

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS
for
LIMERICK GENERATING STATION

Units 1 & 2
Control Structure El. 217'
Switchgear Area
Fire Area 2)

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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 ft² (1285 m²) (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/ft² 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

Three 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

ft² 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. With all doors leading into the room closed, the only air for combustion will be the air available in the room. The duration of the fire is given by $T = \frac{29 V_R (m^3)}{Q (kW)}$ in minutes where the volume of the room is 3686 m³ and Q = 1700. The duration of the fire will be 64 minutes.

Case number 2 assumed the same spreading cable fire as in case 1, with one 4' wide by 10' high door leaf open.

Case number 3 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 182°F at 64 minutes which is below the critical temperature for the structural steel (see Attachment C for results of analysis).

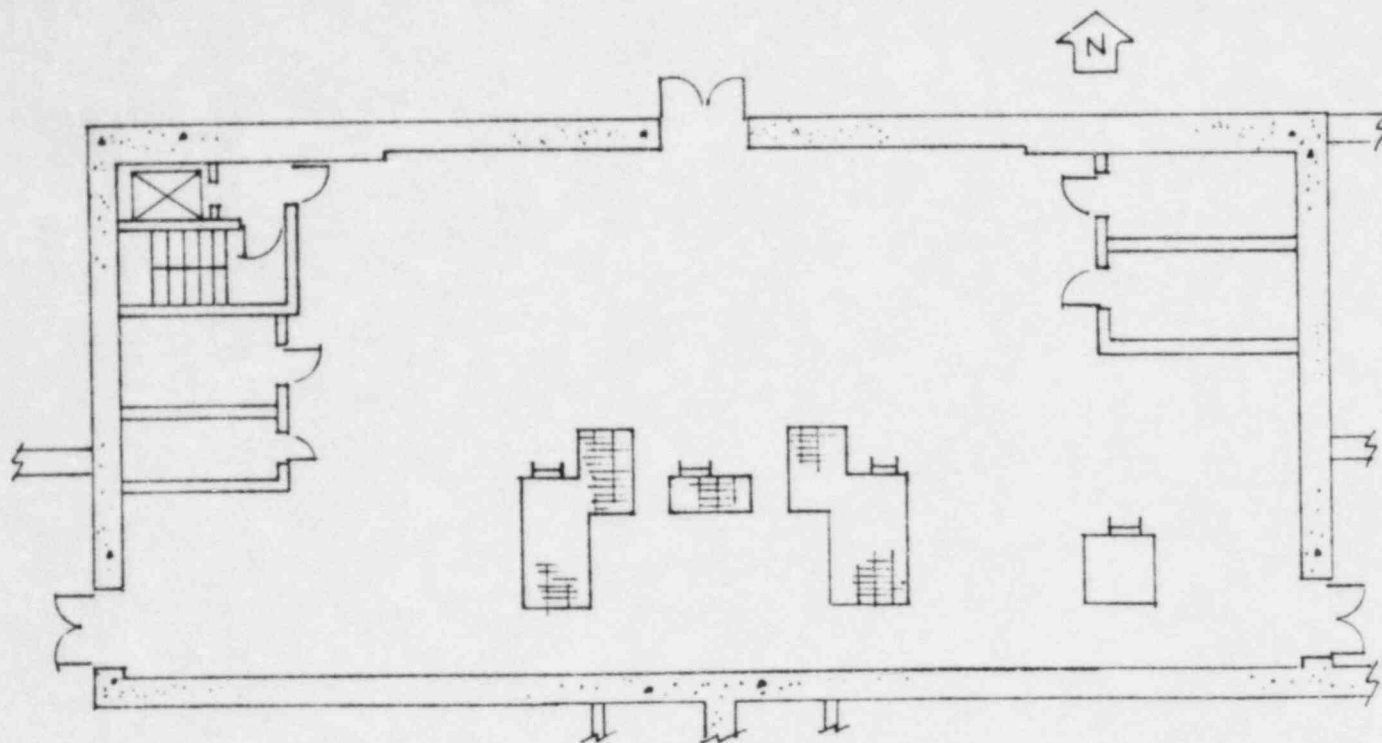
Case number 2 resulted in a fire temperature of 256°F when the fire duration was taken to 180 minutes. This temperature is below the critical temperature for the structural steel (see Attachment C for results of analysis). This fire was fuel controlled, therefore having additional door leaves open would not change the results.

Case number 3 resulted in a fire temperature of 1087°F at 150 minutes. This temperature is below 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 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 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 their critical temperature within the exposure period. Appendix D includes a sketch of the structural members which will fail due to localized heating.



Control Structure El. 217'
Switchgear Area

Surface Area Calculation

Walls

North wall (126' x 21')
West wall (56' x 21')
South wall (126' x 21')
East wall (56' x 21')

2646 ft²
1176 ft²
2646 ft²
1176 ft²

7644 ft²

Ceiling

126' x 56' (-20' x 16') - (16' x 34')

6192 ft²

Total Surface Area for Heat Transfer

13,836 ft² (1285 m²)

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
			<hr/> 96 ft ²

Heat output with the above cable trays burning simultaneously:

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

CASE NUMBER: 1
 BUILDING: CONTROL STRUCTURE UNITS 1 & 2
 ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
 CASE DESCRIPTION: NO DOORS OPEN

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE			13836	1700

NO OPENINGS INTO ROOM

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	91
4	99
6	106
8	111
10	115
12	120
14	123
16	127
18	130
20	133
22	136
24	139
26	142
28	145
30	147
32	150
34	152
36	154
38	157
40	159
42	161
44	163
46	165
48	167
50	169
52	171
54	173
56	175
58	177
60	178
62	180
64	182

CASE NUMBER: 2
 BUILDING: CONTROL STRUCTURE UNITS 1 & 2
 ELEVATION AND AREA DESCRIPTION: 217' SWITCHGEAR AREA
 CASE DESCRIPTION: ONE DOOR LEAF OPEN 4'x 10'

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft ²)	Ho (ft)	Aw (ft ²)	Q (kW)
3.0	CONCRETE	40	10	13836	1700

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	115
20	133
30	147
40	159
50	169
60	178
70	187
80	195
90	202
100	209
110	216
120	222
130	229
140	234
150	240
160	246
170	251
180	256

CASE NUMBER: 3
 BUILDING: CONTROL STRUCTURE UNITS 1 & 2
 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	10	13836	10254

FIRE IS VENTILATION CONTROLLED

FIRE DURATION
(min)

GAS TEMPERATURE
(deg.F)

10	335
20	443
30	526
40	596
50	658
60	714
70	765
80	813
90	858
100	901
110	941
120	980
130	1017
140	1053
150	1087

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AREA 13, SEI 2106 2-1

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): 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

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): 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

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): 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

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): 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

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): 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

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): 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: 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): 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

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): 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