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AUG 08 1984

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

Docket Nos.: 50-352
50-353

SUBJECT: Limerick Generating Station, Units 1 and 2
Structural Steel Survivability Evaluation
Additional Clarification Information

Reference: Telecon between NRC Staff and PECO on August 8, 1984

File: GOVT 1-1 (NRC)

Attachment: Responses to Additional Questions Concerning the Structural Steel Survivability Evaluation

Dear Mr. Schwencer:

Pursuant to the Referenced telecon, the attachment provides our responses to additional questions raised by your Chemical Engineering Branch in concert with their Fire Protection consultant.

We hope that this information will support the final resolution of the SER open item no. 14.

Should any additional information be required, please do not hesitate to contact us.

Sincerely,

JW Gallagher
for
JS Kemper

GJR/mlb/08088402

Copy to: See Attached Service List

B002
1/1

cc:	Judge Lawrence Brenner	(w/enclosure)
	Judge Richard F. Cole	(w/enclosure)
	Troy B. Conner, Jr., Esq.	(w/enclosure)
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	Atomic Safety & Licensing Board Panel	(w/enclosure)
	Docket & Service Section	(w/enclosure)
	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)

1. Columns - The latest revision (rev. 3) to the methodology describes the exposure criteria and acceptance criteria for columns. The "exposed columns" in the methodology included all steel columns not imbedded in the walls.

Columns were exposed to plume temperatures of 1500°F either from cable tray local effects, pool fires, or transient combustibles. The exposure durations were (1) the duration of cable exposure, (2) the duration of pool fires, or (3) 30 minute transient fire exposure. The longest of these exposures were used where multiple exposures were possible. For Limerick areas containing columns, all in-situ exposures exceeded the 30 minute transient exposure. The calculations contained in the appendix to the steel analysis contains the time-temperature history calculated for each column. The results are summarized in the table below.

The failures were as follows:

Calc #	Column	Corrective Action
4	W14X730	Automatic Sprinklers
18,19,20,23	W14X87	Not required structurally
19	W14X119	Coated Column - 3 hr. protection

Summary of Column Response to
Localized Fire Exposure

Calc #	Localized Fire Type	& Duration	Column Sizes	Column T(s)
1	Oil	85 minutes	W14X730	893°F
	Oil	44 minutes	W14X730	590°F
2	Oil	85 minutes	W14X730	893°F
	Oil	44 minutes	W14X730	590°F
4	Oil	180 minutes	W14X730	>1000°F
12	Cables	35 minutes	W14X730	494°F
13	Cables	35 minutes	W14X550	584°F
			W14X342	775°F
15	Cables	65 minutes	W14X730	757°F
16	Cables	32 minutes	W14X730	463°F
			W14X550	548°F
			W14X287	810°F
18	Cables	35 minutes	W14X730	494°F
			W14X87	1402°F
19	Cables	47 minutes	W14X730	610°F
			W14X665	642°F
			W14X550	714°F
			W14X370	989°F
			W14X342	926°F
			W14X119	1385°F
			W14X87	1460°F
20	Cables	40 minutes	W14X730	544°F
			W14X665	574°F
			W14X87	1434°F
23	Cables	35 minutes	W14X87	1402°F
25	Cables	35 minutes	W14X398	709°F
			W14X287	857°F

2. <u>Cables in oil hazard rooms</u> - For calculating No. 1, 2, 3, 4, 5, 7, and 8, minor amounts of cables are present in these rooms but were not included in the duration of these ventilation controlled fires. The table below shows the additional duration for the addition of cables.

Calculation No.	In-situ Oil (gal)	Transient Oil (gal)	Cables Insulation (lb)	Duration Oil Only (min)	Oil & Cable (min)
1 Case 1	72	72	78	85	88
Case 2	72	72	78	44	46
2 Case 1	72	72	84	85	88
Case 2	72	72	84	44	46
3	80	80	137	125	132
4	155	155	27	180	180
5	24	24	19	37	38
7	24	24	17	37	38
8	24	24	19	37	38

The areas addressed in Calc #3 and 4 are protected with automatic sprinklers. The other calculations were redone using both the large quantity of transient oil and the in-situ cables. The addition of cable in no case increased the area temperature greater than 15°F.

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' RHR
CASE DESCRIPTION: ONE 3'X7' DOOR

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	7846	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
90	852

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' RHR
CASE DESCRIPTION: TWO 3'X7' DOORS

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	42.0	7.0	7848	9000

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
2	834
4	849
6	862
8	876
10	890
12	903
14	917
16	930
18	944
20	958
22	971
24	985
26	998
28	1012
30	1025
32	1039
34	1052
36	1066
38	1079
40	1092
42	1105
44	1118
46	1131

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' RHR
CASE DESCRIPTION: W 24 x 68

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1131
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	442
10.00	685
15.00	842
20.00	944
25.00	1010
30.00	1052
35.00	1080
40.00	1098
45.00	1110
50.00	1117
55.00	1122
60.00	1125
65.00	1127

Calculation No. 1
Attachment 3

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 172' RHR ROOM 103
CASE DESCRIPTION: ONE 3'X7' DOOR

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
90	779

Calculation No. 2

ATTACHMENT 1

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' RHR
CASE DESCRIPTION: TWO 3'X7' DOORS

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)
2	788
4	801
6	812
8	824
10	835
12	846
14	857
16	868
18	879
20	890
22	901
24	912
26	923
28	934
30	945
32	955
34	966
36	977
38	988
40	998
42	1009
44	1020
46	1030

Calculation No. 2

ATTACHMENT 2

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION. 177' CORE SPRAY RM 110
CASE DESCRIPTION: ONE DOOR

****

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)
2	860
4	876
6	891
8	907
10	922
12	937
14	952
16	968
18	983
20	998
22	1014
24	1029
26	1044
28	1060
30	1075
32	1090
34	1105
36	1120
38	1135

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' C.S. RM110
CASE DESCRIPTION: W27x84

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1135
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	406
10.00	640
15.00	798
20.00	905
25.00	978
30.00	1028
35.00	1062
40.00	1086
45.00	1101
50.00	1112
55.00	1119
60.00	1124
65.00	1128

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' CORE SRRAY RM 113
CASE DESCRIPTION: ONE DOOR

****

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)
2	834
4	849
6	862
8	876
10	890
12	903
14	917
16	931
18	944
20	958
22	971
24	985
26	999
28	1012
30	1026
32	1039
34	1052
36	1066
38	1079

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' CORE SPRAY RM 114
CASE DESCRIPTION: ONE DOOR

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)
2	856
4	872
6	887
8	902
10	917
12	932
14	947
16	962
18	977
20	992
22	1007
24	1022
26	1037
28	1052
30	1067
32	1082
34	1096
36	1111
38	1126

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' C.S. RM114
CASE DESCRIPTION: W27x145

EFFECTS OF LOCAL HEATING ON STRUCTURAL STEEL

FIRE TEMPERATURE (deg. F): 1126
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	295
10.00	473
15.00	613
20.00	723
25.00	809
30.00	877
35.00	931
40.00	972
45.00	1005
50.00	1031
55.00	1052
60.00	1067
65.00	1080

3. Stratification - The use of a maximum constant fire size from time zero throughout the fire, and the omission of radiative and convective heat losses through openings make the estimates of area temperature conservatively high. These conservatisms for the area temperature, combined with the evaluation of plume effects adequately address the problem of stratification.

At the request of NRC, the heat balance area temperature method was applied to the UL conducted 20 foot separation test for comparison purposes. This comparison is shown in the tables below and indicate that the heat balance area temperature is conservative enough to compensate for the problem of potential stratification.

UL Test Comparison

Test Description	Q	Heat Balance T	Measured Peak Temp. Room Average	Measured Peak Temp. Hot Layer Average
#1 5 gal heptane and E/PVC PE/PVC cables, Exp. peak at 5 min duration 15 min	1160 kW heptane 1750 kW cables	1284°F	784°F	1212°F
#2 5 gal heptane and XLPE cables, exp peak at 6 min duration 14 min	1160 kW heptane 1234 kW cables	1036°F	659°F	1027°F
#3 10 gal heptane Experimental peak at 20 min Duration 25 min	1160 kW	696°F	524°F	710°F

4. <u>Enclosure Feedback Effects</u> - In those cases where enclosures are small, all cables are burning simultaneously, and adequate ventilation is supplied (so the fire is fuel controlled), the question regards whether the "open burning" mass loss rates from EPRI/FMRC intermediate scale test are conservative enough to account for potential enclosure feedback effects. Also, if mass loss rates increase with a corresponding decrease in fire duration, how significant would the change in enclosure temperature be?

Tests conducted at Sandia Laboratories on cable trays containing cross-linked polyethylene cable insulation showed that mass loss rate was a function of the inverse square of the diagonal distance from the ceiling-wall corner. The tests also showed that these effects drop off rapidly within the first five feet of this distance. Beyond that distance, the mass loss rate was rather flat. Based on these Sandia tests and the Limerick cable configuration below deep beams, it is not anticipated that the enclosure feedback effect would have a significant impact on the conservatism built into the methodology.

Sample calculations were run for calculation #9 and #31 picked as arbitrary examples of all cable burning to assess the effect of increased mass loss rate. For Calc 9 mass loss rates were increased by 7, 25, and 50%. These increases resulted in increases in calculated temperatures of 19°F, 63°F, and 118°F, respectively. For calculation 31 mass loss rates were increased by 17, 40, and 55%. These increases resulted in increases in calculated temperatures of 61°F, 139°F, and 157°F, respectively. Since in both cases 50% increase in mass loss rate only increased the resultant calculated temperature by approximately 15%, enclosure feedback effects would not have a significant effect on the conservatism built into the methodology.

CASE NUMBER: 1
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' SUMP ROOM
CASE DESCRIPTION: ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	W (kW)
2.5	CONCRETE	17.5	5.8	2595	1820

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	681
2	686
3	691
4	695
5	699
6	703
7	707
8	711
9	714
10	718
11	721
12	725
13	729
14	732

Calculation No. 9

ATTACHMENT 1

CASE NUMBER: 2
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' SUMP ROOM
CASE DESCRIPTION: ALL CABLES BURNING

CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft↑2)	Ho (ft)	Aw (ft↑2)	Q (kW)
2.5	CONCRETE	17.5	5.8	2595	2125

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	724
2	730
3	736
4	741
5	745
6	750
7	754
8	759
9	763
10	768
11	772
12	776

Calculation No. 9

ATTACHMENT 2

CASE NUMBER: 3
BUILDING: UNIT 1 REACTOR
ELEVATION AND AREA DESCRIPTION: 177' SUMP ROOM
CASE DESCRIPTION: 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	2550

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
1	778
2	785
3	791
4	797
5	803
6	809
7	814
8	820
9	825
10	831

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 180' TANK AREA 163
CASE DESCRIPTION: ALL CABLES BURNING

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CEILING/WALL THICKNESS (ft)	CEILING/ WALL MATERIAL	Ao (ft2)	Ho (ft)	Aw (ft2)	Q (kW)
3.0	CONCRETE	21.0	7.0	2772	3380

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	
10	877
15	914
20	951
25	988
30	1026
	1063

Calculation No. 31

ATTACHMENT 1

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 150' TANK AREA 163
CASE DESCRIPTION: 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	4060

FIRE IS FUEL CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	945
10	993
15	1042
20	1092
25	1141

CASE NUMBER: 1
BUILDING: CONTROL STRUCTURE
ELEVATION AND AREA DESCRIPTION: 180' TANK AREA 163
CASE DESCRIPTION: 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	4504

FIRE IS VENTILATION CONTROLLED

FIRE DURATION (min)	GAS TEMPERATURE (deg.F)
5	986
10	1043
15	1101
20	1159

Calculation No. 31

ATTACHMENT 3

5. EPR/Hypalon Cable Test Data - Questions were raised regarding the temperature at which pyrolysis occurs for the EPR/Hypalon Cables. Data reported in EPRI-NP 1767 indicated one cable sample started to pyrolyze at 297°C. Others were reported at 488°C. To clarify these data, Dr. A Tewarson of FMRC, who conducted the tests, was contacted by telephone. Dr. Tewarson indicated that one sample did start to "give off gases" at around 300°C (570°F) but not in sufficient quality or quantity to support piloted ignition. Dr. Tewarson said a range of 450-500°C is where piloted ignition could occur. He further indicated that even with very high radiant heat flux, 70kW/m^2, they could not create autoignition in the EPR/Hypalon cables.

Relating these test data to the potential for secondary fires in areas where spreading cables fires were quantified, of the 7 areas evaluated for fuel controlled spreading cables fires, only 3 exceeded 800°F (426°C). The other four areas resulted in temperatures calculated between 395°F and 650°F. For the 3 areas exceeding 800°F, two are provided with automatic sprinkler protection and the third was shown to have a self-supporting floor slab not requiring the beams for support.

Based on the test data for EPR/Hypalon and the specific results for Limerick, the potential for secondary fires need not be further evaluated.

6. Ventilation Parameters - Calculations 1 and 2 for the RHR heat exchanger and pump rooms were performed using two doors open as the ventilation flow path. The selection of two doors open is conservative for these cases and would be conservative for any fire area location containing safe shutdown equipment. The RHR rooms have two watertight doors at elevation 177' and two steamtight doors at elevation 201'. All four doors are electrically supervised and monitored at the plant security panel. Whenever a door in a fire barrier is inoperable plant technical specifications require a fire watch. Considering that these doors have multiple design and operational functions including not only fire but security and plant safety (flood and steam line break) the likelihood of even one door being open for longer than the time it takes for personnel access is remote.

GJR/bls/07318404

7. Program to assure that changes to plant fire protection features are controlled. The Limerick Fire Protection Evaluation Report will be maintained as a working document for the life of the plant. Engineering and Research Department Procedures will require that all project engineers evaluate the effect of every proposed modification on fire protection features and safe shutdown separation. All modifications are accompanied by a safety evaluation. The Project Engineer will include in the safety evaluation a conclusion addressing the effects of the modification on fire protection features. The conclusion will be based on review of a fire protection checklist which includes an evaluation of possible increased combustible loadings, relocation of safe shutdown equipment, and the effect of the modification on existing fire protection features, including sprinklers and fire detectors.

A certain margin of safety has already been accounted for in our combustible loading and fire temperature calculations by doubling the quantity of fixed lubricant or fuel oil and adding 10% to the cable quantity.