March 16, 1994

MEMORANDUM FOR: Conrad E. McCracken, Chief
Plant Systems Branch
Division of Systems Safety and Analysis

THRU: K. Steven West, Chief
Special Project Section
Plant Systems Branch
Division of Systems Safety and Analysis

FROM: Amarjit Singh, Reactor Systems Engineer
Plant Systems Branch
Division of Systems Safety and Analysis

SUBJECT: TRIP TO OMEGA POINT LABORATORIES, NUCLEAR MANAGEMENT AND RESOURCES COUNCIL PHASE II THERMO-LAG FIRE BARRIER TEST PROGRAM

The enclosed trip report (Enclosure 1) covers my observations of Thermo-Lag fire endurance testing performed by the Nuclear Management and Resources Council (NUMARC) for the generic qualification of Thermo-Lag fire barriers for the industry. This report covers the testing activities from February 15 through 17, 1994, at Omega Point Laboratories, Inc. (OPL) Elmendorf, Texas.

Original signed by

Amarjit Singh, Reactor Systems Engineer
Special Projects Section
Plant Systems Branch
Division of Systems Safety and Analysis

Enclosures:
1. Trip Report. Omega Point Laboratories, Inc.

DISTRIBUTION:

Central File	NRC PDR	SPLB File	ASingh
GHubbard	JLyons	DOudinot	SWest
PMadden	JHolmes	EPawlik, R:III	
GMulley	CMcCracken	LPlisco	

SPLB:DSSA	SPLB:DSSA	SPLB:DSSA
ASingh;cf	SWest	CMcCracken
3/16/94	3/16/94	3/16/94

[G:\SECTIONC\SINGH\SINGH2.OPL]

MH-S-3-1B
X-O+M-157

003027

RETURN TO REGULATORY CENTRAL FILES

ENCLOSURE 1

Trip Report

Industry Group:	Nuclear Management and Resources Council (NUMARC)
Activity:	NUMARC Phase II Thermo-Lag Fire Barrier Test Program
Test Facility:	Omega Point Laboratories, Inc., Elmendorf, Texas
Trip Date:	February 15 through 17, 1994
Reviewer:	Amarjit Singh, NRR/DSSA/SPLB

INTRODUCTION

On February 15 through 17, 1994 I visited Omega Point Laboratories, Inc. (OPL), Elmendorf, Texas to witness the fire endurance tests of NUMARC's tests for generic qualification of Thermo-Lag fire barriers throughout the industry. The NUMARC test program for the generic qualification of Thermo-Lag fire barriers includes two phases. Phase I program was documented in previous trip reports. Phase II includes 11 test configurations (existing industry installations and additional upgrades) funded by NUMARC.

Some of the Phase II program test assemblies have reduced amounts of exposed cable tray length in the furnace. In lieu of using a horseshoe configuration similar to those which were used in Phase I, some of the test specimens are L-shaped. This change was not reviewed by the staff.

Industry personnel and contractors contacted during this visit were Richard Lehman of TSI, Cal Banning and Rick Dible of VECTRA, Biff Bradley and Alex Marion of NUMARC. In addition, the following OPL personnel were contacted: Deggary Priest, President; Constance Humphrey, Quality Assurance Manager and Vice President; and Kerry Hitchcock, Shop Foreman.

FIRE ENDURANCE TESTING

Test Assembly 2-1, 1-Hour Baseline

Fire Barrier Construction

NUMARC tested assembly 2-1 (1-hour) on February 17,1994. The test assembly was comprised of four aluminum conduit configurations (3/4", 2",4" and 6" diameter). No cables were included in the conduit assemblies. Only bare #8 AWG copper conductors with thermocouples every 6" were installed in each conduit. Each configuration consisted of a U-shaped conduit run with a radial bend on one side and a lateral bend box (LBD) on the other side. The baseline Thermo-Lag conduit applications consisted of pre-buttered half round preshaped conduit sections. Box configurations at conduits utilized one hour baseline panels with pre-buttered joints. Radial bends had mitered pre-buttered Thermo-Lag half round pieces.

Test Results

The initial temperature at the start of the fire exposure was 55 °F Using this temperature, the acceptance criteria temperatures were 305 °F for any set of

thermocouple averages 380 °F for any single thermocouple. Table 1 provides the preliminary test data.

The 3/4" diameter conduit exceeded both the single point and average temperature criteria at 27 minutes into the test. The 2" diameter conduit exceeded The average temperature criterion at 39 minutes and the single point temperature criterion at 45 minutes. The 4" diameter conduit exceeded the average temperature at 48 minutes. The 6" diameter conduit exceeded the average temperature criterion at 50 minutes.

At the completion of the fire test, a hose stream test was performed using a 30-degree fog stream at 75 gpm with a minimum 75 psi nozzle pressure applied to the entire test specimen from a distance of 5 feet for 5 minutes.

Following the hose stream test, barrier burnthrough was noted for the 3/4" conduit. For the 2", 4" and 6" diameter conduits, no openings were noted in the barrier through which the conduit or conduits could be visually observed.

Based on the preliminary test data and post-fire visual examination, this 1-hour baseline conduit assembly appears to be unsatisfactory.

Test Assembly 2-8, 1-Hour Upgrade

Fire Barrier Construction

NUMARC tested assembly 2-8 on February 15, 1994. This test assembly consisted of two 24" by 4" and two 6" by 4" aluminum ladder back cable trays in a common test deck. Each tray contained a single layer of cables. The Thermo-Lag barrier was a baseline 1 hour application with upgrades. Two trays (tray C, 6" and tray D, 24") utilized a baseline score and fold application for the bottom and side panels on the straight vertical and horizontal runs. A separate panel was installed on the top surface of the trays. Two trays (tray A, 24" and tray B, 6") utilized a baseline four panel application. The baseline fire barrier installation was post-buttered. Radial bends were covered using separate mitered pieces for all four cable trays. Upgrades for all four cable trays consisted of 330-1 trowel grade material and external stress skin applications with fasteners. Tray A had a Thermo-Lag 330-1 fire stop located 6" from the wall of furnace which closed the envelope. This tray fire stop was 4" minimum to 5" maximum depth. The envelope in the vicinity of the fire stop was upgraded with an external steel reinforcement bracket.

Thermocouples were placed at 6-inch intervals on the exterior surface of the tray rails underneath the fire barrier material. One bare copper conductor with thermocouples was also installed on top of the single layer of cables in the longitudinal center of the tray, positioned parallel to and above the bare copper conductor which was installed on the cable tray rungs. One bare copper conductor with thermocouples was installed on the top of the cable tray rungs along the entire length of the cable tray run at the longitudinal center of the tray and was secured to each tray rung. One bare copper conductor with thermocouples was installed below the cable tray rungs along the entire length of the cable tray run near the longitudinal center of the tray (offset approximately 1 inch from the conductor installed above the tray rungs).

Test Results

The initial starting temperature was 54 °F which establishes temperature acceptance criteria of 304 °F as for the average and 379 °F for any single thermocouple. Table 2 provides preliminary test data.

At the completion of the fire test, a hose stream test was performed using 30-degree fog stream at 75 gpm with a minimum 75 psi nozzle pressure applied to the entire test specimen from a distance of 5 feet for 5 minutes.

Trays B, C and D exhibited acceptable temperatures throughout the 60 minute duration of the fire test and had barrier continuity following the hose stream test. Tray A had a single high thermocouple that exceeded the single point temperature criterion at 58 minutes and reached 395 °F at 60 minutes. This thermocouple was on the tray rail adjacent to tray fire stop. All other thermocouples for this tray were below the temperature criterion. The barrier for tray A exhibited barrier continuity following the hose stream test. Cable visual inspection for all trays revealed that the cables did not show any visual damage.

Based on the preliminary temperature data and the post-fire visual examination, this 1-hour upgraded fire barrier assembly appears to be satisfactory.

Test Assembly 2-10, 3-Hour Baseline

Fire Barrier Construction

NUMARC tested assembly 2-10 on February 16, 1994. This assembly consisted of two 24" by 4" and two 6" by 4" aluminum ladder back trays in a common test deck. Each tray contained a single layer of cables. The Thermo-Lag barrier was a 3-hour baseline application, with no upgrades. Two trays (tray C, 6" and tray D, 24") utilized a baseline score and fold application for the bottom and side panels on the straight vertical and horizontal runs. Two trays (tray B, 6" and tray A, 24") utilized a baseline application. The baseline fire barrier installation was pre-buttered. Radial bends were installed using separate mitered pieces for all four cable trays.

Thermocouples were placed at 6-inch intervals on the exterior surface of the tray rails underneath the fire barrier material. One bare copper conductor with thermocouples was also installed on top of the single layer of cables in the longitudinal center of the tray, positioned parallel to and above the bare copper conductor which was installed on the cable tray rungs. One bare copper conductor with thermocouples was installed on the top of the cable tray rungs along the entire length of the cable tray run at the longitudinal center of the tray and was secured to each tray rung. One bare copper conductor with thermocouples was installed below the cable tray rungs along the entire length of the cable tray run near the longitudinal center of the tray (offset approximately 1 inch from the conductor installed above the tray rungs).

Test Results

The initial starting temperature was 57 °F which establishes temperature acceptance criteria of 307 °F for the average and 382 °F for any single thermocouple. Table 3 provides preliminary test data.

The single maximum thermocouple temperature criterion was exceeded on the four piece 24" tray A on the tray side rail at 86 minutes into the test. The single maximum thermocouple temperature criterion was exceeded on the score and fold 24" tray D on the bare copper conductor under the tray rungs and above the tray rungs at 85 minutes into the test. At 85 minutes into the test, a lower panel piece fell off the score and fold 24" wide tray in the area of the mitered radial bend area of tray D which caused a large opening of the envelope system. The cables in tray D were charred where the opening occurred just before the vertical L. The visual examination also indicated that the right hand side aluminum melted and burned through the tray. The trays B and C Thermo-Lag barrier material did not appear to be burned through and there was no sign of cable degradation at the termination of the test. The test was terminated at the end of 86 minutes.

At the completion of the fire test, a hose stream test was performed using 30-degree fog stream at 75 gpm with a minimum 75 psi nozzle pressure applied to the entire test specimen from a distance of 5 feet for 5 minutes.

During the visual examination after the stream hose test the trays A and D exhibited burn through of the barriers at the butt joint underneath and at the metered radial bend. Tray B and tray C visual observations indicated no barrier openings following the hose stream test.

Based on the preliminary temperature data and the post-fire visual examination, this 3-hour baseline fire barrier assembly appears to be unsatisfactory.

Table 1. 1-Hour Fire Endurance Test of Assembly 2-1

Acceptance Criteria: 305 °F Average, 380 °F Maximum

Description	Results
3/4" Conduit w/o cables inside	Conduit Surface Avg temp. 310 °F, Max 387 °F @ 27 minutes
3/4" Conduit Bare Copper Conductor	Avg temp. 302 °F, Max, 387 °F @ 31 minutes
2" Conduit w/o cables inside	Conduit Surface Avg temp. 323 °F, Max 382 @ 41 minutes
2" Conduit Bare Copper Conductor	Avg temp. 311 °F, Max 360 °F @ 45 minutes
4" Conduit w/o cables inside	Conduit Surface Avg.temp. 309 °F, Max 364 °F @ 48 minutes
4" Conduit Bare Copper Conductor	Avg. temp. 281 °F @ 50 minutes
6" Conduit w/o cables inside	Conduit Surface Avg. temp. 310 °F, Max 369 °F @ 50 minutes
6" Conduit Bare Copper Conductor	Avg. temp. 268 °F @ 50 minutes

Table 2. 1-Hour Fire Endurance Test of Assembly 2-8

Acceptance Criteria: 304 °F Average, 379 °F Maximum

Description	Results
Tray A Bare Copper on Rungs	Average temp. 238 °F, Max. 349 at @60 minutes
Tray A Bare copper on Cables	Average temp. 240 °F, Max. 325 °F at 60 minutes
Tray A Bare copper under Rungs	Average temp. 254 °F, Max. 363 °F at 60 minutes
Tray B Bare copper on Rungs	Average temp.207 °F, Max. 209 °F at 60 minutes
Tray B Bare copper on Cables	Average temp.206 °F, Max. 208 °F at 60 minutes
Tray B Bare copper under Rungs	Average temp. 220 °F, Max temp. 250 °F at 60 minutes
Tray B side rails	Average temp. 228 °F, Max temp. 255 °F at 60 minutes
Tray C Bare copper on Rungs	Average temp. 207 °F, Max temp. 212 °F at 60 minutes
Tray C Bare copper on Cables	Average temp. 206 °F, Max temp. 207 °F at 60 minutes
Tray C Bare copper under Rungs	Average temp. 219 °F, Max temp. 260 °F at 60 minutes
Tray C side rails	Average temp. 228 °F, Max temp. 253 °F at 60 minutes
Tray D Bare copper on Rungs	Average temp. 235 °F, Max temp. 279 °F at 60 minutes
Tray D Bare copper on Cables	Average temp. 236 °F, Max temp. 287 °F at 60 minutes
Tray D Bare copper under Rungs	Average temp. 263 °F, Max temp. 300 °F at 60 minutes
Tray D side rails	Average temp. 233 °F, Max temp. 242 °F at 60 minutes
Tray A side rails	Average temp. 242 °F, Max temp. 384 °F at 58 minutes

Table 3. 3-Hour Fire Endurance Test of Assembly 2-10

Acceptance Criteria: 307 °F Average, 382 °F Maximum

Description	Results
Tray A- Bare Copper on Rungs	Average temp. 224 °F, Max. 282 °F @ 86 min.
Tray A- Bare Copper on Cables	Average temp. 237 °F, Max. 291 °F @ 86 min.
Tray A- Bare Copper under Rungs	Average temp. 255 °F, Max. 328 °F @ 86 min.
Tray A- Left Side Rail	Average temp. 262 °F, Max. 359 °F @ 86 min.
Tray A- Right Side Rail	Average temp. 278 °F, Max. 385 °F @ 86 min.
Tray B- Bare Copper on Rungs	Average temp. 211 °F, Max. 213 °F @ 86 min.
Tray B- Bare Copper on Cables	Average temp. 213 °F, Max. 233 °F @ 86 min.
Tray B- Bare Copper under Rungs	Average temp. 231 °F, Max. 270 °F @ 86 min.
Tray B- Left Side Rail	Average temp. 243 °F, Max. 290 °F @ 86 min.
Tray B- Right Side Rail	Average temp. 246 °F, Max. 299 °F @ 86 min.
Tray C- Bare Copper on Rungs	Average temp. 208 °F, Max. 212 °F @ 86 min.
Tray C- Bare Copper on Cables	Average temp. 211 °F, Max. 224 °F @ 86 min.
Tray C- Bare Copper under Rungs	Average temp. 234 °F, Max. 265 °F @ 86 min.
Tray C- Left Side Rail	Average temp. 245 °F, Max. 290 °F @ 86 min.
Tray C- Right Side Rail	Average temp. 240 °F, Max. 280 °F @ 86 min.
Tray D- Bare Copper on Rungs	Average temp. 921 °F, Max. 1514 °F @ 86 min.
Tray D- Bare Copper on Cables	Average temp. 246 °F, Max. 300 °F @ 86 min.
Tray D- Bare Copper under Rungs	Average temp. 958 °F, Max. 1510 °F @ 86 min.
Tray D- Left Side Rail	Average temp. 313 °F, Max. 474 °F @ 86 min.
Tray D- Right Side Rail	Average temp. 288 °F, Max 312 °F @ 86 min.