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MAY 31 1984

Docket Nos: 50-352
50-353

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Limerick Generating Station, Units 1 and 2
Structural Steel Survivability Evaluation

Reference: J. S. Kemper to A. Schwencer
letter dated February 29, 1984

File: GOVT 1-1 (NRC)

Dear Mr. Schwencer,

The reference letter submitted the Structural Steel Survivability Evaluation dated February 24, 1984, which presented our program to close out SER Open Item #14; Structural Steel Protection.

In response to comments made by personnel from Brookhaven National Laboratory, the NRC's consultant on this item, we are submitting the attachment which provides clarifying information. The attachment contains errata sheets to be inserted in the Structural Steel Survivability Evaluation dated February 24, 1984.

B001
1/1

This letter completes our response to those items raised by Brookhaven National Laboratory. Should you have any questions, require additional information, or wish to hold an additional meeting; please do not hesitate to contact us.

Sincerely,

John S. Kemper

DMG/bls 15/5

Attachment

Copy to: See Attached Service List

cc:	Judge Lawrence Brenner	(w/enclosure)
	Judge Richard F. Cole	(w/enclosure)
	Troy B. Conner, Jr., Esq.	(w/enclosure)
	Ann P. Hodgdon, Esq.	(w/enclosure)
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	Charles W. Elliot, Esq.	(w/enclosure)
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	Mr. Thomas Gerusky	(w/enclosure)
	Director, Penna. Emergency Management Agency	(w/enclosure)
	Angus R. Love, Esq.	(w/enclosure)
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	Spence W. Perry, Esq.	(w/enclosure)
	Jay M. Gutierrez, Esq.	(w/enclosure)
	Atomic Safety & Licensing Appeal Board	(w/enclosure)
	Atomic Safety & Licensing Board Panel	(w/enclosure)
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	Martha W. Bush, Esq.	(w/enclosure)
	Mr. James Wiggins	(w/enclosure)
	Mr. Timothy R. S. Campbell	(w/enclosure)
	Ms. Phyllis Zitzer	(w/enclosure)
	Judge Peter A. Morris	(w/enclosure)

Limerick Generating Station Units 1 and 2
Structural Steel Survivability Evaluation
Errata Pages Dated May 14, 1984

The attached errata pages are considered part of the Structural Steel Survivability Evaluation dated February 24, 1984 and should be incorporated by following the collating instructions below:

REMOVE FROM EVALUATION DATED FEBRUARY 24, 1984	INSERT PAGE DATED MAY 15, 1984
Methodology - page 17	Methodology - page 17
Methodology - page 18	Methodology - page 18
Methodology - page 19	Methodology - page 19
Summary pages 2, 3, 4, 5, 6	Summary Pages 2, 3, 4, 5, 6
1-2 & 3	1-2 & 3
2-2 & 3	2-2 & 3
4-2	4-2
12-2	12-2
Calc. 12 Attachment C Cases 3, 4, 5, 6, 7, 8,	Calc. 12 Attachment C Cases 3, 4, 5, 6, 7, 8
13-2	13-2
Calc. 13 Attachment C Cases 3, 4	Calc. 13 Attachment C Cases 3,4
15-2	15-2
16-2	16-2
	Calc. 16 Attachment D
17.2	17.2
	Calc. 17 Attachment D
18-1 & 2	18-1 & 2
	Calc. 18 Attachment D
19-2	19-2
Calc. 19 - Attachment D	Calc. 19 Attachment D

20-2	20-2
Calc. 20 - Attachment D Cases 1, 2	Calc. 20 - Attachment D Cases 1, 2
25-2	25-2
34-2	34-2
Calc. 34 - Attachment C	Calc. 34 - Attachment C
37-1, 2, 3	37- 1,2,3
Calc. 37 - Attachment C Case 2	Calc. 37 - Attachment C Case 2
	Calc. 37 - Attachment C1 Cases 1, 2, 3, 4, 5, 6, 7, 8
Calc. 37 - Attachment D Case 8	Calc. 37 - Attachment D Case 8

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. Transient fires were quantified up to 21,100 kW (20,000 Btu/sec). Since these are such large fires, it was not considered necessary to quantify any larger. 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 1000°F cross sectional average temperature of the steel member has been established for columns with the following verification steps:

1. If the area temperatures are less than 1000°F, then only localized heating is evaluated.
2. Columns are exposed to plume temperatures of 1500°F from cable trays, pool fires or transient combustibles. Exposure duration is the greater of the following: a) the duration of cable exposure, b) the duration of the pool fire, or c) 30 minutes from transient combustibles. If the columns exposed do not reach 1000°F, the unprotected member is acceptable.

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).

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

Where T = 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)

t = time interval in hours

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.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(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. STEEL WILL NOT BE FIREPROOFED.
12		2	VENTILATION CONTROLLED FIRE, TWO DOORS OPEN, ALL CABLES BURNING	46	1065		
12		3	FUEL 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. STEEL WILL NOT BE FIREPROOFED.
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.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERATURE(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. STEEL WILL NOT BE FIREPROOFED.
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 24 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 29 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	CABLE TRAY T(S)=1100 AT 41 MIN	PREACTION SPRINKLER SYSTEM INSTALLED IN NE CORNER FOR SAFE SHUTDOWN CONSIDERATIONS. STEEL WILL NOT BE FIREPROOFED.
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 13 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.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
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.
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 ROOM, 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	CABLE TRAY T(S)=685 AT 20 MIN	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
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.
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	VENTILATION 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.

CALC NO.	AREA DESCRIPTION	CASE NO.	CASE DESCRIPTION	FIRE DURATION (MIN)	MAX. AREA TEMPERA-TURE(F)(1)	LOCALIZED HEATING PROBLEM	COMMENTS
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.
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

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 217' elevation floor slab, Hesketad's relations will be used:

Virtual point source determination:

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

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

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

T_o = 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 217' elevation floor slab, Hesketad's relations will be used:

Virtual point source determination:

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

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

$T_o = 9.1[T \;/(g c_p^2 \quad ^2)]^{333} \; Q_c^{\;667} \; (Z - Z_o)^{1 \; 67}$

T_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.

A W14X730 is located at column line E17. When exposed to a plume temperature of 1500°F for 44 minutes, the steel temperature does not exceed 590°F. When exposed to a plume temperature of 1500°F for 85 minutes, the column temperature does not exceed 900°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

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 217' elevation floor slab, Hesketad's relations will be used:

Virtual point source determination:

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

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

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

T_o = 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 217' elevation floor slab, Hesketad's relations will be used:

Virtual point source determination:

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

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

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

T_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.

A W14X730 column is located at column line E20 in this area. When exposed to a plume temperature of 1500°F for 44 minutes, the steel temperature does not exceed 590°F. When exposed to a plume temperature of 1500°F for 85 minutes, the column temperature does not exceed 900°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

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. A W14X730 column is located at column line F15.5 in the area. When exposed to a plume temperature of 1500°F, the column temperature will exceed 1000°F after 105 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.

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 $3.5 \text{ lbs/ft}^2 \div \frac{.1 \text{ lbs}}{\text{min/ft}^2} = 35$ 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, and W27X114, and greater than 12 inches from member types 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 either 1500°F or 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. One column at Column line F15.5 is partially embedded in the wall. The exposed column is at column line H15.5. 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.

CASE NUMBER: 3
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201′ SAFEGUARDS
CASE DESCRIPTION: 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

ATTACHMENT C

5/15/84

CASE NUMBER: 4
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARDS
CASE DESCRIPTION: 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): 6.06

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	519
10.00	828
15.00	1040
20.00	1185
25.00	1284
30.00	1352
35.00	1399

CASE NUMBER: 5
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARDS
CASE DESCRIPTION: 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

ATTACHMENT C

5/15/84

CASE NUMBER: 6
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARDS
CASE DESCRIPTION: 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

CASE NUMBER: 7
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201' SAFEGUARDS
CASE DESCRIPTION: 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

CASE NUMBER: 8
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 201′ SAFEGUARDS
CASE DESCRIPTION: W33.15?

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

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): 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	1191
25.00	1290
30.00	1357
35.00	1402

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): 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

ATTACHMENT C

5/15/84

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, and W27X102, and greater than 12 inches from member types W21X44 and W18X40.

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 either 1500°F or 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 at column line G21.5 and W14X550 at column line H21.5. When exposed to a plume temperature of 1500°F, the steel temperature of the W14X342 reaches 775°F after 35 minutes and the steel temperature of the W14X550 reaches 584°F after 35 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

of 8123 kW. The fire duration would be 6.5 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.

Exposed columns in the area are W14X730 at column lines E17, E18.5 and E20. When exposed to a plume temperature of 1500°F, the temperature of the exposed W14X730 columns reaches 757°F after 65 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/m^2)	Q (kW)
65 min	10	4680

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

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. (See Attachment D.)

Exposed columns in the area are W14X550 at column line H21.5, and W14X287 at column G21.5. When exposed to a plume temperature of 1500°F, the steel temperatures of the columns are as follows:

W14X550	548°F after 32 minutes
W14X287	810°F after 32 minutes

6. 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".

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' N.E.
CASE DESCRIPTION: G7 GIRDER

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

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. When exposed to the 1300°F plume temperature for 35 minutes, the W27X84 member exceeds the failure temperature of 1100°F. (See Attachment D.)

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.

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217' SOUTHEAST
CASE DESCRIPTION: 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
55.00	1282
60.00	1288
65.00	1292

ATTACHMENT D

5/15/84

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. When exposed to the 1300°F plume temperature for 35 minutes, the W27X94 beam exceeds the failure temperature of 1100°F (see Attachment D).

Columns in this area are W14X730 at column line H15.5, and W14X87 at column line Hg14.8. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X730	494°F after 35 minutes
W14X87	1402°F after 35 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	

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 217'NORTHWEST
CASE DESCRIPTION: W27x94

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): 6.78

TIME (min)	STEEL TEMPERATURE (deg.F)
5.00	419
10.00	670
15.00	849
20.00	978
25.00	1070
30.00	1135
35.00	1182
40.00	1216
45.00	1240
50.00	1257
55.00	1269
60.00	1278
65.00	1284

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 1500°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 reaches its single point failure temperature of 1100°F during the 47 minute exposure period (time required for a tray to burn to completion).

Columns in the area are W14X730 at column lines E15.5, E17, E18.5, E21.5, F15.5, W14X665 at column line E20, W14X370 at column lines G15.5 and F21.5, W14X550 at column line H15.5, W14X119 at column line G21.5, W14X342 at column line H21.5, and W14X87 at column line Hg14.8. When exposed to a plume temperature of 1500°F, the steel temperatures of the columns are as follows:

W14X730	610°F after 47 minutes
W14X665	642°F after 47 minutes
W14X370	989°F after 47 minutes
W14X550	714°F after 47 minutes
W14X119	1385°F after 47 minutes
W14X342	926°F after 47 minutes
W14X87	1460°F after 47 minutes

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 253' GENERAL
CASE DESCRIPTION: G52 GIRDER

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

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 1500°F when in actuality only a small section of the steel would be subjected to localized heating. As can be seen from the results, these member types 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 at column line E15.5, E17, E18.5, and E21.5, W14X665 at column line E20, and W14X87 at column line Hg14.8. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X730	544°F after 40 minutes
W14X665	574°F after 40 minutes
W14X87	1434°F after 40 minutes

CASE NUMBER: 1
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 283' GENERAL
CASE DESCRIPTION: W18x45

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

5/15/84

CASE NUMBER: 2
BUILDING: REACTOR BUILDING
ELEVATION AND AREA DESCRIPTION: 283' GENERAL
CASE DESCRIPTION: 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

Columns in the area are W14X398 and W14X287. When exposed to a plume temperature of 1500°F, the steel temperatures are as follows:

W14X398	709°F after 35 minutes
W14X287	857°F after 35 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

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 1500°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

CASE NUMBER: 1
BUILDING: CONTROL BUILDING
ELEVATION AND AREA DESCRIPTION: 200' WEST CHILLER
CASE DESCRIPTION: 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

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 all doors in the room closed. 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 a ventilation controlled fire 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 (until all combustibles are consumed).

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.

Since the fire evaluated in Case 1 was 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.

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).

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 member G1 (W42X316), and greater than 12 inches below member types 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 1500°F (for G1) or 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

CASE NUMBER: 2
BUILDING: CONTROL STRUCTIRE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: ONE DOOR LEAF OPEN 4'x10'

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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 VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	715
10	735
15	754
20	772
25	790
30	808
35	826
40	843
45	861
50	878
55	895
60	912
65	928
70	945
75	961
80	977
85	993
90	1009
95	1025
100	1041
105	1056
110	1071
115	1086
120	1101
125	1116
130	1130
135	1145
140	1159
145	1173
150	1188

CASE NO.: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W27X84

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 84
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 6.78

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	171.274
10	735.200	348.044
15	754.012	474.585
20	772.352	566.675
25	790.409	635.186
30	808.256	687.565
35	825.922	728.895
40	843.419	762.647
45	860.751	791.186
50	877.919	816.123
55	894.922	838.555
60	911.761	859.228
65	928.433	878.651
70	944.939	897.169
75	961.279	915.020
80	977.454	932.361
85	993.464	949.304
90	1009.31	965.924
95	1024.99	982.271
100	1040.52	998.382
105	1055.89	1014.28
110	1071.10	1029.98
115	1086.16	1045.51
120	1101.08	1060.86
125	1115.84	1076.05
130	1130.46	1091.08
135	1144.94	1105.95
140	1159.28	1120.68
145	1173.48	1135.26
150	1187.55	1149.70

5/15/84

CASE NO.: 2
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 21'' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W30X99

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 99
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 7.37

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	163.251
10	735.200	328.651
15	754.012	451.070
20	772.352	542.927
25	790.409	613.106
30	808.256	667.914
35	825.922	711.817
40	843.479	747.974
45	860.751	778.614
50	877.919	805.314
55	894.922	829.184
60	911.761	851.009
65	928.433	871.342
70	944.939	890.573
75	961.279	908.978
80	977.454	926.751
85	993.464	944.029
90	1009.31	960.910
95	1024.99	977.463
100	1040.52	993.737
105	1055.89	1009.76
110	1071.10	1025.58
115	1086.16	1041.19
120	1101.08	1056.62
125	1115.84	1071.88
130	1130.46	1086.97
135	1144.94	1101.90
140	1159.28	1116.68
145	1173.48	1131.30
150	1187.55	1145.79

5/15/84

CASE NO.: 3
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W33X118

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CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 118
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 8.15

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	156.372
10	735.200	311.704
15	754.012	429.909
20	772.352	520.910
25	790.409	592.032
30	808.256	648.636
35	825.922	694.632
40	843.419	732.870
45	860.751	765.422
50	877.919	793.795
55	894.922	819.087
60	911.761	842.093
65	928.433	863.392
70	944.939	883.405
75	961.279	902.438
80	977.454	9[illegible]0.713
85	993.464	938.392
90	1009.31	955.593
95	1024.99	972.40[illegible]
100	1040.52	988.883
105	1055.89	1005.08
110	1071.10	1021.03
115	1086.16	1036.76
120	1101.08	1052.28
125	1115.84	1067.62
130	1130.46	1082.78
135	1144.94	1097.78
140	1159.28	1112.61
145	1173.48	1127.29
150	1187.55	1141.83

5/15/84

CASE NO.: 4
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE G1

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13036	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 316
SURFACE AREA OF STEEL HEATED (SQ. FT. T.): 10.91

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	112.175
10	735.200	195.854
15	754.012	270.754
20	772.352	337.967
25	790.409	398.489
30	808.256	453.201
35	825.922	502.869
40	843.419	548.157
45	860.751	589.641
50	877.919	627.817
55	894.922	663.114
60	911.761	695.903
65	928.433	726.504
70	944.939	755.192
75	961.279	782.206
80	977.454	807.752
85	993.464	832.007
90	1009.31	855.126
95	1024.99	877.242
100	1040.52	898.469
105	1055.89	918.907
110	1071.10	938.642
115	1086.16	957.751
120	1101.08	976.296
125	1115.84	994.336
130	1130.46	1011.91
135	1144.94	1029.08
140	1159.28	1045.87
145	1173.48	1062.32
150	1187.55	1078.45

5/15/84

CASE NO.: 5
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W36X300

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 300
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 9.99

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	110.607
10	735.200	191.523
15	754.012	264.335
20	772.352	330.007
25	790.409	389.430
30	808.256	443.392
35	825.922	492.589
40	843.419	537.623
45	860.751	579.021
50	877.919	617.240
55	894.922	652.677
60	911.761	685.677
65	928.433	716.538
70	944.939	745.520
75	961.279	772.848
80	977.454	798.719
85	993.464	823.303
90	1009.31	846.748
95	1024.99	869.181
100	1040.52	890.716
105	1055.89	911.449
110	1071.10	931.466
115	1086.16	950.841
120	1101.08	969.638
125	1115.84	987.914
130	1130.46	1005.71
135	1144.94	1023.09
140	1159.28	1040.07
145	1173.48	1056.70
150	1187.55	1073.00

5/15/84

CASE NO.: 6
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W36X230

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 230
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 9.84

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	122.740
10	735.200	224.646
15	754.012	312.590
20	772.352	388.801
25	790.409	455.201
30	808.256	513.406
35	825.922	564.770
40	843.419	610.420
45	860.751	651.294
50	877.919	688.172
55	894.922	721.703
60	911.761	752.425
65	928.433	780.784
70	944.939	807.153
75	961.279	831.839
80	977.454	855.100
85	993.464	877.149
90	1009.31	898.162
95	1024.99	918.288
100	1040.52	937.649
105	1055.89	956.348
110	1071.10	974.471
115	1086.16	992.089
120	1101.08	1009.26
125	1115.84	1026.04
130	1130.46	1042.46
135	1144.94	1058.57
140	1159.28	1074.39
145	1173.48	1089.95
150	1187.55	1105.27

5/15/84

CASE NO.: 7
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W36X245

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CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 245
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 9.87

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	119.545
10	735.200	216.012
15	754.012	300.199
20	772.352	373.936
25	790.409	438.828
30	808.256	496.243
35	825.922	547.343
40	843.419	593.104
45	860.751	634.351
50	877.919	671.775
55	894.922	705.961
60	911.761	737.397
65	928.433	766.494
70	944.939	793.600
75	961.279	819.004
80	977.454	842.952
85	993.464	865.648
90	1009.31	887.267
95	1024.99	907.953
100	1040.52	927.830
105	1055.89	947.002
110	1071.10	965.556
115	1086.16	983.566
120	1101.08	1001.09
125	1115.84	1018.19
130	1130.46	1034.91
135	1144.94	1051.28
140	1159.28	1067.34
145	1173.48	1083.11
150	1187.55	1098.62

5/15/84

CASE NO.: 8
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: GENERALIZED HEATING OF MEMBER TYPE W36X260

CEILING/WALL THICKNESS (FT.)	CEILING/WALL MATERIAL	AO SQ. FT.	HO FT.	AW SQ. FT.	Q KW
3	CONCRETE	40	10	13836	10254.4

GENERALIZED HEATING OF STRUCTURAL STEEL CALCULATION

WEIGHT OF STEEL MEMBER (LBS./FT.): 260
SURFACE AREA OF STEEL HEATED (SQ. FT./FT.): 9.9

FIRE DURATION (MIN.)	GAS TEMPERATURE (DEG. F)	STEEL TEMPERATURE (DEG. F)
5	715.294	116.719
10	735.200	208.323
15	754.012	289.051
20	772.352	360.423
25	790.409	423.791
30	808.256	480.322
35	825.922	531.017
40	843.419	576.727
45	860.751	618.177
50	877.919	655.984
55	894.922	690.673
60	911.761	722.686
65	928.433	752.403
70	944.939	780.144
75	961.279	806.181
80	977.454	830.745
85	993.464	854.035
90	1009.31	876.216
95	1024.99	897.432
100	1040.52	917.803
105	1055.89	937.433
110	1071.10	956.410
115	1086.16	974.809
120	1101.08	992.695
125	1115.84	1010.12
130	1130.46	1027.13
135	1144.94	1043.78
140	1159.28	1060.08
145	1173.48	1076.08
150	1187.55	1091.80

5/15/84

CASE NUMBER: 8
BUILDING: CONTROL BUILDING
ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
CASE DESCRIPTION: G1 GIRDER

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