controlled with a duration of 30 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
30 min	13.5	1914

The ceiling height in the area is 16 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W24X130.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6,960	
1300	9,069	38 min
1500	11,388	26 min



Control Structure El. 180'
Corridor 166

Surface Area Calculations

Walls		
North wall	(45' x 18')	810 ft^2
South wall	(45' x 18')	810 ft^2
Ceiling	(45' x 8')	360 ft^2
Total Surface Area for Heat Transfer		1980 ft^2

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 180' CORRIDOR 166
CASE DESCRIPTION: OPEN CORRIDOR ENDS ALL CABLES BURNING

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	64.0	8.0	1980	570

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	477
10	486
15	493
20	499
25	505
30	511

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 34

Control Structure El. 200'

West Chiller Equipment Room, Room 258

Fire Area 1L

Prepared by: M F Wall

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the West Chiller Equipment Room, Room 258, on the 200' elevation of the Control Structure (Fire Area 1L). The bounding walls of the room are of reinforced concrete and concrete masonry unit construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 5944 ft^2 (see Attachment A for sketch and surface area calculations).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of cable insulation in cable trays. The total surface area of the cable trays is 195 ft^2 with an average combustible loading of 2 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There are four doors which enter the area. Two of the doors are double doors, each measuring 8' high by 10' wide. One door is located in the west wall while the other door is located in the east wall. The remaining two doors are 3' wide by 7' high. These are both located in the north wall of the room.

4. CASES EXAMINED

With the light combustible loading in this area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 195 ft^2 would be involved. This corresponds to a heat output of approximately 3446 kW. With all cables assumed to be burning simultaneously, the duration of the fire would be

$$2.0\ lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2} = 20\ minutes.$$

5. RESULTS

With all the cable trays in the area burning simultaneously and one 3' x 7' door open, the resulting fire was fuel controlled. A gas temperature of 689°F was achieved after 20 minutes, which is below the critical temperature for the structural steel (see Attachment B). Since the fire was fuel

controlled with only one door open, the opening of additional doors into the area will not effect the burn rate or final gas temperature.

The location of cable trays relative to structural steel members was examined in the area. Cable tray 10CNF is located within 12 inches below the bottom of a W36X300 steel member.

Attachment C contains the results of calculations performed to determine the response of the steel member to localized heating. These calculations are conservative because they assume that the entire length of the steel member is subjected to a temperature of 1300°F when in actuality only a small section of the steel would be subjected to localized heating. As can be seen from the results the member does not exceed the single point failure temperature of 1100°F during the 20 minute exposure period (time required for tray to burn to completion).

6. EFFECTS OF TRANSIENT COMBUSTIBLES

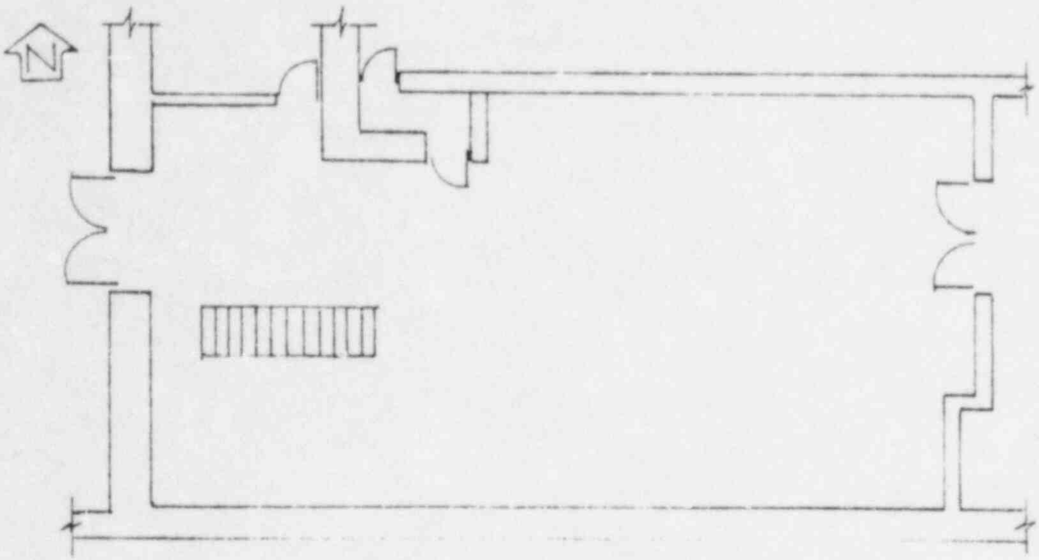
The fire examined was fuel controlled with a duration of 20 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
20 min	15.5	5116

The ceiling height in the area is 13'9". This distance is measured from the floor slab to the bottom of the typical structural steel member in the area which are W30X210.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4,745	
1300	6,326	>50 min



Control Structure El. 200'
West Chiller Equipment Room 258

Surface Area Calculation

Walls		
North wall	(72' x 16')	1152 ft^2
East wall	(35' x 16')	560 ft^2
South wall	(72' x 16')	1152 ft^2
West wall	(35' x 16')	560 ft^2
		3424 ft^2
Ceiling	(72' x 35')	2520 ft^2
Total Surface Area for Heat Transfer		5944 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 200' WEST CHILLER EQ. RM.
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	21.0	7.0	5944	3446

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	630
2	635
3	639
4	642
5	646
6	649
7	652
8	655
9	658
10	661
11	664
12	667
13	670
14	673
15	675
16	678
17	681
18	683
19	686
20	689

CASE NUMBER: 1
BUILDING: CONTROL BUILDING
ELEVATION AND AREA DESCRIPTION: 200' WEST CHILLER EQ. ROOM
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x300

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 300
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.99

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	230
10.00	371
15.00	493
20.00	599

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 35

Control Structure El. 200'

Recombiner Access Area Room 259

Fire Area 1N

Prepared by: W F Mall

Reviewed by: [signature]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Recombiner Access Area, Room 259, on the 200' elevation of the Control Structure (Fire Area 1N). Bounding walls are of concrete masonry units and reinforced concrete construction with an average thickness of 2 ft. The south wall of the access area is a non-fire rated barrier. The total surface area for heat transfer is 5456 ft^2 (see Attachment A for sketch and surface area calculations.)

2. COMBUSTIBLE LOADING

There are no cable trays or combustible liquids located in this area.

3. VENTILATION PARAMETERS

Three doors enter the area. On the east wall is a set of double doors with each leaf measuring 5' wide by 8' high. Two doors, each measuring 3' wide by 7' high, are located in the south wall.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the access area, there is no fuel in the area to support combustion.

5. RESULTS

The structural steel in this area will not fail since there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

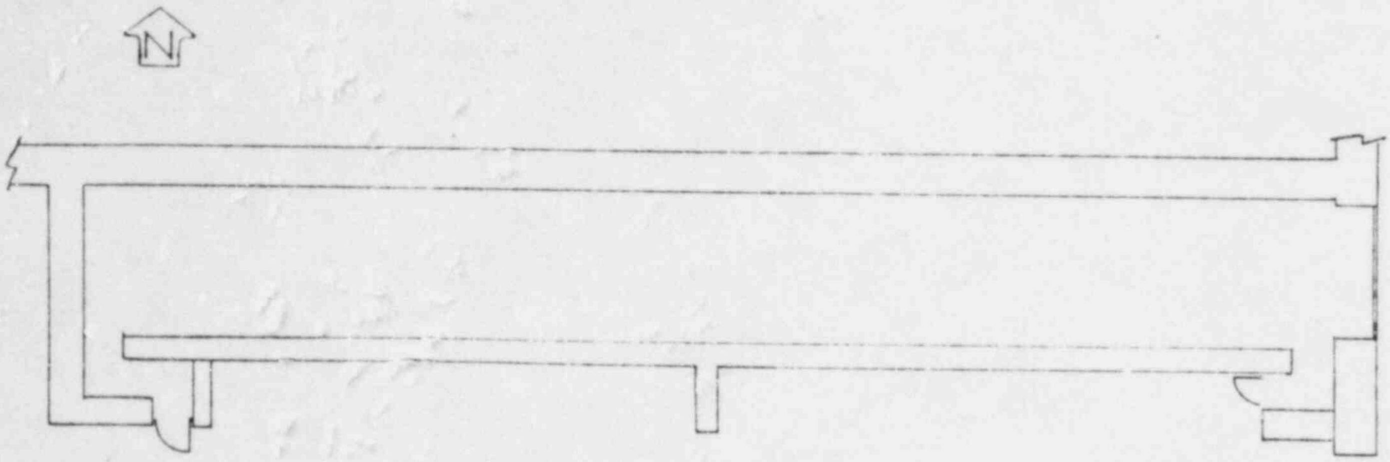
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	5324
2 hours	7.5	3802
3 hours	6.5	3295

The ceiling height in the area is 13'9". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W30X210.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4745	
1300	6326	>50 min
1500	7908	>35 min



Control Structure El. 200'
Recombiner Access Area Room 259

Surface Area Calculation

<u>Walls</u>		
North wall	(112' x 16')	1792 ft^2
East wall	(13' x 16')	208 ft^2
South wall	(112' x 16')	1792 ft^2
West wall	(13' x 16')	208 ft^2
		4000 ft^2
<u>Ceiling</u>	(112' x 13')	1456 ft^2
Total Surface Area for Heat Transfer		5456 ft^2

ATTACHMENT A

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 36

Control Structure El. 200'

East Chiller Equipment Room, Room 263

Fire Area 1M

Prepared by: W F Wahl

Date: February 7, 1984

Rev'iewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the East Chiller Equipment Room, Room 263, on the 200' elevation of the Control Structure (Fire Area 1M). The bounding walls of the room are of reinforced concrete and concrete masonry unit construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 4872 ft^2 (see Attachment A for sketch and surface area calculations).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of cable insulation in cable trays. The total surface area of the cable trays is 160 ft^2 with an average combustible loading of 2.0 lbs/ft^2 of cable tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There are three doors which enter the area. Two of the doors are double doors, each measuring 8' high by 10' wide. One door is located in the east wall while the other door is located in the west wall. The third door is 3' wide by 7' high and is located in the north wall.

4. CASES EXAMINED

With the light combustible loading in this area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 160 ft^2 would be involved. This corresponds to a heat output of approximately 2828 kW. With all cables assumed to be burning simultaneously, the duration of the fire would be

$$2.0\ lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2} = 20\ minutes.$$

5. RESULTS

With all the cable trays in the area burning simultaneously and one 3' x 7' door open, the resulting fire was fuel controlled. A gas temperature of 689°F was achieved after 20 minutes, which is below the critical temperature for the structural steel (see Attachment B). Since the fire was fuel

controlled with only one door open, the opening of additional doors into the area will not effect the burn rate or final gas temperature.
The location of cable trays relative to structural steel members was examined in the area. No cable trays were positioned so as to present a localized heating exposure to the structural steel.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

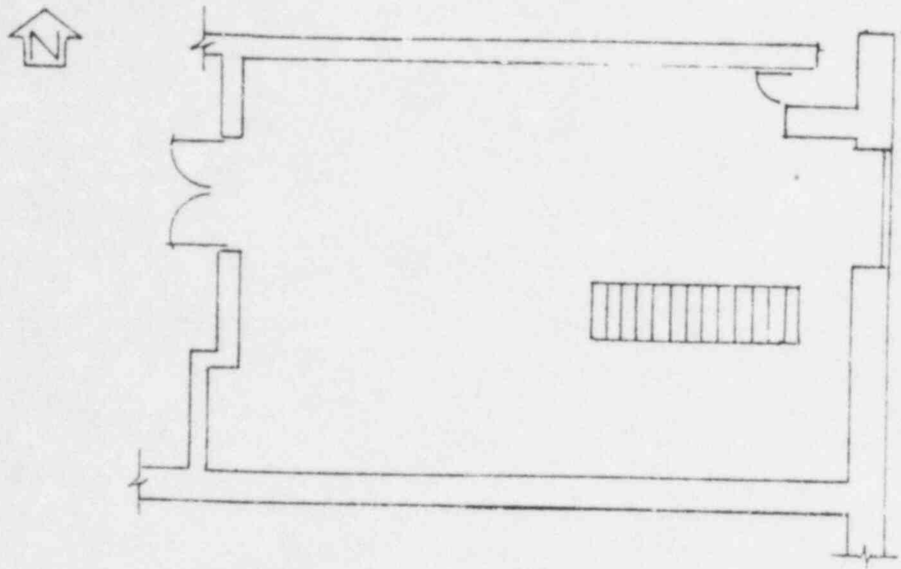
The fire examined was fuel controlled with a duration of 20 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
20 min	15.5	4190

The ceiling height in the area is 13'9". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a W30X210.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4,745	
1300	6,326	>50 min
1500	7,908	>35 min



Control Structure El. 200'
East Chiller Equipment Room 263

Surface Area Calculation

Walls		
North wall	(56' x 16')	896 ft^2
East wall	(35' x 16')	560 ft^2
South wall	(56' x 16')	896 ft^2
West wall	(35' x 16')	560 ft^2
		2912 ft^2
Ceiling	(56' x 35')	1960 ft^2
Total Surface Area for Heat Transfer		4872 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 200' EAST CHILLER EQ. RM.
CASE DESCRIPTION: ONE DOOR OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ac (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	21.0	7.0	4872	2828

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	631
2	635
3	639
4	643
5	646
6	649
7	653
8	656
9	659
10	662
11	664
12	667
13	670
14	673
15	676
16	678
17	681
18	684
19	686
20	689

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 37

Units 1 & 2

Control Structure El. 217'

Switchgear Area

Fire Area 2

Prepared by: W F Mahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 2

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the switchgear area on the 217' elevation of the Control Structure (Fire Area 2) (see Attachment A for sketch of area). Bounding walls are of reinforced concrete construction with an average thickness of 3 ft. Total surface area for heat transfer is approximately 13,836 ft^2 (1285 m^2) (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in this area consists of cable trays which are stacked three high along the south wall of the room. At three locations the cable trays are joined by several vertical cable trays. These three areas are located at the east side, center, and west side of the south wall and represent the areas of heaviest combustible loading. The average combustible loading of the cable trays in this area is 3.5 lbs/ft^2 of tray surface area. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Three sets of double doors serve this area. Each set has 2 leaves. The door leaves located in the east and west walls each measure 4' wide by 10' high. The door leaves in the north wall measure 5' wide by 11' high.

4. CASES EXAMINED

Two cases were examined each with a different ventilation parameter and a different quantity of cable assumed to be burning.

Case number 1 assumed a spreading cable fire in the center area of cable trays along the south wall, with one 4' wide by 10' high door open. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread east and west along the south wall, a distance of 6 feet in each direction along the cable trays before the original point source dies out after 35 minutes. A maximum surface area of 96

ft^2 of cable trays (see Attachment B for a list of cable trays) will be involved at any one time, which corresponds to a heat output of 1700 kW. This heat output is assumed constant throughout the fire duration. The actual heat output as the fire spreads out of the area originally involved at any one time would be less since the quantity of cabling that would be involved at any one time would be less.

Case number 2 assumed all exposed combustibles in the room burning simultaneously with one 4' wide by 10' high door open. The heat output of this fire would be 10,254 kW and would last for approximately 150 minutes.

5. RESULTS

Case number 1 resulted in a fire temperature of 395°F when the fire duration was taken to 180 minutes. This temperature is below the critical temperature for the structural steel (see Attachment C for results of analysis). This fire was fuel controlled, therefore having additional door leaves open would not change the results.

Case number 2 resulted in a fire temperature of 1188°F at 150 minutes. This temperature is above the critical temperature for the structural steel (see Attachment C for results of analysis).

Since the fires evaluated were assumed to occur in the area of heaviest combustible loading, the results are considered to be representative for the entire switchgear area on the 217' elevation of the Control Structure.

The position of cable trays relative to structural steel members were examined throughout the 217' elevation of the Control Structure to assess the potential for localized heating. Cable trays 21CQA and 11CQA are located 12 inches below the bottom of structural steel members of the following types: G1 (W42X316), W36X230, W36X245, W36X260, W36X300, W33X118, W30X99, and W27X84.

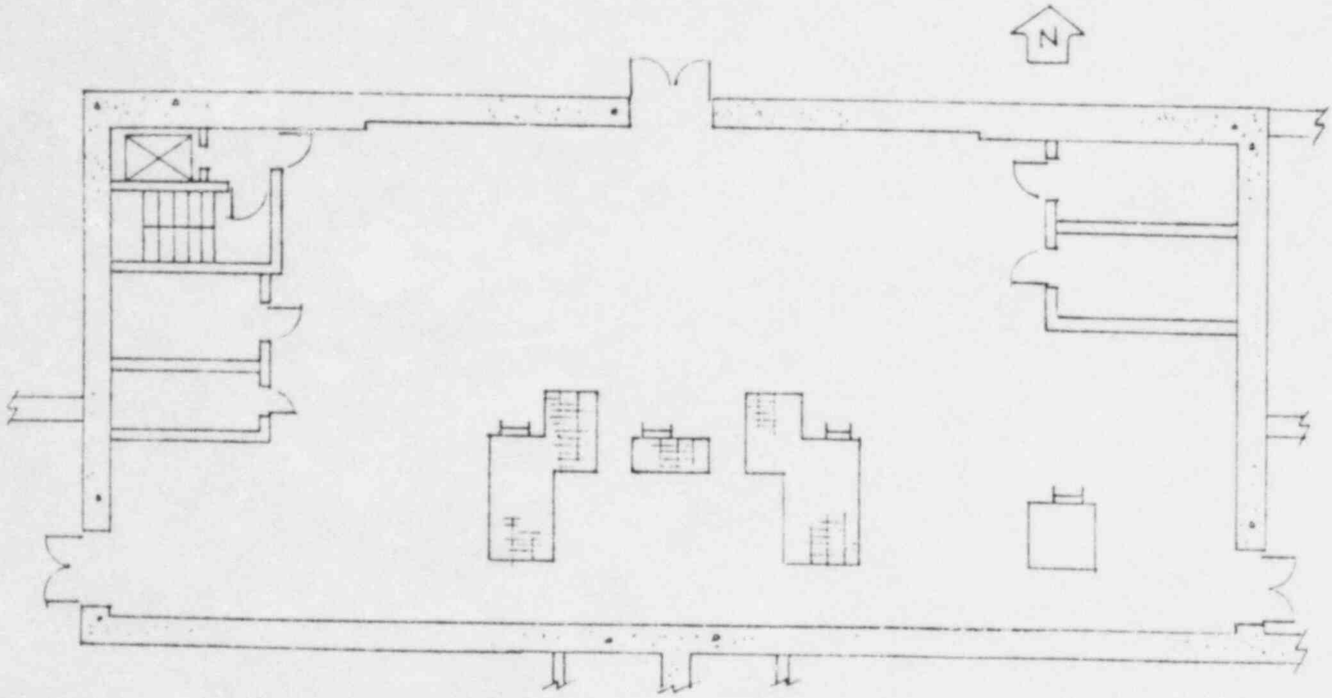
Attachment D contains the results of the calculations performed to determine the response of the structural steel to localized heating. The exposure time was taken to be 35 minutes which is the time required for the tray to burn to completion. These calculations are conservative because they assume that the entire length of the member is subjected to a temperature of 1300°F when in actuality only a small section of the steel would be subjected to localized heating. As can be seen from the results, the member types G1 (W42X316), W36X230, W36X245, W36X260, and W36X300 will not reach their critical temperature during the 35 minute exposure period. Member types W33X118, W30X99, and W27X84 will exceed the single point failure temperature of 1100°F within the exposure period. Attachment D includes a sketch of the structural members which will fail due to localized heating.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

Since case 2 is a ventilation controlled fire, no transient combustibles were quantified for area effects.

The ceiling height in the area is 17'10-1/2". This distance is measured from the floor slab to the bottom of a typical W36 beam. The heat release rates from transient combustibles in the area necessary to reach plume temperatures of 1100°F, 1300°F and 1500°F at 17'10-1/2" above the floor area listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)						
		W27	W30	W33	W36X230	X245	X260	X300
1100	9,500							
1300	12,200	25	26	28	50	>50	>50	>50
1500	15,300	17	18	30	35	37	38	45



Control Structure El. 217'
Switchgear Area

Surface Area Calculation

Walls

North wall	(126' x 21')	2646 ft^2
West wall	(56' x 21')	1176 ft^2
South wall	(126' x 21')	2646 ft^2
East wall	(56' x 21')	1176 ft^2
		7644 ft^2

Ceiling

126' x 56' (-20' x 16') - (16' x 34')	6192 ft^2
Total Surface Area for Heat Transfer	13,836 ft^2 (1285 m^2)

ATTACHMENT A

The following cable trays are present in the center area along the south wall and all of the trays are assumed to be burning simultaneously:

Tray No.	Tray Width (ft)	Tray Length (ft)	Surface Area (ft^2)
21CQA60	2	4.5	9
21CQA59	2	1.5	3
22CPA60	2	4.5	9
22CPA59	2	1.5	3
20CSD60	2	4.5	9
20CSD59	2	1.5	3
11CQA60	2	5	10
11CQA59	2	1	2
12CPA60	2	5	10
12CPA59	2	1	2
10CSD60	2	5	10
10CSD59	2	1	2
12CPB	2	6	12
22CPB	2	6	12
			96 ft^2

Heat output with the above cable trays burning simultaneously:

$$\frac{96\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 1700\ kW$$

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: ONE DOOR LEAF OPEN 4'x 10'

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	40.0	10.0	13836	1700

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	326
20	333
30	339
40	345
50	349
60	354
70	358
80	362
90	366
100	369
110	373
120	376
130	380
140	383
150	386
160	389
170	392
180	395

ATTACHMENT C

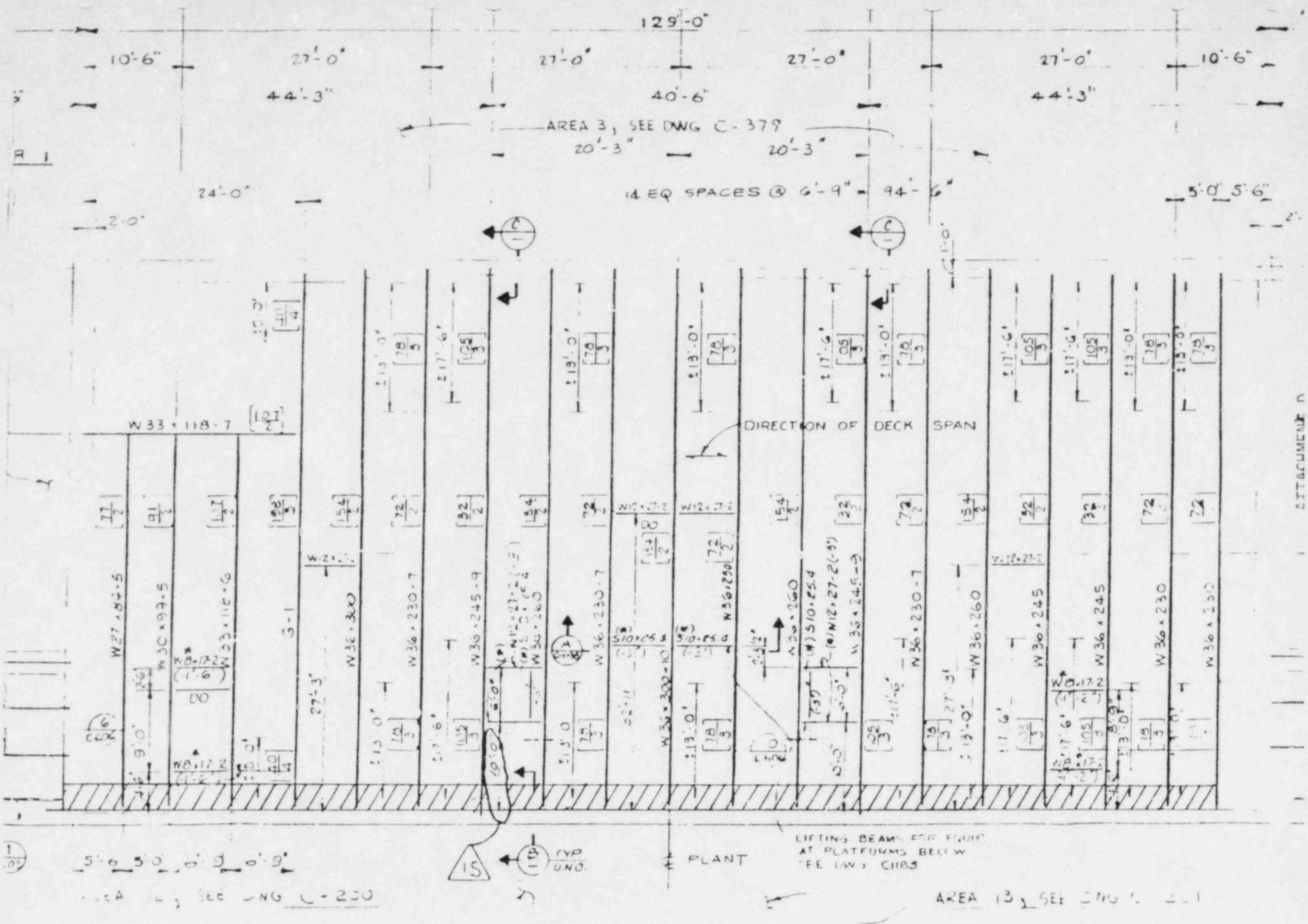
CASE NUMBER: 2
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: ONE DOOR LEAF OPEN 4'x 10'

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	40.0	10.0	13836	10254

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	735
20	772
30	808
40	843
50	878
60	912
70	945
80	977
90	1009
100	1040
110	1071
120	1101
130	1130
140	1159
150	1188

ATTACHMENT C



STEEL FRAMING PLAN EL 239'-0"

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x230

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 230
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.84

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	276
10.00	449
15.00	593
20.00	712
25.00	812
30.00	894
35.00	963

ATTACHMENT D

CASE NUMBER: 2
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x245

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 245
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	264
10.00	429
15.00	567
20.00	684
25.00	782
30.00	864
35.00	934

ATTACHMENT D

CASE NUMBER: 3
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x260

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 260
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.90

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	253
10.00	411
15.00	544
20.00	658
25.00	755
30.00	837
35.00	906

ATTACHMENT D

CASE NUMBER: 4
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x300

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 300
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.99

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	230
10.00	371
15.00	493
20.00	599
25.00	691
30.00	771
35.00	841

CASE NUMBER: 5
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x118

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 118
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.15

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	404
10.00	648
15.00	826
20.00	955
25.00	1049
30.00	1118
35.00	1167

ATTACHMENT D

CASE NUMBER: 6
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x99

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 99
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	430
10.00	686
15.00	866
20.00	994
25.00	1084
30.00	1147
35.00	1192

ATTACHMENT D

CASE NUMBER: 7
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 84
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	461
10.00	728
15.00	911
20.00	1035
25.00	1119
30.00	1177
35.00	1216

ATTACHMENT D

CASE NUMBER: 8
BUILDING: CONTROL STRUCTURE UNITS 1 & 2
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G1(W42x316)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 316
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 10.91

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	236
10.00	381
15.00	506
20.00	615
25.00	708
30.00	789
35.00	858

ATTACHMENT D

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 38

Control Structure El. 304'

Fan Room

Fire Zone 27

Prepared by: W F Wahl

Reviewed by: [illegible]

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Fan Room on the 304' elevation of the Control Structure (Fire Area 27). The bounding walls in the area are of reinforced concrete with an average thickness of 2 ft. The total surface area for heat transfer is 17,071 ft^2 (see Attachment A for sketch and calculation of areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of cable insulation located in cable trays. Total cable tray surface area is 748 ft^2. The average combustible loading of the cable trays is 3.6 lbs/ft^2 of tray surface area. There are no combustible liquids in this area. Enclosed combustibles are not included in the combustible loading.

3. VENTILATION PARAMETERS

Five doors serve this area, four measuring 3' x 7' and one measuring 9' x 10'. Two 3' x 7' doors are located in the north wall, one is located in the east wall while the fourth door is located in the west wall. The 9' x 10' door is also located in the west wall.

4. CASES EXAMINED

With the light combustible loading in this area, the assumption that all cables are burning simultaneously would present the worst case. With all cable trays burning, a surface area of 748 ft^2 would be involved (see Attachment B for a list of trays). Three cases were examined; the first case involving a ventilation opening of 21 ft^2, one 3' x 7' door open. The second case examined involved a ventilation opening of 42 ft^2, two 3' x 7' doors open. The third case examined involved a ventilation opening of 63 ft^2, three 3' x 7' doors open.

5. RESULTS

For the three cases examined, all cable trays in the area are burning simultaneously. In the first case, a gas temperature of 557°F was achieved after 105 minutes. In the second case, a gas temperature of 735°F was achieved after 54 minutes. In the third case, a gas temperature of 849°F

was achieved after 36 minutes (see Attachment C for results of all three analysis). All three temperatures are below the critical temperature for the structural steel. The cable trays in the area were positioned so as to not present a localized heating exposure to the structural steel.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 36 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
36 min	12.5	6623

The ceiling height in the area is 24 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a 38" girder. The heat release rate from transient combustibles in the area necessary to reach a plume temperature of 1100°F is 20,000 kW.

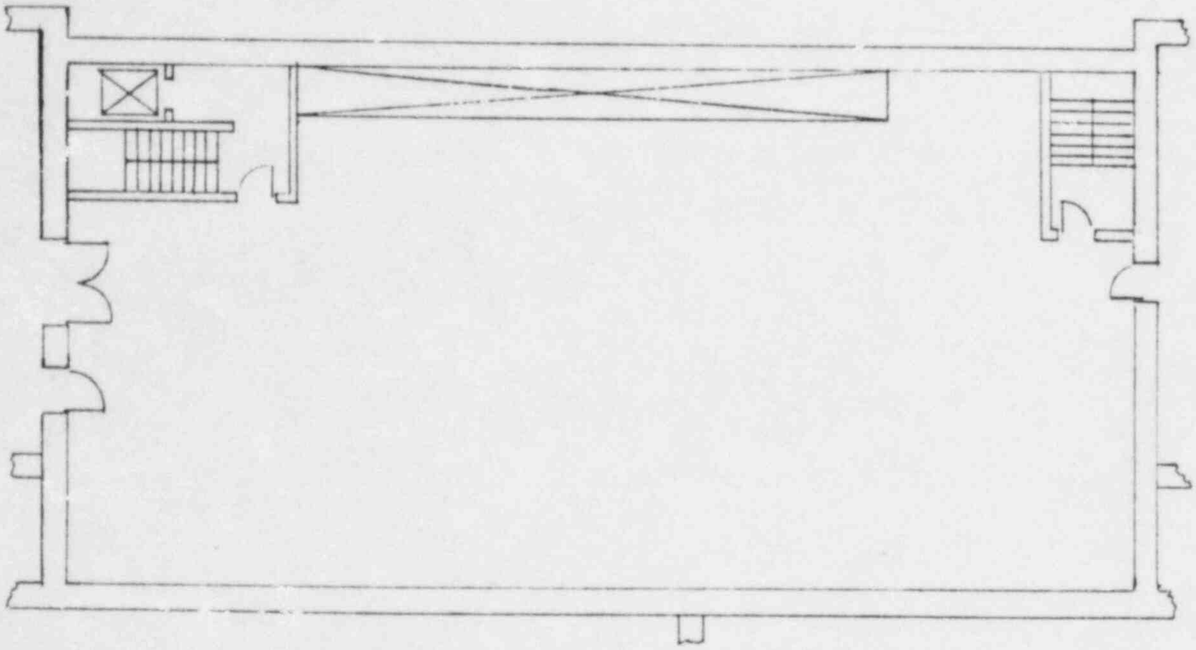
was achieved after 36 minutes (see Attachment C for results of all three analysis). All three temperatures are below the critical temperature for the structural steel. The cable trays in the area were positioned so as to not present a localized heating exposure to the structural steel.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was fuel controlled with a duration of 36 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which will result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
36 min	12.5	6623

The ceiling height in the area is 24 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area which is a 38" girder.



Control Structure El. 304'
Fan Room Fire Zone 27

Surface Area Calculation

Walls		
North wall	(27' x 129')	3483 ft^2
East wall	(27' x 58')	1566 ft^2
South wall	(27' x 129')	3483 ft^2
West wall	(27' x 58')	1566 ft^2
		10,098 ft^2

Ceiling		
Area 1	(58' x 129') - [(21' x 17') + (8' x 19')]	6973 ft^2
Total Surface Area for Heat Transfer		17,071 ft^2

ATTACHMENT A

The following cable trays are assumed to be burning simultaneously.

Tray No.	Width (in.)	Length (ft.)	Surface Area (ft^2)
1DCKM01	24	2	4
1DCKM02	24	5	10
1DCKM03	24	17	34
1DCKM04	24	13	26
1DCKM05	24	13	26
1DCKM06	24	25	50
1DCKM07	24	37	74
1DCKM08	24	23	46
1DCKM09	24	9	18
1CCKM02	24	4	8
1CCKM03	24	10	20
1CCKM04	24	13	26
1CCKM05	24	9	18
1CCKM06	24	12	24
1CCKM07	24	9	18
1CCKM08	24	7	14
1CCKM09	24	23	46
1CCKM10	24	5	10
1DCGF01	24	17	34
1DCGF03	24	10	20
1DCGF04	24	12	24
1DCGF05	24	2	4
1DCGF06	24	17	34
1DCGF07	24	17	34
1DCGF08	24	24	48
1DCGF09	24	31	62
1DCGF10	24	8	16
			748 ft^2

Average combustible loading per tray surface area = 3.6 lbs/ft^2

Fire duration for free burning tray fires = 3.6 $lbs/ft^2 \div \frac{.1\ lb}{ft^2/min}$ = 36 mins.

Heat output with all trays in fire area (above) burning simultaneously:

$$\frac{748\ ft^2}{10.76\ ft^2/m^2} \times 190\ kW/m^2 = 13,208\ kW$$

ATTACHMENT B

CASE NUMBER. 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 304' FAN ROOM
CASE DESCRIPTION: ONE 3'x 7' DOOR OPEN ALL CABLES BURNING

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	21.0	7.0	17071	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	459
10	467
15	474
20	480
25	485
30	491
35	496
40	501
45	505
50	510
55	515
60	519
65	524
70	528
75	532
80	536
85	541
90	545
95	549
100	553
105	557

ATTACHMENT C

CASE NUMBER: 2
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 304' FAN ROOM
CASE DESCRIPTION: TWO 3'x 7' DOORS OPEN ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	42.0	7.0	17071	9008

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	611
4	613
6	624
8	629
10	635
12	640
14	645
16	650
18	655
20	660
22	664
24	669
26	674
28	678
30	683
32	687
34	692
36	696
38	700
40	705
42	709
44	714
46	718
48	722
50	726
52	731
54	735

ATTACHMENT C

CASE NUMBER: 3
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 304' FAN ROOM
CASE DESCRIPTION: THREE 3'x 7' DOORS OPEN ALL CABLES BURNING

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	63.0	7.0	17071	13208

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	714
4	724
6	732
8	741
10	749
12	757
14	765
16	773
18	781
20	788
22	796
24	804
26	811
28	819
30	826
32	834
34	841
36	849

ATTACHMENT C

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 39

Control Structure El. 332'

Standby Gas Treatment System Filter Compartment Room 624

Fire Area 28B

Prepared by: W F Wahl

Reviewed by: K W Dungan

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Standby Gas Treatment System Filter Compartment, Room 624, on the 332' elevation of the Control Structure (Fire Area 28B). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 5564 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There are three doors which enter this area. Two 3' wide by 7' high doors are located in the east wall and a 6' wide by 8' high double door is locatd in the west wall.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

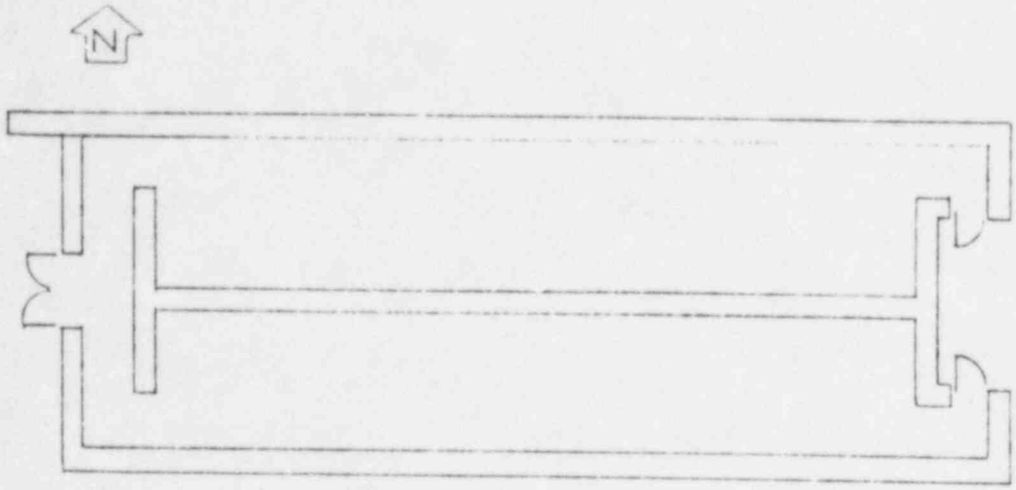
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	5429
2 hours	7.5	3878
3 hours	6.5	3361

The ceiling height in the area is 15'6". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W18X105.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	6,432	
1300	8,426	37 min
1500	10,545	26 min



Control Structure El. 313'
Standby Gas Treatment System Filter Compartment

Surface Area Calculation

Walls		
North wall	(78' x 17')	1326 ft^2
South wall	(78' x 17')	1326 ft^2
East wall	(26' x 17')	442 ft^2
West wall	(26' 17')	442 ft^2
		3536 ft^2
Ceiling	(78' x 26')	2028 ft^2
Total Surface Area for Heat Transfer		5564 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 40

Control Structure El. 332'

Standby Gas Treatment System Access Area Room 625

Fire Area 28A

Prepared by: M F Wahl

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Standby Gas Treatment System Access Area Room 625 on the 332' elevation of the Control Structure (Fire Area 28A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 8928 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

There are two doors which enter the area, each measuring 3' wide by 7' high. These doors are located along the north wall and lead into stairwells.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire, as there are no fixed combustibles in the area to support a fire

6. EFFECT OF TRANSIENT COMBUSTIBLES

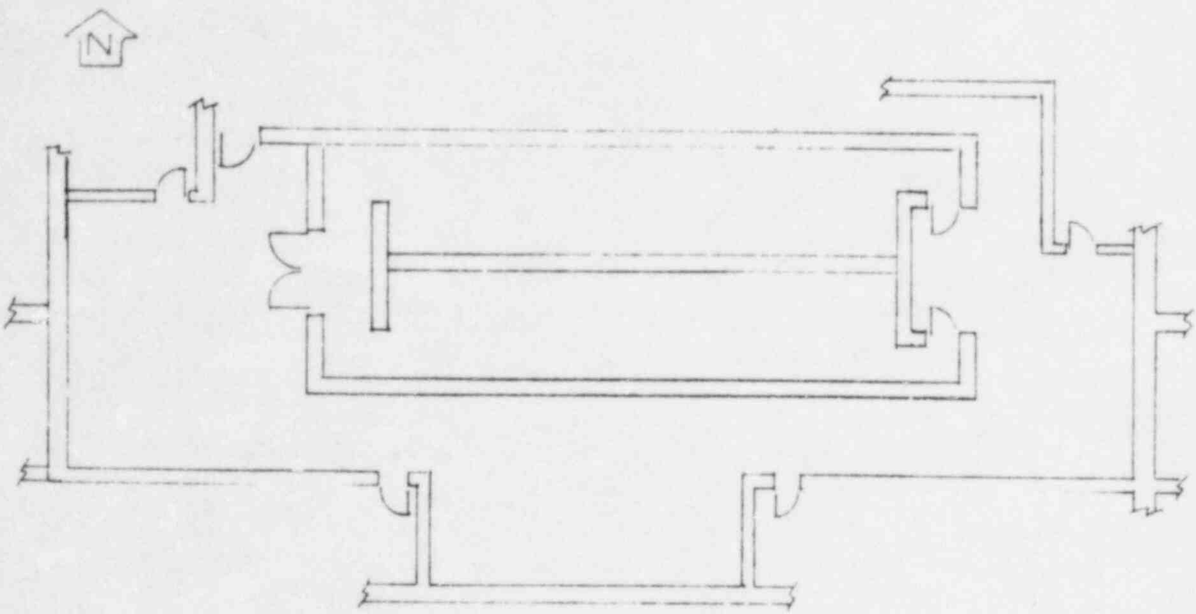
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	8712
2 hours	7.5	6223
3 hours	6.5	5393

The ceiling height in the area is 14'9" feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W27X84.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	5,800	
1300	8,436	24 min
1500	8,279	17 min



Control Structure El. 332'
Standby Gas Treatment System Access Area Room 625

Surface Area Calculation

Walls

North wall	(120' x 17')	2040 ft^2
South wall	(120' x 17')	2040 ft^2
East wall	(72' x 17')	1224 ft^2
West wall	(72' x 17')	1224 ft^2
Ceiling		2400 ft^2
Total Surface Area for Heat Transfer		8928 ft^2

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 41

Control Structure El. 200'

Radwaste Pipe Tunnel

Fire Area 115

Prepared by: W F Wahl

Reviewed by: K W Dungan

Date: February 7, 1984

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Radwaste Pipe Tunnel on the 200' elevation of the Radwaste Enclosure (Fire Area 115). Bounding walls are constructed of concrete masonry units, steel plate, and reinforced concrete. The ceiling is constructed of reinforced concrete with a 76 ft^2 open grating connecting Fire Area 89. The walls and ceiling are not fire rated. The total surface area for heat transfer is 3125 ft. (See Attachment A for sketch and surface area calculations.)

2. COMBUSTIBLE LOADING

There are no cable trays or combustible liquids located in this area.

3. VENTILATION PARAMETERS

Access doors connect to Fire Areas 102 and 118 from the Radwaste Pipe Tunnel.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the tunnel, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail since there is no fuel in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

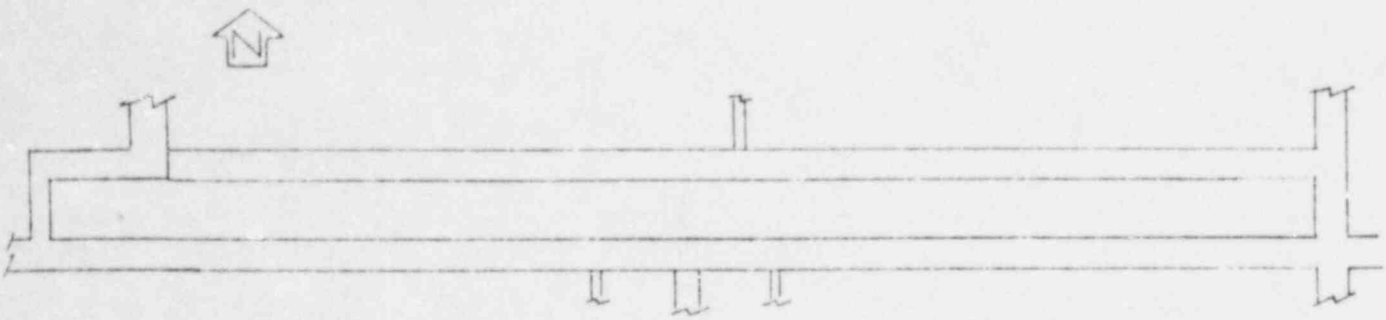
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	3049
2 hours	7.5	2178
3 hours	6.5	1887

The ceiling height in the area is 13'9". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W30X210.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4745	
1300	6326	>50 min
1500	7908	>35 min



Control Structure El. 200'
Radwaste Pipe Tunnel

Surface Area Calculation

Walls		
North wall	(145' x 8')	1160 ft^2
East wall	(5' x 8')	40 ft^2
South wall	(145' x 8')	1160 ft^2
West wall	(5' x 8')	40 ft^2
		2400 ft^2
Ceiling	(145' x 5')	725 ft^2
Total Surface Area for Heat Transfer		3125 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 42

Unit 1 Diesel Generator Enclosure El. 217'

Diesel Generator Cell 1A

Fire Area 79

Prepared by: W F Wahl

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the diesel generator cell 1A on the 217' elevation of the Unit 1 Diesel Generator Building (Fire Area 79). (See Attachment A for a sketch of the area.) The bounding walls in the area are of reinforced concrete with an average thickness of 2 feet. The total surface area for heat transfer is 5579 ft^2 (see Attachment A for calculation of areas).

2. COMBUSTIBLE LOADING

   Combustible loading in the area consists of 198 ft^2 of cable tray, 250 gallons of lubricating oil, and 800 gallons of fuel oil which is assumed to have leaked into the diesel generator cell from a postulated break in t fuel oil supply line.

3. VENTILATION PARAMETERS

   Two intake louvers for the diesel generator cell serve this area, each measuring 5.25' high x 6.5' wide. Both louvers are located in the south wall.

4. CASES EXAMINED

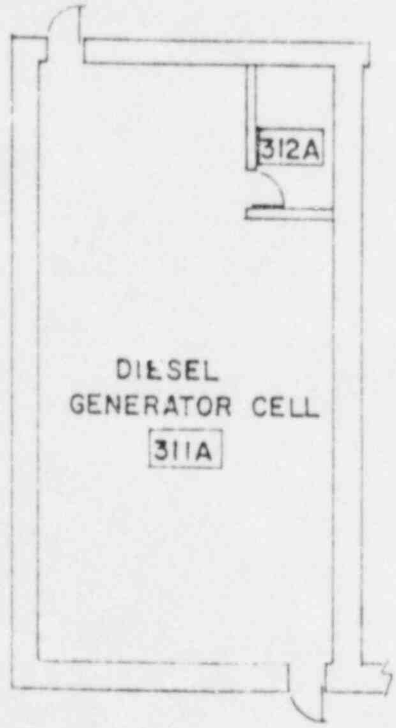
   The case examined assumes a fuel oil fire with both louvers serving the area open which results in a ventilation controlled fire with a maximum heat release rate of 12,747 kW. This case assumes that the pre-action sprinkler system in the room does not operate and/or the fire brigade takes no action toward extinguishing the fire.

5. RESULTS

   As can be seen from the results in Attachment B, the critical temperature of the structural steel will be exceeded within 10 minutes. This is due to the large ventilation openings in the area and the large quantity of fuel oil available for combustion.

6. EFFECTS OF TRANSIENT COMBUSTIBLES

The fire examined was ventilation controlled with a duration of 180 minutes. The temperature at this time exceeded 1100°F, therefore no transient materials were quantified.



Diesel Generator Room 311A

Surface Area Calculation

Walls		
North wall	(25' x 29')	725 ft^2
East wall	(51' x 29')	1479 ft^2
South wall	(25' x 29')	725 ft^2
West wall	(51' x 29')	1479 ft^2
		4408 ft^2
Ceiling		
(51' x 25') - (8' x 13')		1171 ft^2
		5579 ft^2

ATTACHMENT A

CASE NUMBER: 1
BUILDING: UNIT 1 DIESEL GENERATOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' CELL 1A FIRE AREA 79
CASE DESCRIPTION: TWO 5.25'x 6.5' VENTS OPEN LUBE OIL FIRE

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.0	CONCRETE	68.3	5.3	5579	12747

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	1237
20	1436
30	1627
40	1806
50	1972
60	2128
70	2274
80	2412
90	2544
100	2669
110	2789
120	2905
130	3016
140	3123
150	3227
160	3328
170	3425
180	3520

ATTACHMENT B

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 43

Spray Pond Pump Structure El. 237'

RHRSW Pipeway

Fire Area 122F

Prepared by: M. F. Wahl Date: February 7, 1984

Reviewed by: [illegible] Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the RHRSW Pipeway on the 237' elevation of the Spray Pond Pump Structure (Fire Area 122F). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 1679 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Ventilation to the area is through a hatch located on the 251' elevation in the northeast corner of Fire Area 122E.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

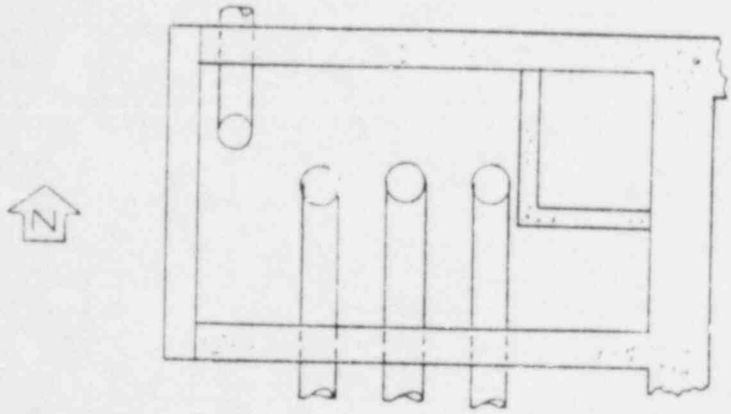
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature of less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	1638
2 hours	7.5	1170
3 hours	6.5	1014

The ceiling height in the area is 10'6". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W18X85.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	2,319	
1300	3,163	27 min
1500	3,796	21 min



Spray Pond Pump Structure El. 237'
RHRSW Pipeway

Surface Area Calculation

Walls		
North wall	(31' x 12')	372 ft^2
South wall	(31' x 12')	372 ft^2
East wall	(17' x 12')	204 ft^2
West wall	(17' x 12')	204 ft^2
		1152 ft^2
Ceiling	(31' x 17')	527 ft^2
Total Surface Area for Heat Transfer		1679 ft^2

ATTACHMENT A

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 44

Spray Pond Pump Structure El. 168'

ESW and RHRSW Pump Area

Fire Area 122A

Prepared by: M. F. Wahl

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

P. O. Box 446 • Oak Ridge, Tennessee 37830 • (615) 482-3541

LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the ESW and RHRSW Pump Area on the 268' elevation of the Spray Pond Pump Structure (Fire Area 122A). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 3860 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Ventilation to the area is through a doorway located in the west wall of the area.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

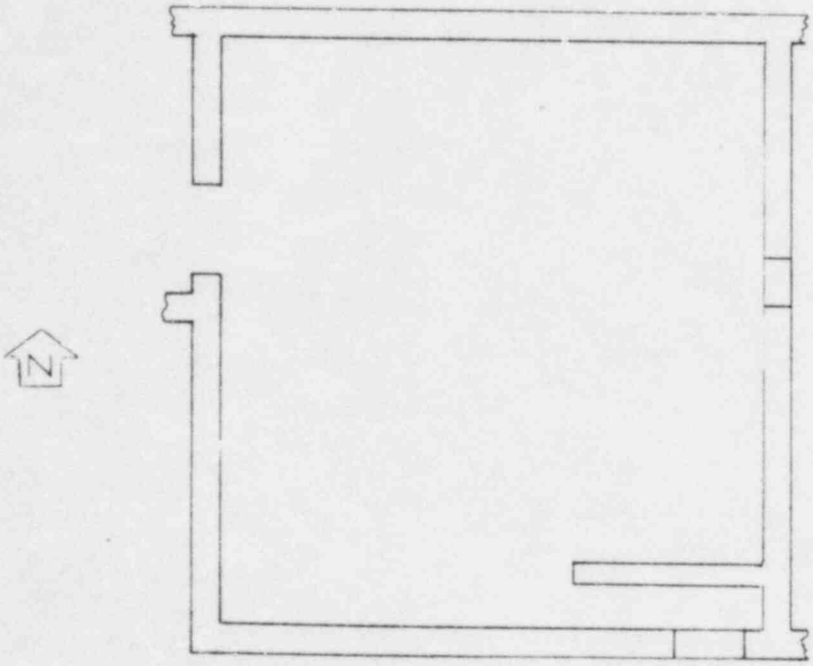
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	3766
2 hours	7.5	2690
3 hours	6.5	2331

The ceiling height in the area is 12'7". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W33X118.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	3,690	
1300	4,956	29 min
1500	6,326	20 min



Spray Pond Pump Structure El. 268'
ESW and RHRSW Pump Area

Surface Area Calculation

Walls

North wall	(38' x 15')	570 ft^2
South wall	(38' x 15')	570 ft^2
East wall	(40' x 15')	600 ft^2
West wall	(40' x 15')	600 ft^2
		2340 ft^2
Ceiling	(38' x 40')	1520 ft^2
Total Surface Area for Heat Transfer		3860 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 45

Spray Pond Pump Structure El. 237'

Wet Pit

Fire Area 122B

Prepared by: W F Wall

Date: February 7, 1984

Reviewed by: [illegible]

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the Wet Pit on the 237' elevation of the Spray Pond Pumphouse (Fire Area 122B). The bounding walls of the area are of reinforced concrete construction with an average thickness of 3 ft. The total surface area for heat transfer is 4656 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Ventilation to the area is through the ceiling on the 268' elevation which is metal grating.

4. CASES EXAMINED

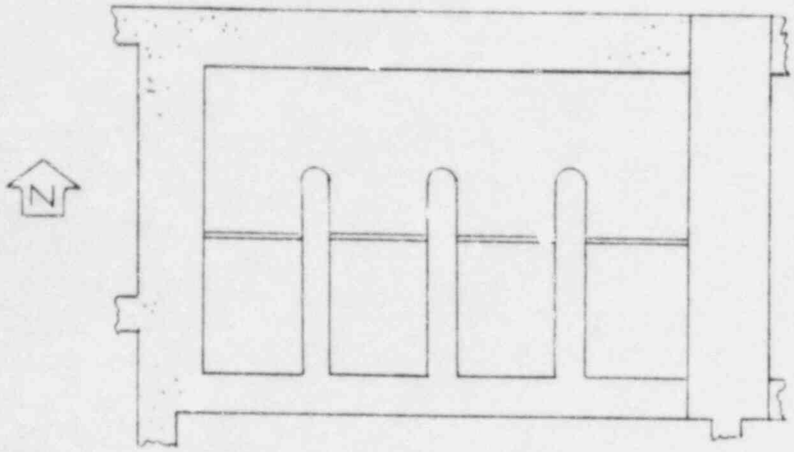
With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

This area contains no fixed combustibles. This area is normally filled with water so no transient materials were quantified.



Spray Pond Pump Structure El. 237'
Wet Pit

Surface Area Calculation

Walls		
North wall	(38' x 31')	1178 ft^2
South wall	(38' x 31')	1178 ft^2
East wall	(23' x 31')	713 ft^2
West wall	(23 x 31')	713 ft^2
		3782 ft^2
Ceiling	(38' x 23')	874 ft^2
Total Surface Area for Heat Transfer		4656 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 46

Spray Pond Pump Structure El. 251'

ESW and RHRSW Pump Area

Fire Area 122C

Prepared by: W F Mahl

Date: February 7, 1984

Reviewed by: W Dungan

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the ESW and RHRSW Pipeway on the 251' elevation of the Spray Pond Pump Structure (Fire Area 122C). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 2372 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

Ventilation to the area is through a hatch located in the southwest corner of the area and is open to the 268' elevation.

4. CASES EXAMINED

With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

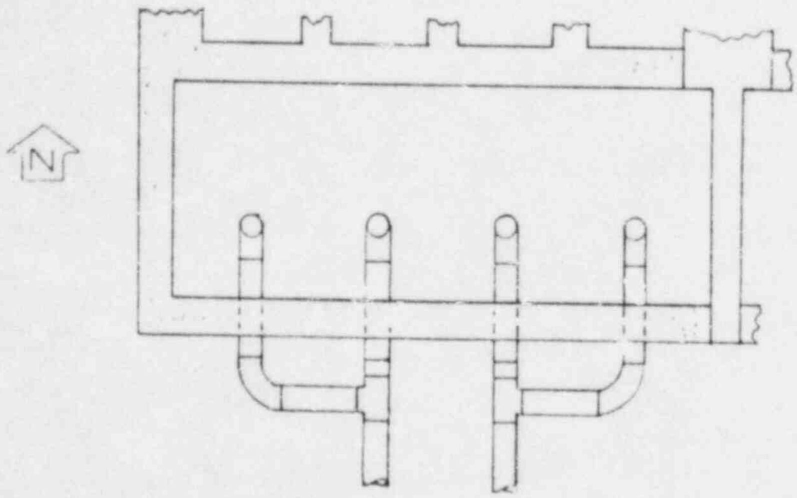
This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in area temperature of 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	2314
2 hours	7.5	1653
3 hours	6.5	1432

The ceiling height in the area is 17 feet. This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W10X39.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	8,225	
1300	10,545	20 min
1500	13,181	14 min



Spray Pond Pump Structure El. 251'
ESW and RHRSW Pipeway

Surface Area Calculation

Walls

North wall	(38' x 17')	646 ft^2
South wall	(38' x 17')	646 ft^2
East wall	(15' x 17')	255 ft^2
West wall	(15' x 17')	255 ft^2
		1802 ft^2
Ceiling	(38 x 15')	570 ft^2
Total Surface Area for Heat Transfer		2372 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 47

Spray Pond Pump Structure El. 268'

Access Hatch Area

Fire Area 122D

Prepared by: W. F. Wahl

Reviewed by: K W Dungan

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

   The area under consideration is the Access Hatch Area on the 268' elevation of the Spray Pond Pump Structure (Fire Area 122D). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2 ft. The total surface area for heat transfer is 2014 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

   All cabling in this area is routed in conduit, there are no cable trays. There are no combustible liquids in this area.

3. VENTILATION PARAMETERS

   There are three openings into this area. The open stairwell from the 251' elevation, an opening into the ESW and RHRSW Pump Area, and a door leading to the outside.

4. CASES EXAMINED

   With no exposed combustible cabling and no combustible liquids in the area, there is no fuel in the area to support a fire.

5. RESULTS

   The structural steel in this area will not fail due to a fire as there are no fixed combustibles in the area to support a fire.

6. EFFECT OF TRANSIENT COMBUSTIBLES

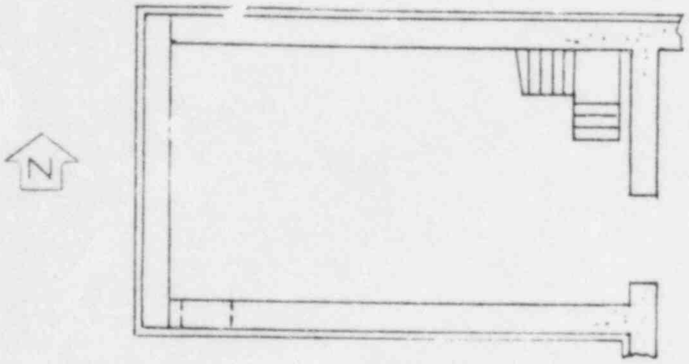
   This area contains no fixed combustibles. The table below lists the maximum heat release rates for transient materials for different fire durations which result in an area temperature less than 1100°F.

Fire Duration	Q/A (kW/m^2)	Q (kW)
1 hour	10.5	1965
2 hours	7.5	1403
3 hours	6.5	1216

The ceiling height [illegible] is 13'6". This distance is measured from the floor slab to t[illegible] the largest structural steel member in the area, which is a W2[illegible]

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	4,640	
1300	5,905	32 min
1500	7,487	23 min



Spray Pond Pump Structure El. 268'
Access Hatch Area

<u>Surface Area Calculation</u>

Walls		
North wall	(32' x 15')	480 ft^2
South wall	(32' x 15')	480 ft^2
East wall	(17' x 15')	255 ft^2
West wall	(17' x 15')	255 ft^2
		1470 ft^2
Ceiling	(32' x 17')	544 ft^2
Total Surface Area for Heat Transfer		2014 ft^2

ATTACHMENT A

PLC Professional Loss Control, Inc.

STRUCTURAL STEEL ANALYSIS

for

LIMERICK GENERATING STATION

Calculation No. 48

Spray Pond Pump Structure El. 251'

RHRSW Valve Compartment

Fire Area 122E

Prepared by: W. F. Mabl

Reviewed by: [signature]

Date: February 7, 1984

Revision: 1

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LIMERICK GENERATING STATION

1. AREA DESCRIPTION

The area under consideration is the RHRSW Valve Compartment on the 251' elevation of the Spray Pond Pump Structure (Fire Area 122E). The bounding walls of the area are of reinforced concrete construction with an average thickness of 2.5 ft. The total surface area for heat transfer is 1871 ft^2 (see Attachment A for sketch and calculation of surface areas).

2. COMBUSTIBLE LOADING

Combustible loading in the area consists of the cable insulation in a single cable tray. The total surface area of the cable tray is 64 ft^2 with an average combustible loading of 3 lbs/ft^2 of cable tray surface area. There are no combustible liquids in the area.

3. VENTILATION PARAMETERS

Ventilation to the area is through an open stairwell which leads to the 268' elevation.

4. CASES EXAMINED

With the light combustible loading in the area, the assumption that all cables were burning simultaneously would present the worst case. With all cables burning, a cable tray surface area of 64 ft^2 would be involved. This corresponds to a heat output of 1130 kW. The fire duration with all cables burning would be 3 $lbs/ft^2 \div \frac{.1\ lbs}{min/ft^2}$ = 30 minutes.

5. RESULTS

With all cables burning simultaneously, a gas temperature of 729°F would be achieved after 30 minutes, which is below the critical temperature of the structural steel (see Attachment B).

The position of the cable tray relative to the structural steel members was examined in the area. The cable tray was positioned so as to not present a localized heating exposure to the structural steel.

6. EFFECT OF TRANSIENT COMBUSTIBLES

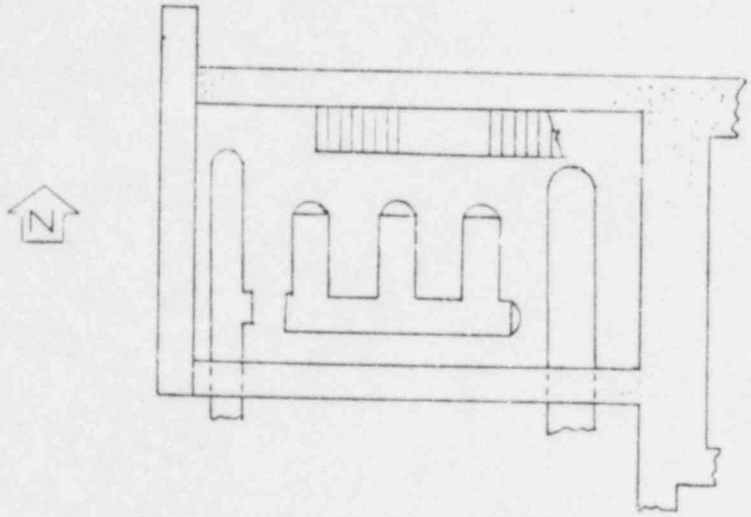
The fire examined was fuel controlled with a duration of 30 minutes. The temperature at this time was below 1100°F. The maximum additional heat release rate due to transient materials in the area which result in an area temperature less than 1100°F is listed below.

Fire Duration	Q/A (kW/m^2)	Q (kW)
30 min	13.5	1217

The ceiling height in the area is 12'6". This distance is measured from the floor slab to the bottom of the largest structural steel member in the area, which is a W24X76.

The heat release rates from transient combustibles in the area necessary to reach plume temperature of 1100°F, 1300°F and 1500°F at the bottom flange of the beam are listed in the table below. For temperatures greater than 1100°F, the time required to heat the steel to 1100°F are also listed.

T (°F)	Q (kW)	Time to 1100°F (min)
1100	3,690	
1300	4,956	24 min
1500	6,326	18 min



Spray Pond Pump Structure El. 251'
RHRSW Valve Compartment

Surface Area Calculation

Walls		
North wall	(31' x 14')	434 ft^2
South wall	(31' x 14')	434 ft^2
East wall	(17' x 14')	238 ft^2
West wall	(17' x 14')	238 ft^2
		1344 ft^2
Ceiling	(31' x 17')	527 ft^2
Total Surface Area for Heat Transfer		1871 ft^2

CASE NUMBER: 1
BUILDING: SPRAY POND PUMP STRUCTURE
ELEVATION AND AREA DESCRIPTION: 251' RHRSW VALVE COMPARTMENT
CASE DESCRIPTION: OPEN STAIRWELL ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
2.5	CONCRETE	36.0	12.0	1871	1130

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	646
4	653
6	660
8	66[illegible]
10	6[illegible]3
12	6[illegible]9
14	685
16	691
18	696
20	702
22	707
24	713
26	718
28	724
30	729

SECTION 5

APPENDICES

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

APPENDIX I

LOCALIZED HEATING OF

REACTOR BUILDING COLUMNS

LIMERICK GENERATING STATION

Columns

Various levels of the Reactor Building contain 14" columns of different weights. These range from W14X87 for the smallest to W14X730 for the largest. The fire exposure to these columns was evaluated from a fire plume exposure, either from transients or fixed combustibles at the base of the column. The acceptance criteria was that the cross sectional temperature of the column remain below 1000°F. The heat transfer calculations, as with beams, ignore conductive heat losses along the column.

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x730 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 730
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.10

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	139
10.00	206
15.00	269
20.00	330
25.00	387
30.00	442
35.00	494
40.00	544
45.00	591
50.00	636
55.00	678
60.00	719
65.00	757

CASE NUMBER: 2
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x342 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 342
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.83

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	201
10.00	321
15.00	431
20.00	530
25.00	620
30.00	701
35.00	775
40.00	843
45.00	904
50.00	959
55.00	1009
60.00	1055
65.00	1096

CASE NUMBER: 3
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x550 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 550
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.[illegible]2

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	157
10.00	240
15.00	318
20.00	391
25.00	460
30.00	524
35.00	584
40.00	641
45.00	694
50.00	744
55.00	791
60.00	835
65.00	876

CASE NUMBER: 4
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x287 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 287
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.86

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	223
10.00	361
15.00	484
20.00	594
25.00	692
30.00	779
35.00	857
40.00	927
45.00	989
50.00	1044
55.00	1093
60.00	1137
65.00	1177

CASE NUMBER: 5
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x665 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 665
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.93

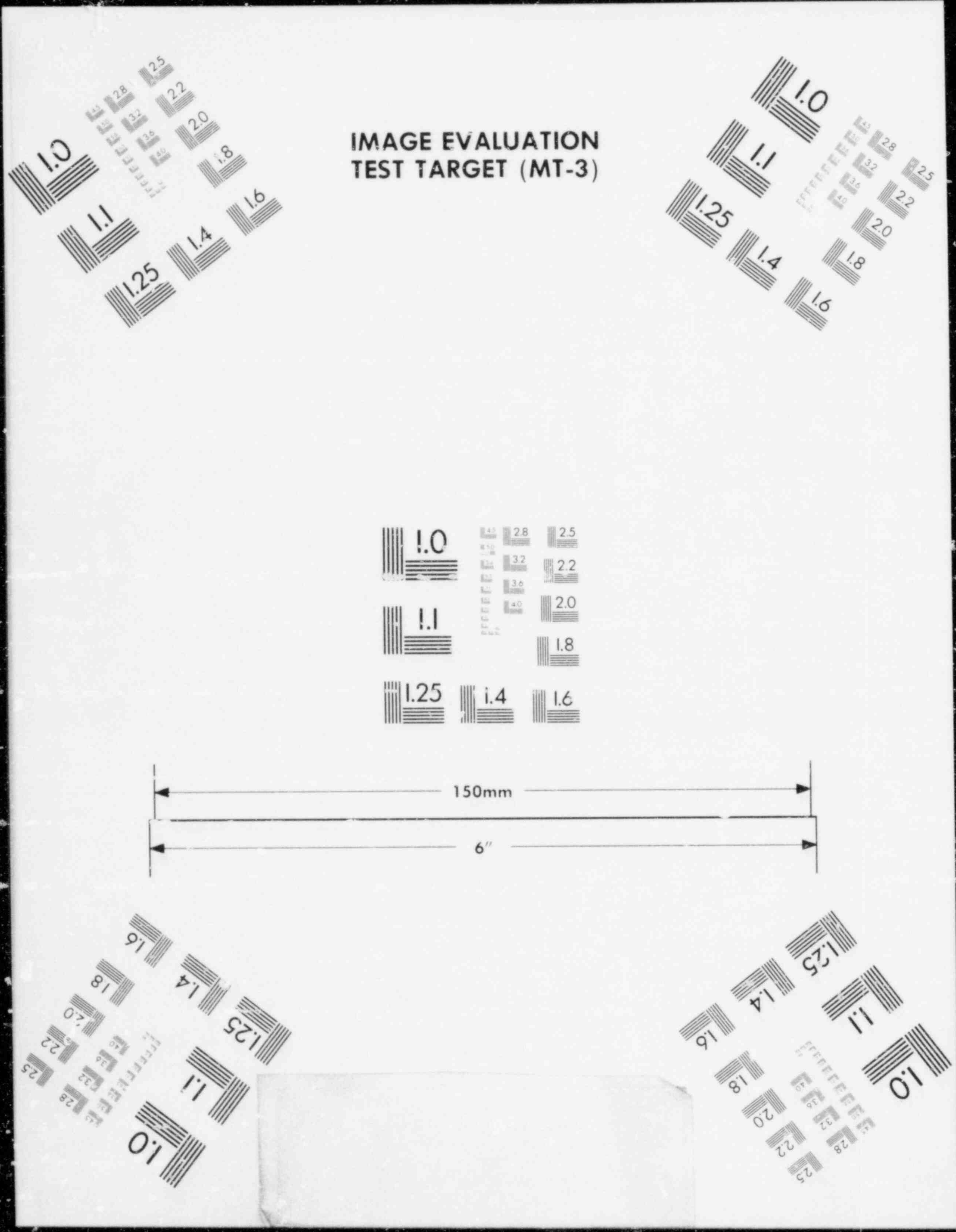
TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	144
10.00	216
15.00	284
20.00	348
25.00	410
30.00	467
35.00	522
40.00	574
45.00	623
50.00	670
55.00	71[illegible]
60.00	755
65.00	795

CASE NUMBER: 6
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x370

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 370
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.12

TIME (min)	STEEL TEMPERATURE (Deg.F)
5.00	192
10.00	305
15.00	409
20.00	504
25.00	590
30.00	669
35.00	741
40.00	807
45.00	867
50.00	922
55.00	972
60.00	1018
65.00	1059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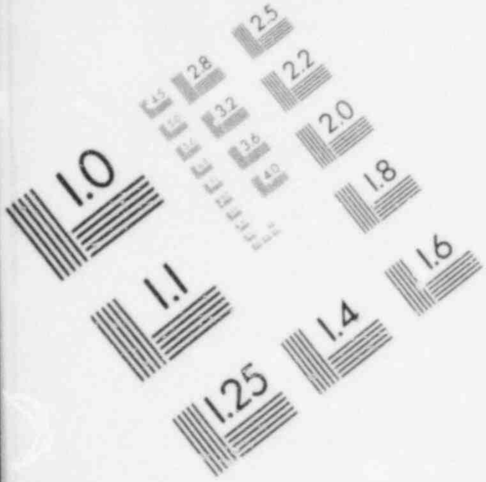
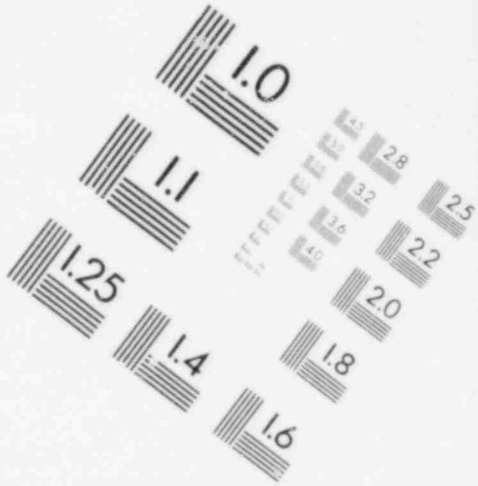
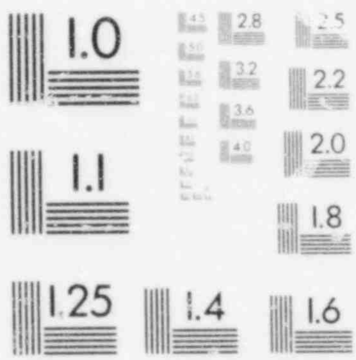
TEST TARGET (MT-3)
150mm
6″

IMAGE EVALUATION TEST TARGET (MT-3)

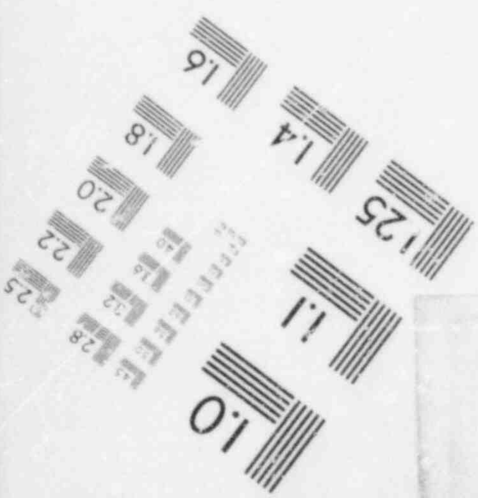


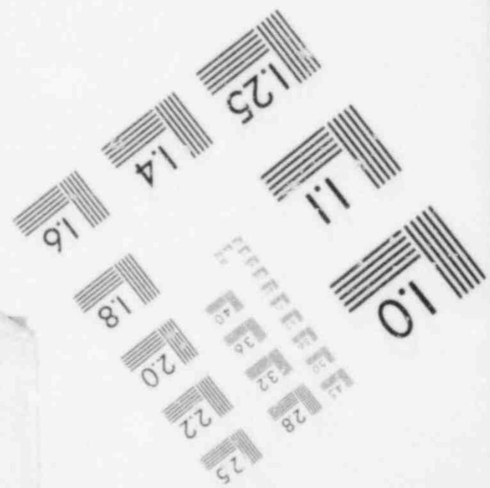




150mm

6"





CASE NUMBER: 7
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: W14x398 COLUMN

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 398
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.20

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	185
10.00	292
15.00	390
20.00	480
25.00	563
30.00	639
35.00	709
40.00	774
45.00	833
50.00	887
55.00	937
60.00	983
65.00	1025

CASE NUMBER: 8
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W14x87

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 87
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.02

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	524
10.00	835
15.00	1047
20.00	1191
25.00	1290
30.00	1357
35.00	1402
40.00	1434
45.00	1455
50.00	1469
55.00	1479
60.00	1486
65.00	1490

CASE NUMBER: 9
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: ALL
CASE DESCRIPTION: COLUMN W14x119

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 119
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.12

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	406
10.00	665
15.00	862
20.00	1013
25.00	1128
30.00	1216
35.00	1283
40.00	1334
45.00	1373
50.00	1403
55.00	1426
60.00	1444
65.00	1457

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APPENDIX II

LOCALIZED HEATING OF BEAMS

P. O. Box 446 • Oak Ridge, Tennessee 37831 • (615) 482-3541

CASE NUMBER: 1
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x40

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 40
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.38

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	601
10.00	903
15.00	1075
20.00	1172
25.00	1227
30.00	1259
35.00	1277
40.00	1287
45.00	1292
50.00	1296

CASE NUMBER: 1
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x40

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 40
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.38

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	687
10.00	1039
15.00	1238
20.00	1351
25.00	1416
30.00	1452
35.00	1473
40.00	1485
45.00	1491
50.00	1495

CASE NUMBER: 2
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE 18WF45

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 45
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.41

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	545
10.00	837
15.00	1016
20.00	1126
25.00	1193
30.00	1235
35.00	1260
40.00	1275
45.00	1285
50.00	1291

CASE NUMBER: 2
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE 18WF45

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 45
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.41

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	622
10.00	962
15.00	1170
20.00	1298
25.00	1376
30.00	1424
35.00	1453
40.00	1471
45.00	1483
50.00	1489

CASE NUMBER: 3
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x44

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 44
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.94

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	614
10.00	918
15.00	1088
20.00	1182
25.00	1234
30.00	1263
35.00	1280
40.00	1289
45.00	1294
50.00	1296

CASE NUMBER: 3
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x44

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 44
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 4.94

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	703
10.00	1056
15.00	1253
20.00	1363
25.00	1424
30.00	1457
35.00	1476
40.00	1487
45.00	1493
50.00	1496

CASE NUMBER: 4
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x55

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 55
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.01

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	511
10.00	795
15.00	977
20.00	1093
25.00	1167
30.00	1215
35.00	1246
40.00	1265
45.00	1278
50.00	1286

CASE NUMBER: 4
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x55

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 55
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.01

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	583
10.00	913
15.00	1124
20.00	1259
25.00	1346
30.00	1401
35.00	1437
40.00	1460
45.00	1474
50.00	1483

CASE NUMBER: 5
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x68

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 68
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.06

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	502
10.00	783
15.00	965
20.00	1083
25.00	1159
30.00	1209
35.00	1241
40.00	1262
45.00	1275
50.00	1284

CASE NUMBER: 5
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x68

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 68
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.06

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	572
10.00	899
15.00	1110
20.00	1247
25.00	1336
30.00	1394
35.00	1431
40.00	1455
45.00	1471
50.00	1481

CASE NUMBER: 6
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x76

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 76
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.09

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	458
10.00	724
15.00	907
20.00	1031
25.00	1116
30.00	1174
35.00	1214
40.00	1241
45.00	1260
50.00	1273

CASE NUMBER: 6
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x76

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 76
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.09

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	521
10.00	831
15.00	1043
20.00	1187
25.00	1286
30.00	1354
35.00	1400
40.00	1432
45.00	1453
50.00	1468

CASE NUMBER: 7
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G1(W24x293)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 293
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	190
10.00	301
15.00	400
20.00	489
25.00	570
30.00	642
35.00	708
40.00	767
45.00	820
50.00	867

CASE NUMBER: 7
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G1(W24x293)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 293
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	210
10.00	338
15.00	454
20.00	558
25.00	651
30.00	736
35.00	812
40.00	880
45.00	942
50.00	997

CASE NUMBER: 8
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 84
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	461
10.00	728
15.00	911
20.00	1035
25.00	1119
30.00	1177
35.00	1216
40.00	1243
45.00	1261
50.00	1273

CASE NUMBER: 8
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 84
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	524
10.00	835
15.00	1047
20.00	1192
25.00	1290
30.00	1357
35.00	1403
40.00	1434
45.00	1455
50.00	1469

CASE NUMBER: 9
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x102

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 102
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.85

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	395
10.00	635
15.00	811
20.00	941
25.00	1036
30.00	1106
35.00	1158
40.00	1195
45.00	1223
50.00	1243

CASE NUMBER: 9
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x102

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 102
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.85

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	448
10.00	727
15.00	932
20.00	1083
25.00	1193
30.00	1275
35.00	1334
40.00	1378
45.00	1411
50.00	1434

CASE NUMBER: 10
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x114

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 114
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.89

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	362
10.00	586
15.00	756
20.00	886
25.00	985
30.00	1060
35.00	1117
40.00	1161
45.00	1194
50.00	1219

CASE NUMBER: 10
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x114

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 114
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.89

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	410
10.00	670
15.00	868
20.00	1019
25.00	1134
30.00	1221
35.00	1288
40.00	1338
45.00	1377
50.00	1406

CASE NUMBER: 11
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x99

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 99
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	430
10.00	686
15.00	866
20.00	994
25.00	1084
30.00	1147
35.00	1192
40.00	1224
45.00	1246
50.00	1262

CASE NUMBER: 11
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x99

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 99
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.37

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	489
10.00	786
15.00	996
20.00	1144
25.00	1249
30.00	1323
35.00	1375
40.00	1412
45.00	1438
50.00	1456

CASE NUMBER: 12
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x118

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 118
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.15

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	404
10.00	648
15.00	826
20.00	955
25.00	1049
30.00	1118
35.00	1167
40.00	1204
45.00	1230
50.00	1249

CASE NUMBER: 12
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x118

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 118
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.15

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	459
10.00	743
15.00	949
20.00	1099
25.00	1209
30.00	1288
35.00	1346
40.00	1388
45.00	1419
50.00	1441

CASE NUMBER: 13
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x152

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 152
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.27

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	333
10.00	541
15.00	704
20.00	832
25.00	932
30.00	1011
35.00	1073
40.00	1122
45.00	1160
50.00	1190

CASE NUMBER: 13
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x152

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 152
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.27

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	376
10.00	617
15.00	807
20.00	956
25.00	1073
30.00	1165
35.00	1237
40.00	1293
45.00	1338
50.00	1373

CASE NUMBER: 14
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x230

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 230
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.84

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	276
10.00	449
15.00	593
20.00	712
25.00	812
30.00	894
35.00	963
40.00	1020
45.00	1067
50.00	1106

CASE NUMBER: 14
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x230

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 230
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.84

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	310
10.00	511
15.00	678
20.00	817
25.00	932
30.00	1028
35.00	1108
40.00	1174
45.00	1229
50.00	1275

CASE NUMBER: 15
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x245

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 245
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	264
10.00	429
15.00	567
20.00	684
25.00	782
30.00	864
35.00	934
40.00	992
45.00	1041
50.00	1082

CASE NUMBER: 15
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x245

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 245
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	296
10.00	487
15.00	649
20.00	784
25.00	898
30.00	994
35.00	1074
40.00	1142
45.00	1199
50.00	1247

CASE NUMBER: 16
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x260

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 260
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.90

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	253
10.00	411
15.00	544
20.00	658
25.00	755
30.00	837
35.00	906
40.00	965
45.00	1016
50.00	1059

CASE NUMBER: 16
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x260

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 260
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.90

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	283
10.00	466
15.00	622
20.00	754
25.00	866
30.00	961
35.00	1042
40.00	1111
45.00	1170
50.00	1219

CASE NUMBER: 17
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x300

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 300
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.99

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	230
10.00	371
15.00	493
20.00	599
25.00	691
30.00	771
35.00	841
40.00	901
45.00	954
50.00	999

CASE NUMBER: 17
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x300

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 300
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 9.99

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	256
10.00	420
15.00	562
20.00	685
25.00	792
30.00	886
35.00	966
40.00	1037
45.00	1097
50.00	1150

CASE NUMBER: 18
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G1(W42x316)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 316
SURFACE OF STEEL MEMBER HEATED (sq ft./ft): 10.91

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	236
10.00	381
15.00	506
20.00	615
25.00	708
30.00	789
35.00	858
40.00	919
45.00	971
50.00	1016

CASE NUMBER: 18
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G1(W42x316)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 316
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 10.91

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	263
10.00	432
15.00	578
20.00	703
25.00	812
30.00	906
35.00	987
40.00	1057
45.00	1117
50.00	1169

CASE NUMBER: 19
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G52(W54x366)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 366
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 13.30

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	245
10.00	396
15.00	526
20.00	637
25.00	732
30.00	814
35.00	883
40.00	943
45.00	994
50.00	1038

CASE NUMBER: 19
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE G52(W54x366)

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 366
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 13.30

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	274
10.00	450
15.00	600
20.00	729
25.00	840
30.00	935
35.00	1016
40.00	1085
45.00	1145
50.00	1196

CASE NUMBER: 20
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x194

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 194
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.88

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	291
10.00	473
15.00	623
20.00	745
25.00	845
30.00	928
35.00	995
40.00	1050
45.00	1095
50.00	1132

CASE NUMBER: 20
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W36x194

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 194
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.88

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	327
10.00	539
15.00	713
20.00	855
25.00	972
30.00	1067
35.00	1145
40.00	1209
45.00	1262
50.00	1305

CASE NUMBER: 21
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x130

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 130
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.12

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	334
10.00	543
15.00	707
20.00	835
25.00	936
30.00	1015
35.00	1076
40.00	1125
45.00	1163
50.00	1192

CASE NUMBER: 21
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x130

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 130
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.12

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	378
10.00	620
15.00	811
20.00	960
25.00	1077
30.00	1168
35.00	1240
40.00	1296
45.00	1340
50.00	1375

CASE NUMBER: 22
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x110

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 110
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.04

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	379
10.00	612
15.00	786
20.00	916
25.00	1013
30.00	1086
35.00	1140
40.00	1180
45.00	1211
50.00	1233

CASE NUMBER: 22
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x110

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 110
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.04

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	430
10.00	700
15.00	903
20.00	1054
25.00	1166
30.00	1251
35.00	1314
40.00	1361
45.00	1396
50.00	1422

CASE NUMBER: 23
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x210

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 210
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.71

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	270
10.00	439
15.00	580
20.00	698
25.00	796
30.00	879
35.00	948
40.00	1006
45.00	1054
50.00	1094

CASE NUMBER: 23
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W30x210

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 210
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.71

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	303
10.00	499
15.00	663
20.00	800
25.00	915
30.00	1010
35.00	1091
40.00	1158
45.00	1214
50.00	1261

CASE NUMBER: 24
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x105

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 105
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.77

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	335
10.00	545
15.00	709
20.00	837
25.00	937
30.00	1016
35.00	1078
40.00	1126
45.00	1164
50.00	1193

CASE NUMBER: 24
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x105

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 105
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.77

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	379
10.00	622
15.00	813
20.00	962
25.00	1079
30.00	1170
35.00	1242
40.00	1298
45.00	1342
50.00	1376

CASE NUMBER: 25
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x145

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 145
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	332
10.00	540
15.00	703
20.00	831
25.00	931
30.00	1010
35.00	1072
40.00	1121
45.00	1160
50.00	1190

CASE NUMBER: 25
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W27x145

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 145
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 7.87

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	375
10.00	616
15.00	806
20.00	954
25.00	1071
30.00	1163
35.00	1235
40.00	1292
45.00	1337
50.00	1372

CASE NUMBER: 26
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x55

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 55
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.54

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	558
10.00	853
15.00	1031
20.00	1138
25.00	1202
30.00	1241
35.00	1265
40.00	1279
45.00	1287
50.00	1292

CASE NUMBER: 26
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x55

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 55
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.54

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	638
10.00	981
15.00	1187
20.00	1312
25.00	1387
30.00	1432
35.00	1459
40.00	1475
45.00	1485
50.00	1491

CASE NUMBER: 27
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x141

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 141
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.23

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	352
10.00	571
15.00	739
20.00	868
25.00	968
30.00	1044
35.00	1103
40.00	1149
45.00	1183
50.00	1210

CASE NUMBER: 27
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W33x141

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 141
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 8.23

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	398
10.00	652
15.00	848
20.00	998
25.00	1114
30.00	1203
35.00	1271
40.00	1324
45.00	1365
50.00	1396

CASE NUMBER: 28
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x94

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 94
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.16

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	387
10.00	623
15.00	798
20.00	928
25.00	1024
30.00	1096
35.00	1149
40.00	1188
45.00	1217
50.00	1238

CASE NUMBER: 28
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W24x94

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 94
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.16

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	439
10.00	713
15.00	917
20.00	1068
25.00	1180
30.00	1263
35.00	1324
40.00	1370
45.00	1403
50.00	1428

CASE NUMBER: 29
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x112

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 112
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.51

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	351
10.00	569
15.00	737
20.00	866
25.00	966
30.00	1042
35.00	1101
40.00	1147
45.00	1182
50.00	1209

CASE NUMBER: 29
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W21x112

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 112
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 6.51

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	397
10.00	650
15.00	845
20.00	995
25.00	1111
30.00	1201
35.00	1269
40.00	1322
45.00	1363
50.00	1394

CASE NUMBER: 30
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x85

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 85
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.70

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	394
10.00	634
15.00	810
20.00	940
25.00	1035
30.00	1106
35.00	1157
40.00	1195
45.00	1223
50.00	1243

CASE NUMBER: 30
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W18x85

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 85
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 5.70

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	447
10.00	726
15.00	931
20.00	1082
25.00	1192
30.00	1274
35.00	1334
40.00	1378
45.00	1410
50.00	1434

CASE NUMBER: 31
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W10x39

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 39
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 3.53

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	508
10.00	791
15.00	973
20.00	1070
25.00	1165
30.00	1213
35.00	1244
40.00	1264
45.00	1277
50.00	1285

CASE NUMBER: 31
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: LOCALIZED HEATING OF MEMBER TYPE W10x39

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 39
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 3.53

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	580
10.00	909
15.00	1120
20.00	1256
25.00	1343
30.00	1399
35.00	1435
40.00	1458
45.00	1473
50.00	1483

CASE NUMBER: 32
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: G7

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1300
WEIGHT OF STEEL MEMBER (lbs./ft): 435
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 11.25

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	194
10.00	307
15.00	408
20.00	499
25.00	581
30.00	655
35.00	720
40.00	780
45.00	833
50.00	881
55.00	923
60.00	962
65.00	996

CASE NUMBER: 32
BUILDING:
ELEVATION AND AREA DESCRIPTION:
CASE DESCRIPTION: G7

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1500
WEIGHT OF STEEL MEMBER (lbs./ft): 435
SURFACE OF STEEL MEMBER HEATED (sq.ft./ft): 11.25

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	214
10.00	346
15.00	463
20.00	569
25.00	664
30.00	750
35.00	826
40.00	895
45.00	957
50.00	1012
55.00	1062
60.00	1107
65.00	1147

ATTACHMENT (2)

Comparison of PECo Heat Balance Model With NUREG/CR-3192

Data for the tests reported on in NUREG/CR-3192 has been received from Sandia National Laboratories; enabling us to complete a comparison between the results of the UL tests and the calculated temperatures from the PECo heat balance model. We have evaluated Tests 1 through 6 and Experiment 3. The results of the comparison are as follows:

Test 1

5 gallons Heptane and non-qualified cables (PE/PVC)
Experimental peak temperatures at 5 minutes
Duration - 15 minutes

Heat release rate	1160 KW Heptane
	1750 KW Cables
	2910 KW Total

PECo Heat Balance Calculated Temperature	- 1507°F
Test 1 Average Room Temp.	- 784°F
Test 1 Temp without lowest level thermocouples	- 1212°F

Test 2

5 gallons Heptane and qualified cables (XLPE)
Experimental peak temperatures at 6 minutes
Duration - 14 minutes

	Case A	Case B
Heat release rate	1160 KW Heptane	1160 KW Heptane
	1234 KW Cables	1410 KW Cables
	2394 KW Total	2570 KW Total

PECo Heat Balance Calculated Temperature	- 1304°F	1363°F
Test 2 Average Room Temp.	- 659°F	
Test 2 Temp without lowest level thermocouples	- 1027°F	

Test 3

5 gallons Heptane and non-qualified cables with ceramic fiber blanket
Experimental peak temperature at 15 minutes
Duration - 20 minutes

Heat release rate	1160 KW Heptane
	1312 KW Cables
	2472 KW Total

PECo Heat Balance Calculated Temperature	- 1461°F
Test 3 Average Room Temp.	- 539°F
Test 3 Temp without lowest level thermocouples	- 753°F

Test 4

5 gallons Heptane and qualified cables with ceramic fiber blanket
Experimental peak temperature at 16 minutes
Duration - 30 minutes

Heat release rate	1160 KW	Heptane
	575 KW	Cables
	1735 KW	Total

PECo Heat Balance Calculated Temperature - 1283°F
Test 4 Average Room Temp. - 519°F
Test 4 Temp without lowest level thermocouples - 742°F

Test 5

5 gallons Heptane and nonqualified coated cables
Experimental peak temperature at 10 minutes
Duration - 20 minutes

Heat release rate	1160 KW	Heptane
	1312 KW	Cables
	2472 KW	Total

PECo Heat Balance Calculated Temperature - 1461°F
Test 5 Average Room Temp. - 560°F
Test 5 Temp without lowest level thermocouples - 789°F

Test 6

5 gallons Heptane and qualified coated cables
Experimental peak temperature at 19 minutes
Duration - 23 minutes

Heat release rate	1160 KW	Heptane
	693 KW	Cables
	1853 KW	Total

PECo Heat Balance Calculated Temperature - 1249°F
Test 6 Average Room Temp. - 559°F
Test 6 Temp without lowest level thermocouples - 774°F

Experiment 3

10 gallons Heptane
Experimental peak temperature at 20 minutes
Duration - 25 minutes
Heat release rate 1160 KW Heptane

PECo Heat Balance Calculated Temperature - 959°F
Exper 3 Average Room Temp. - 524°F
Exper 3 Temp without lowest level thermocouples - 710°F

The above comparisons were made on the following bases:

1. Average temperature calculation: Sandia Laboratories provided thermocouple readings and temperature plots for the six full-scale tests conducted by UL. These readings were used to calculate a volumetric average of the 76 thermocouple locations (Figure 1). In evaluating the data, thermocouples #26 and 28 were not functioning properly, #56 was not included in the data and #31 and 32 were interchanged. To replace #26 and 28, thermocouples #102 and 100, respectively, were used (see p. 116, NUREG/CR 3192). The value for #56 was taken to be the average of adjacent thermocouples #44 and 68.

   The test room was divided into the 76 zones shown on Figure 2. Each of these zones was assigned the temperatures of the thermocouple within the zone. Weighted volumetric averaging was then performed by using the following formula.

$$\frac{\sum_{i=1}^{N} T_i \times V_i}{\sum_{i=1}^{N} V_i} = T$$

   Where V_i = Each of the 76 volumes shown on Figure 2

   T_i = The thermocouple data for V_i

   All 76 zones were used in calculating the average room temperature. An average temperature for the upper portion of the room was calculated by eliminating the lower layer of thermocouples and their associated volumes. The average temperatures were calculated using the peak temperatures from the test data.

2. Heat Release Rate

   Heptane - Literature values for heat release rates for flammable liquid pool fires generally and heptane specifically vary in the range of 2500 to 3300 kW/m^2. For the Sandia and UL tests, the heat release rate was calculated by taking the total heat value of the fuel divided by the duration of the fire, and is 1966 kW/m^2. The table below shows the heat release rate for the heptane fire using this data.

Heat Release Rate for Heptane Pool Fire

Q	Source
913 kW	Sandia/UL - NUREG/CR-3192
1160 kW	Based on 120,000 BTU/gal - Coulbert Fire Technology Aug. 1977
1530 kW	FMRC-Alpert & Ward, SFPE-TR 83-2

The methodology used for Limerick for pool fires was based on Coulbert's approach. Therefore, for this comparison, the value of 1160 kW was used.

Cables - The heat release rate for the non-qualified PE/PVC was calculated using the mass loss data and heat of combustion similar to the methodology used for Limerick. The FM test data (see EPRI NP-1881) for PE/PVC was used. This yields a heat release rate of 628 kW/m^2 of cable tray.

In the case of the qualified (IEEE 383) XLPE cables, no large scale test data was available similar to that on PE/PVC or hypalon jacket conducted by FMRC. To develop the heat release rate for these cables, the small scale tests outlined in EPRI NP 1200 (see Table S-4) were used as a comparison to develop a heat release rate. Two such values were developed. The first was developed by taking the PE/PVC data from EPRI NP-1881 and multiplying by the ratio of small scale heat release rates from EPRI NP-1200 as follows:

$$628\ kW/m^2 \times \frac{475\ XLPE}{589\ PE/PVC} = 506\ kW/m^2 \text{ from PE/PVC}$$

The second was developed by taking the hypalon data and multiplying by the ratio of small scale heat release rates as follows:

$$190\ kW/m^2 \times \frac{475\ XLPE}{204\ hypalon} = 443\ kW/m^2 \text{ from hypalon}$$

These comparisons yield a range of heat release rates for Test 2 of 1234 kW - 1410 kW.

In the cases where cable protection schemes were provided (i.e., ceramic fiber insulation or cable coatings) no test data exists regarding heat release rates. To estimate these heat release rates, the duration of the fire for protected cables was compared to that of unprotected cables. The heat release rate was then developed by multiplying the heat release rate of the unprotected cables by the ratios of fire duration.

3. Fire duration: The fire duration was determined from the thermocouple readings in the fire plume (Nos. 13, 14, 15, and 16 on Figure 1). When the temperature of these thermocouples dropped sharply, the fire was assumed to be completed.

Summary

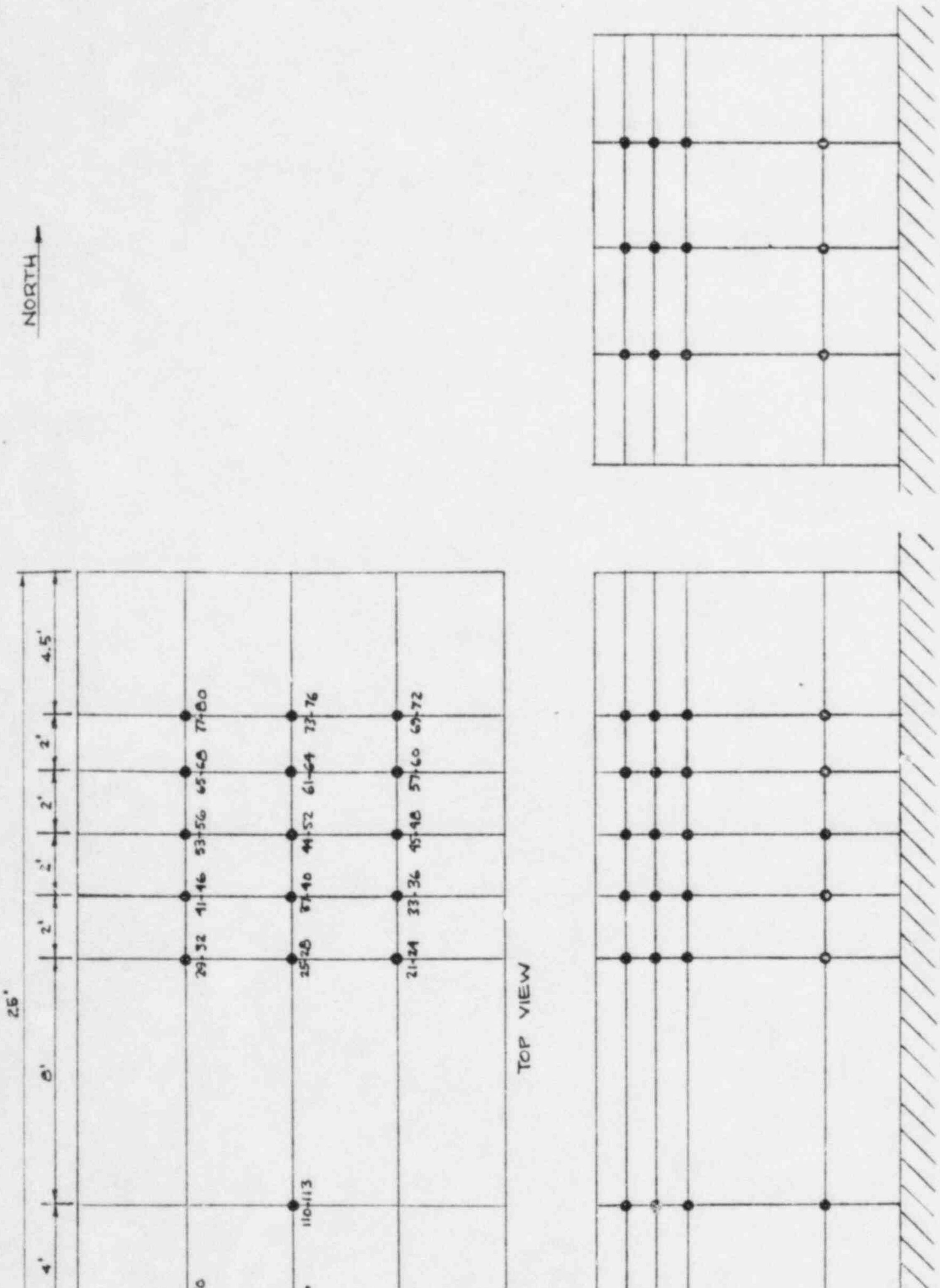
The results of the work undertaken to compare the test data of the UL test fires analyzed by Sandia National Laboratories in NUREG/CR-3192 with the analysis of identical fires using the PECo heat balance model indicate that the model predicts temperatures which are higher than the weighted volumetric average temperatures obtained from the test data. Note that the calculated average temperatures from the test data are based on instantaneous maximum peak values.

To perform calculations for these comparisons required that assumptions be made for burn rates and heat releases because no data was available for some of the materials being burned. The input to the Limerick and Peach Bottom calculations have been gathered from test data and were not based upon assumptions.

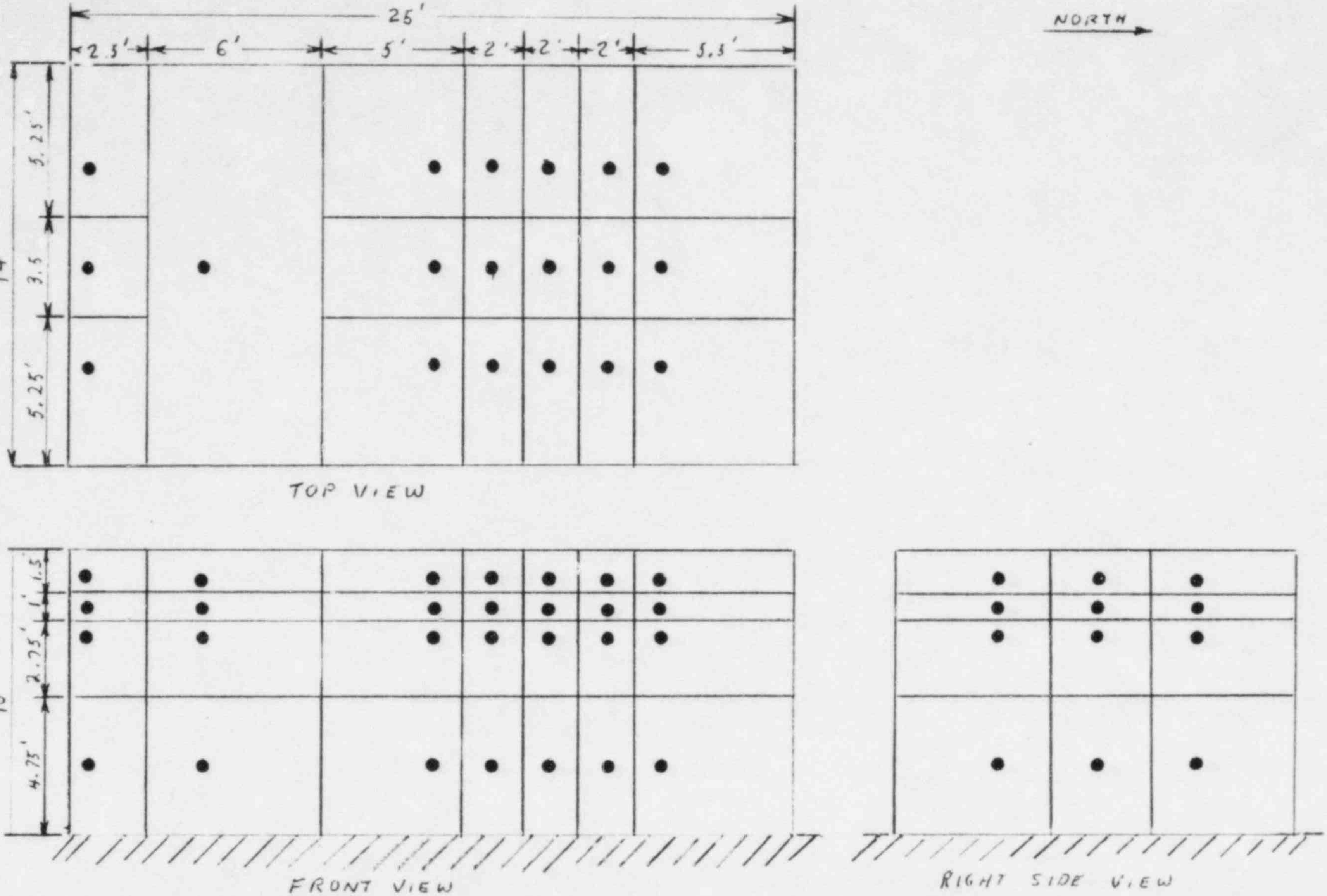
The heat balance methodology is not intended for use as a tool for calculating a precise temperature that results from a fire. The intended application is that of a conservative screening device in the process of determining the survivability of structural steel during a fire. In addition to using the heat balance model to determine overall room or area temperatures localized effects of fires on the structural steel are evaluated. This is accomplished by looking at the plumes of the hypothesized fires. Once temperatures are obtained from these devices steel temperatures are calculated by using the methodology presented by Stanzak as submitted with our calculations.

DMC:mtk 1/13/84-1

FIGURE 1



THERMOCOUPLE LOCATION FOR UL TESTS 1-6



VOLUMETRIC SUBDIVISION OF UL TEST ROOM

FIGURE 2

CASE NUMBER: 1
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 1
CASE DESCRIPTION:

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	2910

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	1119
2	1143
3	1169
4	1195
5	1222
6	1250
7	1278
8	1307
9	1335
10	1364
11	1393
12	1421
13	1450
14	1478
15	1507

CASE NUMBER: 2A
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 2
CASE DESCRIPTION:

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	2390

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	1041
2	1059
3	1078
4	1097
5	1117
6	1137
7	1157
8	1178
9	1198
10	1219
11	1240
12	1261
13	1282
14	1303

CASE NUMBER: 2B
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 2
CASE DESCRIPTION:

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	2570

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	1069
2	1070
3	1110
4	1132
5	1154
6	1177
7	1199
8	1223
9	1246
10	1269
11	1293
12	1316
13	1340
14	1363

CASE NUMBER: 3
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 3
CASE DESCRIPTION:

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	2472

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	1054
2	1073
3	1093
4	1113
5	1134
6	1155
7	1177
8	1198
9	1220
10	1242
11	1264
12	1286
13	1308
14	1330
15	1352
16	1374
17	1396
18	1417
19	1439
20	1460

CASE NUMBER: 4
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 4
CASE DESCRIPTION:

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	1735

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	924
2	937
3	949
4	961
5	973
6	985
7	997
8	1009
9	1022
10	1034
11	1047
12	1059
13	1072
14	1084
15	1097
16	1110
17	1122
18	1135
19	1147
20	1160
21	1172
22	1185
23	1197
24	1209
25	1222
26	1234
27	1246
28	1258
29	1271
30	1283

CASE NUMBER: 5
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 5
CASE DESCRIPTION:

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	2472

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	1054
2	1073
3	1093
4	1113
5	1134
6	1155
7	1177
8	1198
9	1220
10	1242
11	1264
12	1286
13	1308
14	1330
15	1352
16	1374
17	1396
18	1417
19	1439
20	1460

CASE NUMBER: 6
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL TEST 6
CASE DESCRIPTION:

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	1853

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	947
2	961
3	974
4	987
5	1000
6	1014
7	1027
8	1041
9	1055
10	1068
11	1082
12	1096
13	1110
14	1124
15	1138
16	1152
17	1166
18	1180
19	1193
20	1207
21	1221
22	1235
23	1249

CASE NUMBER: 7
BUILDING:
ELEVATION AND AREA DESCRIPTION: UL EXPERIMENT 3
CASE DESCRIPTION:

****

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
.7	BLOCK	32.0	8.0	1130	1160

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	793
2	801
3	808
4	816
5	823
6	830
7	837
8	844
9	850
10	857
11	864
12	871
13	878
14	885
15	891
16	898
17	905
18	912
19	919
20	925
21	932
22	939
23	946
24	952
25	959