SAFETY EVALUATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
DIVISION OF SYSTEM SAFETY AND ANALYSIS
PLANT SYSTEMS BRANCH
DARMATT KM-1 FIRE BARRIER SYSTEMS
LASALLE COUNTY STATION, UNITS 1 AND 2
DOCKET NOS. 50-373 AND 50-374

1. INTRODUCTION

Commonwealth Edison Company (the licensee) installed Thermo-Lag 330-1 (Thermo-Lag) fire barriers at LaSalle County Station, Units 1 and 2 (LaSalle), to separate redundant safe shutdown electrical systems in accordance with Section III.G of Appendix R to 10 CFR Part 50. Concerns regarding the fire-resistive capability of Thermo-Lag led the U.S. Nuclear Regulatory Commission (NRC) to establish a special review team in 1992, and subsequently to develop a plan of action to address Thermo-Lag issues. In an effort to assess the amount of Thermo-Lag at each plant, in December 1993, the staff sent a request for additional information to licensees regarding Generic Letter (GL) 92-08 pursuant to 10 CFR Part 50.54(f). The licensee provided the requested information by letter dated February 10, 1994. In that response, the licensee stated that Thermo-Lag was used in two applications at each unit to provide 1-hour fire-resistive protection for one power cable tray and one control cable tray. These cable trays also include several air drops. The licensee stated that it did not intend to demonstrate the adequacy of the Thermo-Lag fire barriers and that it was considering using alternative fire barrier materials to meet the requirements of Appendix R.

By letter dated April 6, 1994, the licensee informed the staff that it intended to replace its Thermo-Lag fire barriers with a Darmatt KM-1 (Darmatt) fire barrier system. In addition, this letter provided the licensee's test plan for its proposed replacement fire barrier system. By letters dated May 18 and June 22, 1994, the staff requested additional information concerning the test plan, the testing laboratory, and the quality controls for the test program. By letters dated June 2 and July 14, 1994, the licensee responded to these requests.

By letter dated September 8, 1994, the licensee submitted a report dated August 30, 1994, entitled "Test Report for a 1-hour Fire Test on Darmatt KM-1 Fire Protection System for Site Configurations at the Lasalle Nuclear Power Plant." The purpose of this test was to qualify the replication of a plant-specific raceway configuration protected by the Darmatt fire barrier system to the fire endurance testing and acceptance criteria of Generic Letter 86-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains Within the Same Fire Area." By letter dated November 17, 1994, the staff requested additional information regarding test specimen construction, thermocouple placement, and certain observations made during the test. By letter dated June 2, 1995, the licensee responded to this request. Finally, during a conference call with the licensee on August 1, 1995, the staff requested clarifications. The licensee responded by letter dated August 28, 1995.

ATTACHMENT 1

2. EVALUATION

All dimensions, quantities, and other units of measure stated in this evaluation are nominal values.

2.1 General Fire Barrier System Description

The primary component of the Darmatt fire barrier system, which was manufactured by Darchem Engineering Ltd., was a semirigid endothermic reactive insulating board of ⅝-inch thickness and a surface density of 3.1 pounds per square foot. The boards were manufactured from a mixture of commercially available raw materials and were cut into pieces, or panels, as needed for installation. Other components included the ceramic fiber boards, the pre-molded conduit sections, the ceramic fiber paper, the ceramic fiber blanket insulation, the expanding gaskets, the silicone rubber cloth, and the conduit mix. The ceramic fiberboard, about ⅝-inch thick with a surface density ranging from 13 to 18 pounds per square foot, was used only on the inner most layer of the cable tray side rails or the inner layer of the supports. The pre-molded conduit sections consisted of two 5-inch diameter precast half-rounds of the same composition as the insulating board. The ceramic fiber paper, ⅛-inch thick, was placed directly under the cable tray. The expanding paper gasket, Fiberfrax expanding paper, of ⅛-inch thickness, was installed at panel joints and expands to fill small gaps. The silicone rubber cloth, a silicone rubber-coated glass cloth reinforced with an Inconel wire mesh, was wrapped around the outer layer of Darmatt panels. The conduit mix, Darmatt Thermal Filler, was of the same composition as the insulating boards and was used to fill gaps that were too large for the paper gaskets.

2.2 Fire Endurance Test Program

The licensee designed and constructed an electrical raceway test assembly that was intended to replicate a plant-specific LaSalle configuration. The test assembly was covered with the 1-hour fire-rated Darmatt KM-1 fire barrier system. The licensee indicated that the resulting test specimen represented a composite of existing plant-specific configurations currently protected by Thermo-Lag and that the test results were expected to bound the plant-specific conditions. The original equipment supplier of Darmatt was the Favordale Engineering Group of Darchem Engineering Ltd (Darchem/Favordale), a Transco sub-vendor in Darlington, England. The licensee contracted Transco Products Inc. (Transco), of Chicago, Illinois, to provide their expertise of fire protection systems. The test program was conducted as described below.

2.2.1 Test Laboratory and Quality Assurance

The fire endurance test was performed at the Faverdale Technology Centre Limited, Darlington, England. The accreditation of testing laboratories is performed in England by the National Measurement Accreditation Service (NAMAS). NAMAS is a Department of Trade and Industry Registrar for raw materials and commercial products, which acts on behalf of the Secretary of State for Trade and Industry and has the authority for the granting, maintaining, renewing, or terminating of accreditation. NAMAS performs surveillance visits yearly and reassessment inspections every 3 or 4 years.

In early 1994, NAMAS performed a reassessment inspection at Faverdale and renewed its laboratory accreditation.

In May 1994, the licensee performed quality assurance audits of Transco and of Darchem/Faverdale. The areas covered by the audit included design control; software quality assurance; calibrations; material control and dedication; document control and procedure adequacy; nonconformance and corrective action; internal and external audits; records; installer training and certification; and handling, shipping, and storage of materials. On the basis of its audits, the licensee identified six unresolved items. In a letter of July 15, 1994, which was part of the letter of September 8, 1994, the licensee stated that corrective actions for these unresolved items had been completed.

2.2.2 Description of Test Specimens and Installation of Fire Barrier Material

The electrical raceway test assembly consisted of a cable tray, conduits, a junction box (JB), and an airdrop. The assembly did not include cable fill. With the exception of the JB, two conduits, one tray hanger, and one I-beam, which represented intervening components (i.e., thermal shorts), the test assembly was covered with the 1-hour fire-rated Darmatt KM-1 fire barrier system as described below. Darchem/Favordale installed the Darmatt fire barrier system. Faverdale Technology Center performed the quality control inspections of the raceway fabrication and of the Darmatt installation. The licensee witnessed and verified these construction activities, as documented in the letter of July 14, 1994. The licensee also provided to the staff the installation procedure entitled TIQAP 9.20 LS, Revision 1. This document was used as a guideline for the installation of the Darmatt system at Lasalle. The staff reviewed the letter of June 2, 1995, in which the licensee described how Darmatt was installed on the test specimens, and concluded that the procedures used to install the Darmatt system on the test specimens seemed to be consistent with the installation guidelines contained in TIQAP 9.20 LS, Revision 1.

2.2.2.1 Cable Tray

Test Specimen 1 was a 30-inch-wide solid-bottom steel cable tray. It was 4 inches deep and about 12 feet long with a 2-inch rung spacing. This tray entered through a vertical concrete furnace wall and ran parallel to the back furnace wall for about 7 feet. This tray section was installed so that it was 1 inch from the back furnace wall and 12 inches below the furnace ceiling. The tray then made a 90-degree horizontal turn and ran horizontally about 3 feet, where it penetrated the front wall of the furnace. The cable tray was supported from the concrete ceiling by Unistrut hangers.

The 7-foot horizontal section of the tray and a portion of the 90-degree horizontal bend were enclosed in a structural box-type frame constructed from L-shaped steel angles (2 inches by 2 inches by ¼ inch thick). The cable tray fire barrier frame enclosure was two-sided (the frame dimensions were 21 inches high by 33½ inches wide). The furnace concrete wall and ceiling formed the other two sides of the protective envelope system boundary. The frame was attached to the concrete with ¾-inch Hilti "Quick Bolt II" anchors spaced about every 18 inches along the frame and no more than 2 inches from each corner. Anchor pins for holding the Darmatt fire barrier material in place were spaced and welded to the frame about every 6 inches. Before attaching the frame to the concrete ceiling and to the concrete back wall of the furnace, strips of expanding paper gasket were installed along the frame where it came into contact with the concrete. The frame was sized to accommodate two cable trays stacked vertically, but it contained only one tray which occupied the lower portion of the fire barrier enclosure. The two-sided fire barrier system was constructed of two layers of Darmatt fire barrier panels that were cut to size and attached to the frame. The inner layer panels on the vertical face of the enclosure were impaled over the anchor pins and secured with one speed clip washer over each pin, and the bottom panels (horizontal orientation) were lined with a single layer of ceramic fiber paper. These panels were installed with the ceramic paper in contact with the steel frame. Before installing the outer layer panels, each panel was fitted with silicone rubber outer cloth, which was wrapped around the panel and held in place by staples. J-hooks were installed along the panel edges and spaced about every 6 inches. The cloth-covered panels were impaled over the anchor pins, with the staples and the J-hooks on the outside, and secured with one speed clip washer over each pin. A stainless steel lacing wire was used to tie adjacent panel J-hooks in pairs, thus securing the joints and seams between these panels. The minimum air gap between the cable tray and the inner unexposed surface of the Darmatt fire barrier enclosure was about 5 inches.

The straight section (about 36 inches) of the cable tray, which exited the cable tray enclosure, was protected on four sides with Darmatt fire barrier panels (two layers on the top and bottom of the tray and three layers on the side rails). The Darmatt panels were applied directly to the cable tray. On the cable tray side rails, the innermost layer consisted of a ceramic fiberboard. The inner Darmatt panel fitted to the bottom of the cable tray had a layer of ceramic paper attached to the panel where it came into contact with the tray. The preferred installation sequence was to install the top panel first, then the side panels, followed by the bottom panel. After the side panels were connected loosely to the top panel with wires laced around adjacent J-hooks, the bottom panel was secured in place. The panels were then permanently secured by tightening the lacing wire on the adjacent J-hooks. The cloth-covered outer layer was installed in an identical manner.

2.2.2.2 Ceiling-Mounted Conduit

Test Specimen 2 was a ¾-inch diameter steel conduit 72 inches long. It was attached to the concrete ceiling of the furnace and spanned the width of the furnace. The purpose of this conduit was to interface and intervene with the cable tray fire barrier enclosure. This conduit penetrated the cable tray fire barrier enclosure and ran perpendicular to the cable tray enclosure against the furnace ceiling for about 36 inches, where it penetrated the front wall of the furnace.

The conduit was enclosed in an L-shaped steel angle structural frame for a distance of about 36 inches between the furnace wall and the point where it entered the cable tray enclosure. The frame (2½ inches high by 5 inches wide) was attached to the concrete ceiling of the furnace with ¼-inch Hilti "Quick

Bolt II" anchors spaced about every 18 inches along the frame and 2 inches from each corner. Fire barrier anchor pins were welded to and spaced along the frame about every 6 inches. Before the frame was attached to the furnace concrete ceiling, strips of expanding paper gasket were installed along the frame where it came in contact with the concrete. The furnace ceiling formed the protective envelope on one side of the frame. The remaining three sides were protected with [illegible] layers of Darmatt fire barrier panels that were cut to size and installed [illegible] the frame. The first layer panels were impaled over the anchor pins and secured with one speed clip washer over each pin. Before installation, the second layer panels were wrapped with silicone rubber cloth. The cloth was held in place with staples. J-hook fasteners, spaced about every 6 inches, were installed along the panel edges, which interfered with adjacent panels. The cloth-covered panels were impaled over the anchor pins, with the staples and the J-hooks on the outside, and secured with one speed clip washer over each pin. After the bottom panels were fitted to the frame, the side panels and the bottom panels were connected together with stainless steel wire laced around adjacent J-hooks. The panel joints and seams were then permanently secured by tightening the lacing wire on the adjacent J-hooks. The minimum air gap was about 1¾ inches between the conduit surface and the inner unexposed side surface of the Darmatt fire barrier enclosure and 1 inch from the bottom.

2.2.2.3 Mid-Level Conduit

Test Specimen 3 was a ¾-inch diameter steel conduit, 38 inches long, that ran parallel to the furnace ceiling and parallel to the cable tray side rail. This conduit was routed outside the cable tray enclosure open space for about 36 inches, where it penetrated the front wall of the furnace.

The conduit was enclosed in one layer of Darmatt premolded, semicircular panel sections (2-inch nominal thickness with a 5-inch outside diameter) applied directly over the conduit. The semicircular sections were secured together with lacing wires spaced about 9 inches along the barrier length and no more than 2 inches from each circumferential joint in the barrier system. Silicone rubber cloth was then wrapped around the conduit panels and secured to the panels with stainless steel bands spaced about 9 inches on center. In the horizontal span of this conduit, about 12-inches from the two-sided cable tray enclosure, a 1-inch section was unprotected. This break simulated a thermal short into the enclosure.

2.2.2.4 Junction Box and Air Drop Conduit

Test Specimen 4 was a steel 12-inch by 12-inch by 3-inch JB. It was attached to the front furnace wall adjacent to the cable tray. A ¾-inch diameter steel conduit exited the top of the JB, made a short radius 90-degree bend and terminated about 1-inch above the cable tray. A bare No. 8 American Wire Gauge (AWG) copper conductor dropped from the end of the air drop conduit into the cable tray. The JB was attached to the concrete wall of the furnace with ¼-inch Hilti "Quick Bolt II" anchors.

The furnace's concrete wall formed the protective envelope on one side. The remaining sides of the JB were protected with the Darmatt fire barrier panels installed using the same installation method described for Test Specimen 2. The minimum air gap was about 2 inches between the JB sides and the inner unexposed surface of the Darmatt fire barrier enclosure and about ¾-inch between the front of the JB and the fire barrier enclosure. The overall dimensions of the JB fire barrier enclosure were 15½ inches high by 18½ inches wide by 5½ inches deep.

Because of the close proximity of the air drop conduit to the cable tray envelope, it was necessary to notch the outer layer of the Darmatt system protecting the cable tray to accommodate the conduit. Once the outer layer of the tray wrap was notched, two layers of Darmatt were installed on the air drop conduit using methods similar to those used to apply the four-sided fire barrier enclosure to the cable tray.

2.2.2.5 Joint Detail

Edges of the panels on strips of test specimens (straight and semicircular) were selectively lined with strips of expanding paper gasket in such a manner that after installation of the panels, there was a gasket at the interface of each butt joint, each adjacent joint, and each longitudinal or circumferential joint. Expanding gaskets were either preattached to panel section edges or installed during test specimen construction. Gaps larger than ⅛ inch were filled with one additional strip of expanding gasket paper or thermal filler.

2.2.2.6 Material and Installation Deviations

In its letters of September 8, 1994, and June 2, 1995, the licensee indicated that certain minor material and installation deviations that may occur in the field fabrication of these barriers were deliberately included in the test program. These deviations included: (1) fire barrier material end not covered with silicone cloth, (2) cloth stapled to the exterior of the panel instead of wrapped around the panel, and (3) minor outer-layer gaps not filled with thermal filler or conduit mix. The licensee indicated that if these deviations were to occur in field installations, they would be bounded by the tested specimen.

2.2.3 Thermocouple Placement, Acceptance Criteria, and Hose Stream Test Methodology

GL 86-10, Supplement 1, states that fire endurance ratings are demonstrated by testing fire barrier assemblies in accordance with the provisions of the applicable sections of National Fire Protection Association (NFPA) Standard 251, "Standard methods of Fire Tests of Building Construction and Materials," and American Society for Testing and Materials (ASTM) Standard E-119, "Fire Test of building construction and Materials." The licensee followed the guidance of in GL 86-10, Supplement 1.

The temperature of the test specimen components was measured by glass-covered, 24-gauge, C20 type K thermocouples. The placement and the grouping of the thermocouples on the various test specimens and the methods used for averaging them for qualification purposes followed the guidance of GL 86-10, Supplement 1, except for the air drop conduit and its transition into the cable tray. Specifically, the test specimens were instrumented in the following manner: thermocouples every 6 inches on the exterior surface of each tray side rail between the side rail and the fire barrier material; a bare No. 8 AWG copper conductor routed down the center of the cable tray and attached to the top of the tray rungs with thermocouples attached to the conductor at 6-inch intervals; thermocouples spaced every 6 inches on the exterior conduit surface between the conduit and the unexposed surface of the fire barrier material; a No. 8 AWG bare copper conductor routed inside the conduits with thermocouples attached to the conductor at 6-inch intervals; thermocouples attached inside to each face of the junction box (JB) surface at its geometric centers; one thermocouple on the JB within 1 inch of the air drop penetration; and a No. 8 AWG bare copper conductor routed inside the air drop with 3 thermocouples attached to the conductor at 6-inch intervals. Each thermocouple was either soldered to the bare copper conductor or attached to the test specimen component by means of a stainless steel rivet and washer.

GL 86-10, Supplement 1, specifies that the fire endurance qualification test for fire barrier materials applied to a raceway or a component is successful if the following temperature criteria are met:

- The average unexposed side temperature of the fire barrier system, as measured by thermocouples placed on the exterior surface of the component, does not exceed 250 °F (139 °C) above the initial temperature.

- The temperature rise of any single thermocouple does not exceed the maximum allowable temperature rise of 325 °F (181 °C) above the initial temperature.

- The fire barrier system remains intact during the fire exposure and water hose stream test without developing any openings through which the protected component is visible.

The licensee followed these temperature rise acceptance criteria.

Following the fire exposure, the test plan required the specimens to be subjected to a fog hose stream test for a period of 5 minutes. The test report specified that the stream was delivered from a 2½-inch (nominal) diameter hose with a 1½-inch spray discharge nozzle and a 30-degree spray angle, a nozzle pressure of 75 pounds per square inch (psi), and a flow of 75 gallons per minute (gpm), at a distance of 5 feet from the center point of the test specimen. This hose stream test met the criteria of GL 86-10, Supplement 1.

2.2.4 Test Results and Observations

On June 16, 1994, the test assembly was subjected to a 1-hour fire endurance test and to a hose stream test in accordance with the guidance of GL 86-10, Supplement 1, and ASTM E-119. With an initial ambient temperature of 54 °F, the temperature acceptance criteria were 304 °F for the average temperature rise and 379 °F for maximum single point temperature rise. The staff reviewed the temperatures of the test specimens recorded during the test, as documented in the letter of September 8, 1994, and concluded that the maximum recorded temperature of each test specimen did not exceed 203 °F (average) or 237 °F (single point). On the basis of the reported thermocouple test data, the staff concluded that the test assembly met the temperature rise acceptance criteria specified in GL 86-10, Supplement 1.

After the completion of the hose stream test, a visual inspection of the test specimens was performed. The following observations were made: (1) The fire barrier system appeared to be intact. It did not burnthrough and was not breached by the hose stream. The test report included photographs that confirm these general observations. (2) The color of the silicone glass cloth covering the outer layer of the Darmatt system had changed from dark grey to light grey and the cloth had sagged along the underside of the longest straight cable tray section. All of the glass cloth had remained in place and was not dislodged by the hose stream test. (3) The expanding paper gaskets expanded in some areas to fill the voids that developed during the fire endurance test, and small portions along the various joints were dark brown in color. (4) Some of the expanding paper gasket material was dislodged during the hose stream test. (5) The inner panels had discolored in several areas and the gasket material also had some discoloration in certain areas. On the basis of the reported hose stream test results, the staff concluded that the test assembly met the hose stream test acceptance criteria specified in GL 86-10, Supplement 1.

2.3 Comparison of Test Assembly to In-Plant Configurations

The Thermo-Lag fire barriers were originally installed at LaSalle to satisfy an operating license condition and a licensing commitment as specified in the Updated Safety Analysis Report (USAR), Appendix H, Section H.4, "Safe Shutdown Analysis Report." Thermo-Lag was used to protect one power cable tray and one control cable tray at each unit. These power and control cable trays are located in the corridor that separates the diesel generator rooms from the essential switchgear rooms. This plant area is located in the turbine building and is common to both units.

The Unit 1 cable tray (which contains power cables), is 30 inches wide by 4 inches deep by 27 feet long, and is located on elevation 732'-0" of the turbine building (plan elevation 710'-6" between column lines 8 and 9 and J and L). The Unit 1 cable tray (which contains control cables), is 30 inches wide by 6 inches high by 25 feet long and is located on elevation 730'-8" of the turbine building. The trays are stacked on top of each other for about 8 feet. At each end of the run, the trays make a 90-degree turn and run parallel but at different elevations. Based on the fire test results, it appears that an individual Darmatt fire barrier tray enclosure constructed using the same attributes as Test Specimen 1 (individual tray enclosure) and installed on each tray individually will provide the same level of fire resistance as the tested barrier configuration.

The Unit 2 cable tray (which contains power cables), is 30 inches wide by 4 inches high by 30 feet long and is located on elevation 732'-9" of the turbine building (plan elevation 710'-6", between column lines 21 and 22 and J and L). The Unit 2 cable tray (which contains control cables) is 30 inches wide by 6 inches high by 30 feet long and is located on elevation 731'-3" of the turbine building. The trays are stacked on top of each other for 18 feet. On that span, concrete walls form two sides of the envelope on the upper cable tray (which contains power cables). At each end of this run the trays make a 90-degree turn and run parallel but at different elevations. Based on the fire test results, it appears that a two-sided Darmatt fire barrier system constructed using the same attributes as Test Specimen 1 (two-sided enclosure) and installed on the in-plant stacked tray configuration specified above will provide the same level of fire resistance as the tested barrier configuration.

The licensee only submitted information on the LaSalle cable tray configurations protected with Darmatt. The staff, therefore, did not compare the other test specimens to in-plant configurations.

3. CONCLUSION

On the basis of its review and evaluation, the staff concluded that the fire endurance test of the 1-hour fire-rated Darmatt KM-1 fire barrier test specimens described above was conducted in accordance with the methodology and acceptance criteria specified in GL 86-10, Supplement 1. The staff also concluded that the 1-hour fire-rated Darmatt KM-1 fire barriers installed at LaSalle described above were bounded by the plant-specific fire test specimens as to materials, methods of assembly, dimensions, and configurations and are, therefore, acceptable.

SALP INPUT

Plant Name: LaSalle County Station, Units 1 and 2
SER Subject: Safety Evaluation for the Fire Test Report Submitted by Commonwealth Edison Company on September 8, 1994.

TAC Nos.: M85563 and M85564

Summary of Review/Inspection Activities

The staff reviewed the licensee fire endurance test report of September 8, 1994, and prepared a safety evaluation. The licensee conducted this fire endurance test to qualify the Darmatt fire barrier system for application at LaSalle and to resolve Thermo-Lag 330-1 fire barrier issues.

Narrative Discussion of Licensee Performance - Functional Area

The original fire endurance test report was of poor quality and lacked sufficient technical detail from which the staff could base its acceptance of the proposed fire barrier system. However, the licensee was responsive in addressing issues raised by the staff and provided responses to requests for additional information.

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Date: October 24, 1995

ATTACHMENT 2