

STRUCTURAL STEEL ANALYSIS
for
LIMERICK ATOMIC GENERATING STATION

Unit 1
Reactor Building, El. 253'
General Floor Area
Fire Area 45A

November 1, 1983

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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 ft². 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/ft² 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

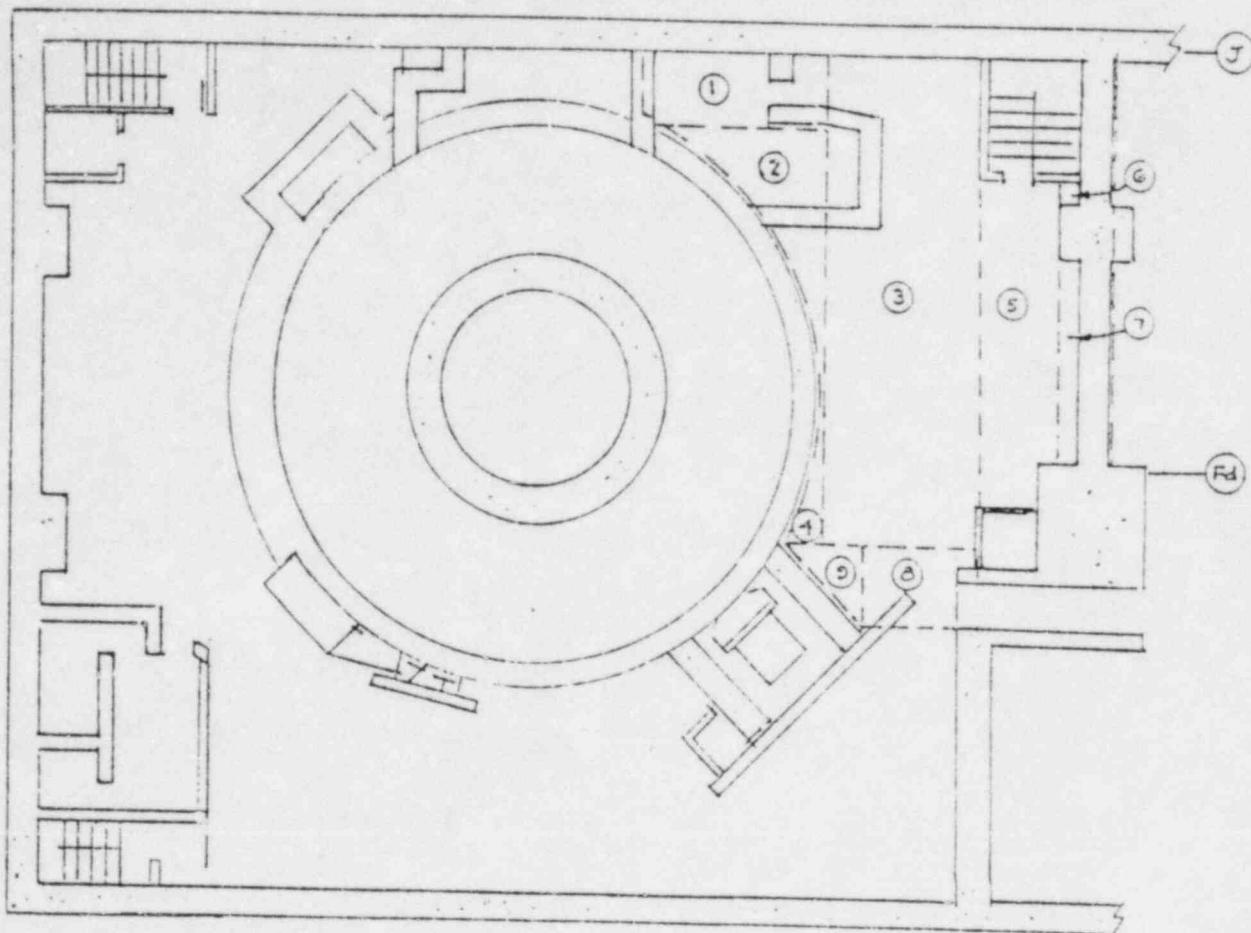
A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire will spread north and 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 ft² 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 940°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 1AGY05 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 does not reach its single point failure temperature of 1300°F during the 50 minute exposure period (time required for a tray to burn to completion).



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
		<hr/>
		6969 ft ²

ATTACHMENT A

Ceiling		
Area 1	(27' x 11')	297 ft ²
Area 2	$\frac{1}{2}(27' \times 41') - 240 \text{ ft}^2$	313.5 ft ²
Area 3	(46' x 74')	3404 ft ²
Area 4	$\frac{1}{2}(22' \times 6') - 21 \text{ ft}^2$	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	$\frac{1}{2}(11' \times 12')$	66 ft ²
		<hr/>
		4805.5 ft ²

Total Surface Area for Heat Transfer = 11,774 ft²

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)
10CPA79	24"	2'	4
10CAA74	24"	16'	32
10CVA72	24"	5'	10
10CBA72	24"	10'	20
10CQA21	24"	12'	24
11CCA21	24"	16'	32
10CZA21	24"	9.5'	19
10CPA74	24"	7'	14
10CPA75,76,78	24"	5'	10
10CQA76	24"	11'	22
11CLA74	24"	11'	22
10CDA74	24"	11'	22
10IYA74	24"	11'	22
10CZA74	24"	8'	16
11CCA74	24"	8'	16
10CBA74	24"	8'	16
10CDB13	24"	11.5'	23
10IYB13	24"	15'	30
10CDB12	24"	8'	16
10IYB12	24"	8'	16

386 ft²

Average Combustible Loading per Tray Surface Area = 4.7 lb/ft²

Fire Duration for Free Burning Cable Tray Fire =

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

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

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

ATTACHMENT B

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

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft ²)	Ho (ft)	Aw (ft ²)	Q (kW)
1.5	CONCRETE	826	29	11774	6816

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg. F)
10	277
20	362
30	427
40	482
50	530
60	573
70	614
80	651
90	686
100	719
110	751
120	781
130	810
140	839
150	865
160	891
170	916
180	940

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): 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

PLC *Professional Loss Control, Inc.*

STRUCTURAL STEEL ANALYSIS
for
LIMERICK GENERATING STATION

Unit 1
Reactor Building El. 283'
General Floor Area
Fire Area 47A

November 1, 1983

Dupe

8311150295

7922 West Chester Pike • Upper Darby, Pa. 19082 • (215) 853-1700

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 ft² (645 m²) (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/ft² 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

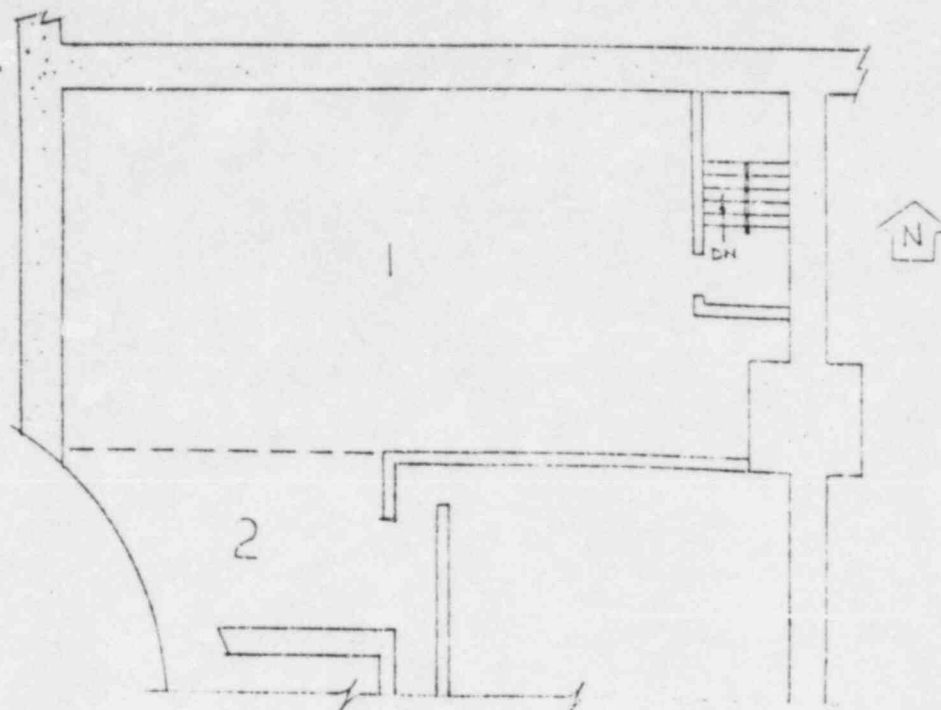
A spreading cable fire was assumed to originate in the area of heaviest cable concentration in order to present the worst case. The fire is assumed to start at a point source and spread horizontally along the cable trays in each direction at a rate of 10 feet per hour. The fire is assumed to extend along 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 ft² 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 731°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. The exposure time for the localized heating was taken to be 40 minutes which is the time required for a tray to burn to completion. As can be seen from the results, the member types 36WF230 will not reach their critical temperature during the 40 minute exposure period. The member type 18WF45 will exceed its critical temperature well within the exposure period. Appendix D includes a sketch showing the location of the structural member which will fail due to localized heating effects.



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 ft²

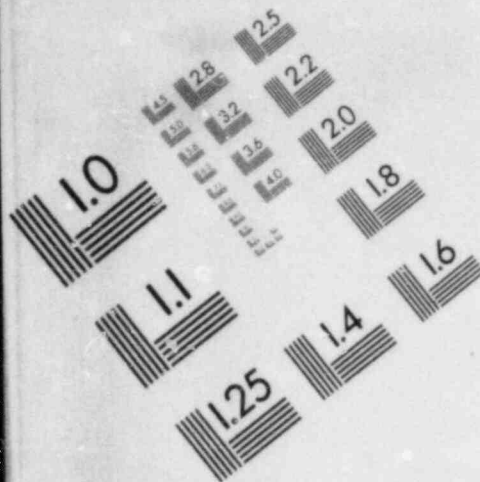
Ceiling

Area 1	(30' x 60') - (18' x 8' stairwell)	1656 ft ²
Area 2	(24' x 14')	336 ft ²

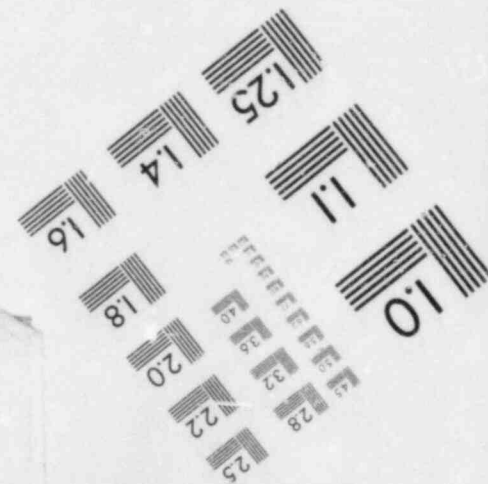
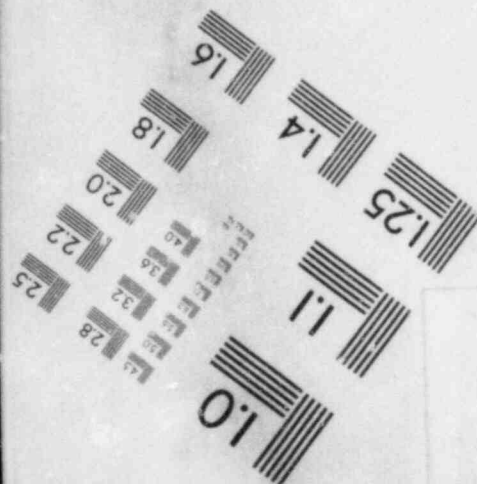
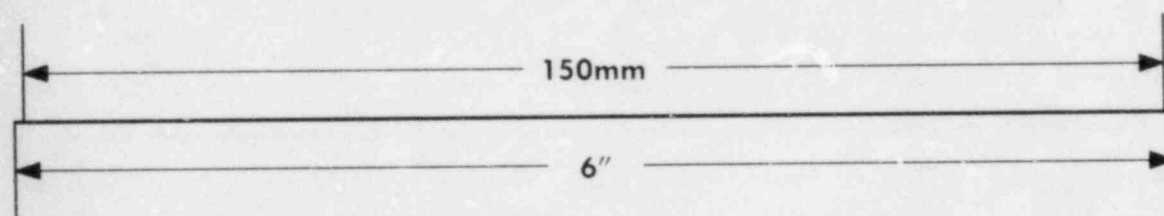
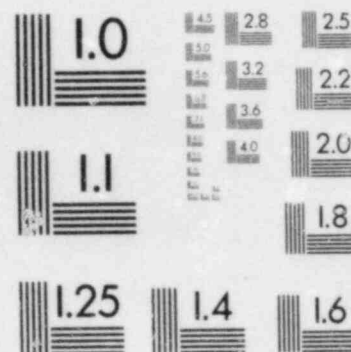
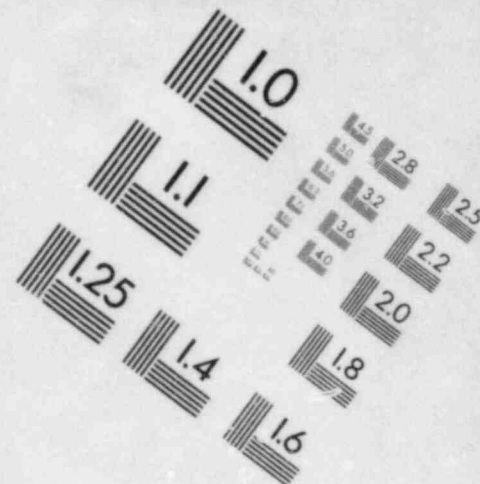
1992 ft²

Total Surface Area for Heat Transfer

6947 ft² (645 m²)



**IMAGE EVALUATION
TEST TARGET (MT-3)**



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.

<u>Cable Tray No.</u>	<u>Tray Width (in)</u>	<u>Tray Length (ft)</u>	<u>Surface Area (ft²)</u>
1M1AC01-02	24	15	30
1M1AD01-02	24	15	30
1M1AE01-02	24	15	30
10CVA18	24	15	30
10ISA73	24	2	4
1BCWA91	24	7	14
1BCWA92	24	5	10
1BCWA80	24	7	14
1BCWA75	24	5	10
			<u>172</u>

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

Average Combustible Loading per Tray Surface Area = 4.0 lb/ft²

$$\text{Fire Duration for Free Burning Tray Fires} = \frac{4.0 \text{ lb/ft}^2 \div 0.1 \text{ lb}}{\text{ft}^2/\text{min}} = 40 \text{ minutes}$$

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	17	6947	3050

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
10	228
20	292
30	341
40	383
50	419
60	452
70	483
80	511
90	538
100	563
110	587
120	610
130	632
140	653
150	673
160	693
170	712
180	731

(17.3)

18.6

19.4

(20)

(21.9)

2' DIA

2'-0"

2'-0"

2'-0"

20'-2 1/2"

16'-6" 10'-6"

2'-2 1/2"

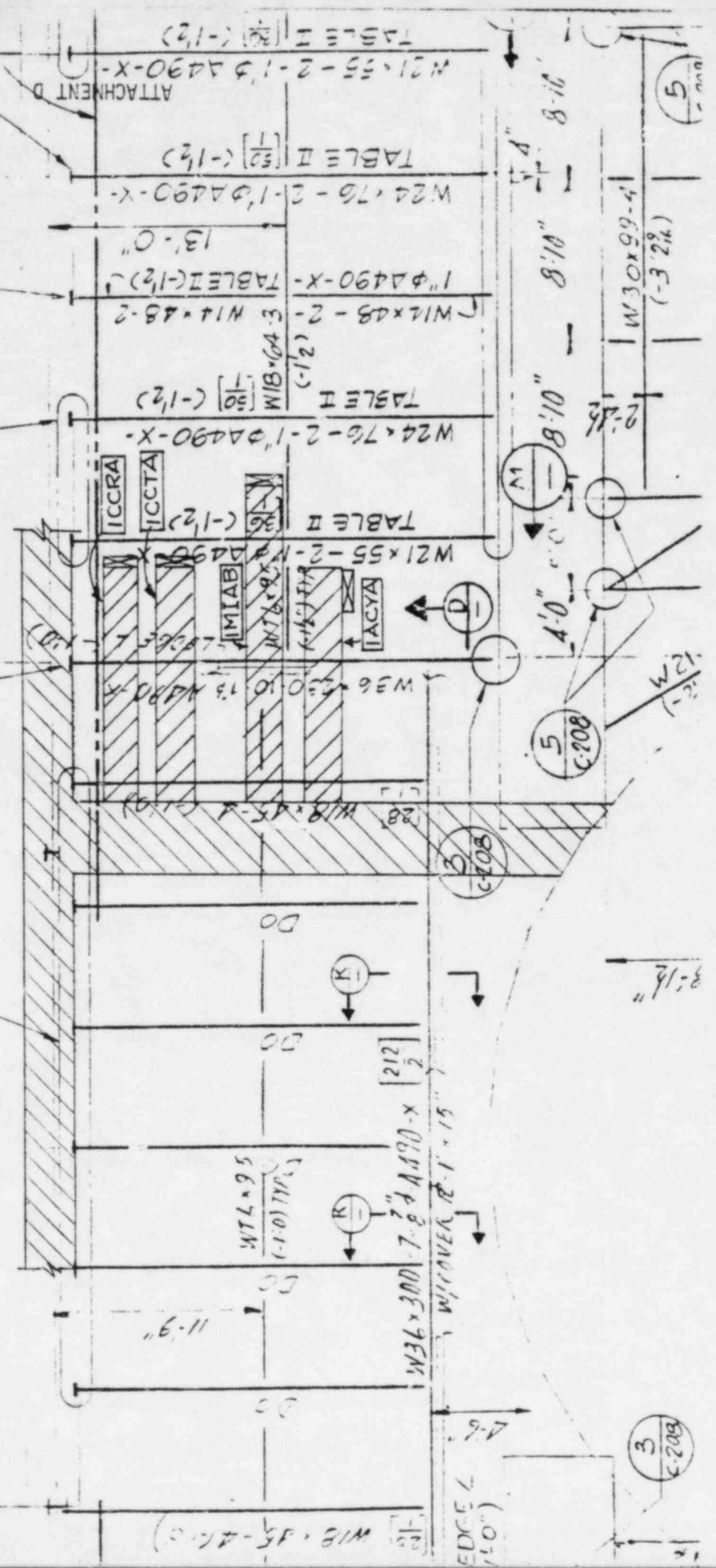
(3) 302.5 C-208

(2B) C-609

(1C) C-609

(1A) C-609

(1C) C-609



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): 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

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): 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