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POLICY ISSUE

(Information)

SECY-94-128

May 12, 1994

FOR: The Commissioners
FROM: James M. Taylor
Executive Director for Operations
SUBJECT: STATUS OF THERMO-LAG FIRE BARRIERS

PURPOSE:

To provide the status of continuing efforts by the U.S. Nuclear Regulatory Commission (NRC) staff and the nuclear industry to resolve Thermo-Lag fire barrier technical issues.

BACKGROUND:

In 1987, Gulf States Utilities reported Thermo-Lag fire barrier installation problems at its River Bend Station and in December 1989 reported a Thermo-Lag fire test failure. During 1991, the staff also received allegations regarding Thermo-Lag. In June 1991, the Office of Nuclear Reactor Regulation (NRR) established a special team to review the installation problems, the test failure, and the allegations. The team concluded in its final report of April 1992 that Thermo-Lag may not provide the fire resistance required to satisfy NRC fire protection requirements and that the reported ampacity derating factors may not be large enough to account for the insulating effects of the material. In July 1992, the NRC staff implemented an action plan to address the issues the team had identified.

The NRR special review team met with the Nuclear Management and Resources Council (NUMARC), now the Nuclear Energy Institute (NEI), to present the results of its review and requested that NUMARC coordinate an industry program to address these issues. During a meeting on August 12, 1992, NUMARC committed to coordinating the industry program, including a test program.

The Congress, the public, and the industry are interested in the Thermo-Lag fire barrier issues. The staff has responded to a number of allegations and

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to several petitions filed in accordance with 10 CFR 2.206. On March 3, 1993, the Commission appeared before the Subcommittee on Oversight and Investigations to discuss the use of Thermo-Lag in nuclear power plants and NRC efforts to resolve concerns about these barriers. The NRC continues to send action plan updates to the Subcommittee and informs the Subcommittee of developments affecting resolution of the Thermo-Lag issues.

The staff has issued a number of generic communications regarding Thermo-Lag fire barriers. The most significant were Bulletin 92-01 of June 26, 1992, and Supplement 1 to Bulletin 92-01 of August 28, 1992, which informed the licensees of failed Texas Utilities Electric Company (TU Electric) fire tests; Generic Letter (GL) 92-08 of December 17, 1992, which identified specific concerns with Thermo-Lag fire barriers; and GL 86-10, Supplement 1, of March 25, 1994, which provided fire endurance test methodology and acceptance criteria for tests of fire barriers used to separate safe shutdown trains within the same fire area, the principal use of Thermo-Lag fire barriers.

In response to Bulletin 92-01 and its supplement, the licensees declared all Thermo-Lag fire barriers inoperable and implemented appropriate compensatory measures, such as fire watches. With the exception of Comanche Peak Steam Electric Station Unit 2 (CPSES 2)—the staff approved the CPSES 2 Thermo-Lag fire barrier program during the licensing of CPSES 2—compensatory measures are still in place at the sites that use Thermo-Lag to meet NRC fire protection requirements. The compensatory measures combined with other plant fire protection features will continue to provide adequate fire safety until final solutions are implemented.

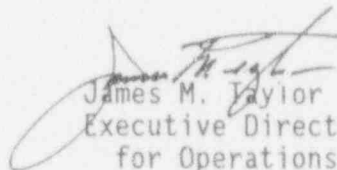
DISCUSSION:

During the NRC staff briefing on October 29, 1993, the Commission expressed concern that industry efforts to resolve the Thermo-Lag issues through a test program may not lead to timely resolution of the issues. Initial actions to address this concern, which were described in SECY-93-362 of December 30, 1993, included (1) increasing NRC senior manager involvement in resolving the issues with the NEI and (2) issuing a request for additional information (RAI) in accordance with 10 CFR 50.54(f) to the licensees that use Thermo-Lag fire barriers.

Enclosure 1 summarizes the RAI and the information submitted by the licensees. As discussed in Enclosure 1, the total number of operating units that have yet to resolve the Thermo-Lag issues has been reduced from 83 to 59. Enclosure 2 provides a plant-by-plant accounting and specific information on the corrective actions that have been completed or are planned at these plants. Enclosure 3 summarizes the overall status and results of the NRC staff and industry efforts to resolve the Thermo-Lag technical issues. Included are: (1) the development of the plant-specific and generic fire endurance test acceptance criteria, (2) the results of the fire test programs conducted by the staff, by the NEI, by various licensees and vendors, and future test plans, (3) performance-based proposals for resolving the Thermo-Lag issues, and (5) information on the issue of Thermo-Lag combustibility.

On the basis of the results of the full-scale fire endurance tests of Thermo-Lag fire barriers conducted by the staff and industry since the final special review team report was issued, the staff has concluded that most baseline 1- and 3-hour Thermo-Lag fire barriers cannot achieve their intended fire ratings. Therefore, the test results substantiated the fire endurance issues raised by the special review team. On the basis of these tests, the staff has also concluded that 1-hour Thermo-Lag fire barriers can be upgraded with additional Thermo-Lag materials to achieve a nominal 1-hour fire resistance rating. The test results also suggest that most baseline 3-hour barriers cannot be upgraded using additional Thermo-Lag materials to achieve a 3-hour fire rating. However, baseline 3-hour Thermo-Lag barriers provide about 1 hour of fire resistance.

The staff is assessing options for resolving the Thermo-Lag fire barrier issues. The staff will provide its assessment in a separate paper.


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SUMMARY OF REQUEST FOR ADDITIONAL INFORMATION PURSUANT
AND LICENSEE RESPONSES

On October 29, 1993, the staff briefed the Commission on the status of the actions to resolve the Thermo-Lag fire barrier issues. On November 24, 1993, NUMARC representatives briefed the Commission on the industry efforts to resolve the issues. During these briefings, the Commission expressed concerns about the timeliness of the resolution of the issues.

The Thermo-Lag action plan assumed that the NEI would complete the industry test program, that the licensees would apply the generic test results to in-plant fire barriers to the extent practicable, and that the licensees would implement plant-specific resolution plans (such as plant-specific fire tests) for plant-specific fire barrier configurations that were not resolved by the NEI test program. This plan assumed that generic Thermo-Lag upgrades could be developed in a timely manner. However, on the basis of the scope and results of the NEI test program, the staff concluded that the NEI program would not be sufficient to resolve the Thermo-Lag fire barrier issues stated in GL 92-08 at many plants. The staff also concluded that the 71 units that were awaiting the results of the NEI test program would need to take additional actions to address fire endurance and ampacity derating concerns stated in GL 92-08. The limited applicability and success of the NEI program complicated the final solution, thereby delaying resolution of the issues.

To help ensure that an acceptable solution is clearly defined in a reasonable time, in December 1993, the staff sent a request for additional information (RAI) in accordance with 10 CFR 50.54(f) to each licensee relying on the NEI test program. The staff requested information on: (1) the configurations and amounts of Thermo-Lag fire barriers installed in the plant, (2) how the NEI test results will be applied, (3) how configurations particular to the plant will be addressed, (4) what alternatives are available for configurations that may not demonstrate satisfactory performance by test or cannot be upgraded, and (5) plans and schedules for resolving the issues. In a letter of January 14, 1994, the NEI sent guidance to the industry for responding to the RAI.

The staff is using the responses to the RAI to review the NEI guidance for evaluating and upgrading Thermo-Lag fire barriers and to assess the plant-specific plans for resolving the issues. The staff is also reviewing the data, information, plans, and schedules submitted by the licensees and will determine the acceptability of plant-specific resolution plans. The following sections summarize the RAI, the NEI guidance for responding, and the licensee responses.

Operating Reactors with Thermo-Lag, Amounts, and Configurations

In response to Bulletin 92-01, Supplement 1, the licensees for 83 operating reactor units stated that Thermo-Lag fire barriers were used to meet NRC fire protection requirements. Subsequently Trojan, San Onofre 1, and Yankee Rowe shutdown permanently, Arkansas 2, Beaver Valley 1, Cooper, Millstone 3,

Monticello, San Onofre 2 and 3, and Vermont Yankee eliminated the use of Thermo-Lag to meet Appendix R requirements. In addition, CPSES 2 was granted an operating license. Therefore, as of December 1993, when the RAI was issued, 73 operating units were using Thermo-Lag to meet NRC fire protection requirements. The staff has reviewed, inspected, and granted final approval of the Thermo-Lag fire barrier program for CPSES 2. In addition, the licensees for 14 operating units have corrective action programs independent of the NEI program to resolve the Thermo-Lag issues. Therefore, the number of operating units that have yet to resolve the Thermo-Lag issues has been reduced from 83 to 59.

The plant-specific programs for the 22 units that have eliminated the use of Thermo-Lag or that have initiated plans to eliminate or resolve the Thermo-Lag issues are summarized in Enclosure 2. The staff will review the corrective actions and modifications implemented by these licensees during the fire barrier inspections specified in the Thermo-Lag Action Plan.

In response to the RAI, each licensee described the types of Thermo-Lag configurations and amounts of Thermo-Lag installed in its facilities. Although the licensees use Thermo-Lag predominately to protect safe shutdown cables in cable trays and conduits, they also use it for fire walls, for floor-ceiling assemblies, for penetration seals, for equipment enclosures, and for radiant energy heat shields. Of the remaining 59 units that use Thermo-Lag, 38 use both 1- and 3-hour barriers, 9 use only 1-hour barriers, and 12 use only 3-hour barriers.

3-Hour Thermo-Lag Fire Barriers

A total of about 7700 linear feet (2348 m) of cable trays at 25 units are protected with 3-hour fire rated Thermo-Lag fire barriers. The amount of Thermo-Lag installed in each unit ranges from 18 linear feet (5.5 m) at Vogtle to 1640 linear feet (500 m) at Washington Nuclear Power 2 (WNP 2). Five units use substantial amounts, 11 units use moderate amounts; and 9 units use minimal amounts.¹ Sixty percent of the 3-hour cable tray fire barriers are installed at three reactor sites (WNP 2, Byron, and South Texas).

About 25,000 linear feet (7622 m) of 3-hour Thermo-Lag barriers are used to protect conduits at 49 units. The amounts per unit range from 6 linear feet (1.8 m) at Nine Mile Point 1 to about 2700 linear feet (823 m) at Peach Bottom 2 and 3. Eighteen units use substantial amounts, 22 units use moderate amounts, and nine units use minimal amounts. Fifty-two percent of the 3-hour conduit fire barriers are installed at seven reactor sites (Peach Bottom, Crystal River 3, Susquehanna, Limerick, South Texas, Beaver Valley, and Brunswick).

¹ Excessive amounts are more than 10,000 linear feet (3050 m) of Thermo-Lag. Substantial amounts are 1000 to 10,000 linear feet (305 m to 3050 m). Moderate amounts are 100 to 999 linear feet (30.5 m to 305 m). Minimal amounts are less than 100 linear feet (30.5 m).

In addition to cable trays and conduits, 3-hour barriers are used to protect junction boxes, about 3300 ft² (307 m²) at 27 units, equipment enclosures, about 700 ft² (65 m²) at seven units, radiant energy shields, about 50 ft² (4.6 m²) at one unit, floor/ceiling assemblies, about 1100 ft² (102 m²) at two units, fire walls, about 10,000 ft² (929 m²) at six units, penetration seals about 635 ft² (59 m²) at nine units. About 13,000 ft² (1208 m²) of miscellaneous 3-hour Thermo-Lag barriers are installed at 28 units.

1-Hour Thermo-Lag Fire Barriers

A total of about 14,000 linear feet (4268 m) of cable trays at 33 units are protected with 1-hour fire rated Thermo-Lag fire barriers. The quantities of Thermo-Lag per unit ranges from 40 linear feet (12 m) at Sequoyah to about 2700 linear feet (823 m) at South Texas. Eleven units use substantial amounts, 14 units use moderate amounts, and eight units use minimal amounts. Fifty-eight percent of the 1-hour cable tray barriers are installed at five reactor sites (South Texas, Susquehanna, Crystal River 3, Limerick, and WNP 2).

About 62,000 linear feet (18,902 m) of conduits at 47 units are protected with 1-hour fire rated Thermo-Lag fire barriers. The linear feet per unit ranges from about 3 linear feet (0.9 m) at Beaver Valley 1 to about 14,600 linear feet (4451 m) at Turkey Point 3 and 4. Two units use extensive amounts, 20 units use substantial amounts, 22 units use moderate amounts, and 3 units use minimal amounts. Sixty-two percent of the 1-hour conduit barriers are installed at five reactor sites (Turkey Point, Susquehanna, Sequoyah, Crystal River 3, and River Bend Station).

In addition to cable trays and conduits, 1-hour barriers are used to protect junction boxes, about 5,500 ft² (511 m²) at 26 units, equipment enclosures, about 1400 ft² (130 m²) at 6 units, radiant energy shields, about 800 ft² (74 m²) at 2 units, penetration seals, about 450 ft² (42 m²) at 2 units, a 142 ft² (13 m²) floor-ceiling assembly at River Bend Station, and a 200 ft² (19 m²) fire wall at Shearon Harris 1. There are also about 5600 ft² (520 m²) of miscellaneous 1-hour Thermo-Lag barriers at 13 units.

Non-Fire Rated Thermo-Lag Fire Barriers

About 1900 linear feet (579 m) of Thermo-Lag barriers, which are not required to be fire rated, are used to achieve physical independence of electrical systems at five units. In addition, about 700 linear feet (213 m) of Thermo-Lag fire barriers are used to enclose intervening combustibles at one unit.

Important Fire Barrier Installation Parameters

In SECY-93-362, the staff stated that the principal test specimen attributes are; raceway type (conduit or cable trays), raceway material (aluminum or steel), raceway size, fire barrier material thicknesses, types of joints and joint sealing methods (pre-buttered or post-buttered) and details (laced with tie wire, or not laced), direction of structural ribs and orientation of stress skin, unsupported span distances and internal supports (if any), band

or tie-wire type and spacing, support and penetrating element protection, cable types and fill, and transitions or interfaces between Thermo-Lag fire barrier materials and any other fire barrier material. In SECY-93-362, the staff also stated that the information and configuration parameters needed to apply fire test data to actual as-built fire barrier configurations are well understood and are not a point of contention between the staff and industry. On the basis of the NEI guidance for responding to the RAI, the RAI responses, and the draft NEI application guide, the staff now believes that there may not be complete agreement on the information and configuration parameters that are important to apply fire test data. The staff proposes to continue its review of this issue as part of its review of the NEI application guide and individual plant corrective action programs.

The RAI requested that each licensee state whether the parameters were obtained and verified and to describe the types and extent of the unknown parameters. The NEI advised the licensees to respond on a general basis and that the parameters concerning cables may not be necessary for most barriers. Many of the licensees did not provide the requested information, but provided a general basis for how they intend to get the information in the future. The licensees also expressed concern that any verification effort may prove to be unnecessary or incomplete.

The staff is concerned that industry has not addressed the important cable parameters, particularly the proximity of cables to the unexposed side (inside) surfaces of the Thermo-Lag fire barriers and the presence of materials between the cables and the unexposed side of the fire barrier material (for example, Sealtemp cloth, which was used in some of the NEI cable tray test specimens). The draft NEI application guide is also silent on the cable parameters identified by the staff in the RAI and in previous discussions and correspondence with the NEI.

Thermo-Lag Barriers Outside the Scope of the NEI Program

Each licensee was asked to describe the barriers that would not be covered by the NEI test program. For barrier configurations that were not bounded by the NEI program, each licensee was asked to describe the plant-specific corrective action plan and schedule to evaluate the installed fire barriers. For utilities that anticipated using a plant-specific fire test program, the test methodology and acceptance criteria were requested.

The NEI advised the utilities to prepare a supplemental response "after taking into consideration the results of the expanded generic test program, if undertaken." The NEI also advised the licensees to defer their response until May 1994 to allow each utility to assess the generic program scope and the potential for plant-specific or joint testing.

Most of the licensees stated that the NEI may expand the scope of the generic raceway testing program which would influence the plant-specific applicability of the program. The licensees also indicated, for non-cable raceway installations, that the NEI may facilitate shared utility testing of fire barrier installations that will not be tested under the NEI program. The licensees stated that after these plans had been completed, they would

supplement their response appropriately. The NEI has indefinitely deferred several tests originally planned under Phase 2 of its program. In addition, the NEI has not proposed any expansion of its test program as of the date of this paper. During a meeting on April 8, 1994, the NEI did, however, inform the staff that it had identified from the responses to the RAI commonalities among licensee fire barriers that could be used to facilitate shared tests of common fire barrier configurations. During the NEI Thermo-Lag workshop on April 21, 1994, NEI representatives stated that a group of eight licensees were working together to develop an approach for resolving questions about the performance of fire walls constructed with Thermo-Lag material.

Ampacity Derating

Each licensee was asked to describe the configurations that would be within the scope of the NEI program and any additional testing or evaluation that would be needed to derive valid ampacity factors for such configurations and to submit information concerning ampacity derating for configurations outside of the NEI program.

The NEI advised licensees to adopt the position that a single ampacity derating factor is applicable to all sizes of cable trays, cable fills, and so forth and that few, if any, installations are expected to fall outside of the generic scope. The licensees' responses were generally consistent with the NEI guidance. In addition, the licensees indicated that the NEI plans to discuss with the staff the generic applicability of the derating factors derived by TU Electric.

Alternatives

The RAI requested that the licensees describe the specific alternatives available for achieving compliance with NRC fire protection requirements and gave examples of options that should be considered. The NEI identified three resolution options that were not stated in the RAI. These were (1) reevaluation of safe shutdown analyses to eliminate circuits requiring protection; (2) exemption requests based on fire modeling and probabilistic safety assessments (PSA); and (3) reevaluation of licensing commitments that may exceed regulatory requirements.

Most of the licensees followed the NEI guidance and stated that because of the uncertainties associated with determining whether upgrades using Thermo-Lag materials are practical they may use a range of alternatives. The majority of the licensees stated that even if successful upgrades were tested, they were considering other potential alternatives. These alternatives included re-evaluation of their Appendix R safe shutdown analysis and methodology to determine if a basis exists for reducing the scope of protected circuits; exemptions based on fire modeling and PSA; and re-evaluation of fire barrier licensing commitments to determine if previous commitments exceed those needed to satisfy NRC fire protection requirements.

The licensees for 21 plants stated that they intend to justify existing Thermo-Lag configurations by applying performance-based approaches that use fire modeling and/or probabilistic risk and safety assessment techniques.

Additional information on performance-based approaches is provided in Enclosure 3.

Schedules

The RAI requested that each licensee submit an integrated schedule that addresses the overall corrective action schedule for the plant. The NEI suggested that the licensees "provide only a very general schedule." These schedules were contingent upon various uncertainties such as, agreement between the industry and the NRC on the acceptance criteria for fire and ampacity testing; the acceptability and use of the NEI application guide; and the testing and qualification of fire barrier configurations not bounded by the industry generic program. The licensees followed the NEI guidance and submitted general schedules with completion forecasts of about two years from the dates of the responses.

SUMMARY OF LICENSEE ACTIONS TO
ELIMINATE THE USE OF THERMO-LAG FIRE BARRIERS

Plants That No Longer Use Thermo-Lag To Meet Appendix R Requirements

The licensees for the following eight units have completed modifications to eliminate the use of Thermo-Lag to meet Appendix R requirements:

Arkansas 2 - The licensee reanalyzed the Thermo-Lag used to protect two conduits and determined that the barriers were not needed to meet Appendix R requirements.

Beaver Valley 1 - The licensee performed an evaluation for a single application and concluded that Thermo-Lag was not needed.

Cooper - The licensee removed three Thermo-Lag radiant energy shields.

Millstone 3 - The licensee removed a single conduit wrapped with Thermo-Lag and replaced it with a 1-hour fire rated cable enclosed in a new conduit.

Monticello - The licensee removed 70 linear feet (12 m) of 1-hour Thermo-Lag barriers from conduits and rerouted the conduits to obtain the required Appendix R separation.

San Onofre 2 and 3 - The licensee removed Thermo-Lag from the floor between two fire areas and replaced it with a material that satisfies previous licensing commitments.

Vermont Yankee - The licensee removed small amounts of 3-hour Thermo-Lag barriers installed on conduits and rerouted the cables or installed a different barrier system.

Plants Currently Eliminating the Use of Thermo-Lag

The licensees for the following 14 units are removing Thermo-Lag, plan to remove Thermo-Lag, are making plant modifications to eliminate reliance on Thermo-Lag to meet Appendix R requirements, or have a plant-specific test program to qualify existing or upgraded Thermo-Lag fire barrier configurations. Compensatory measures will remain in place at these units until the modifications are complete.

Browns Ferry 1, 2, and 3 - The licensee is eliminating the need for Thermo-Lag by modifying circuits, rerouting cables and performing reanalyses. The licensee plans to complete all but one modification for Unit 2 but one before Cycle 8 operation. The licensee plans to complete the final modification, which involves the service water system shared by Browns Ferry 1, 2 and 3, by July 1995.

Fermi - The licensee is either replacing or reclassifying its Thermo-Lag fire barriers. In eight of the 11 areas where Thermo-Lag fire barriers

are installed, the licensee is replacing the barriers with concrete blocks and qualified 3-hour rated fire barriers such as 3M Company barriers, UL designs U435 and X717, Promat boards, silicone foam and elastomer seal. The licensee expects to complete the modifications by fall 1994.

Diablo Canyon 1 and 2 - The licensee uses Thermo-Lag fire barriers to protect conduits and associated junction boxes and as radiant energy heat shields. The licensee has already replaced Thermo-Lag in several areas with Pyrocrete, fire-rated dry wall, and 3M Company fire barrier materials. According to the licensee, it will complete the replacement of all the Thermo-Lag by December 1994.

Maine Yankee - The licensee uses small amounts of 1- and 3-hour Thermo-Lag to protect cable trays and conduits. The licensee will eliminate the use of Thermo-Lag by rerouting cables and by replacing Thermo-Lag barriers with masonry fire barriers and materials with UL fire endurance ratings. Modifications that do not require shutdown will be completed before the end of 1994. Modifications that require shutdown will be completed by 1995.

North Anna 1 and 2 - The licensee either replaced Thermo-Lag with 3M Company fire barrier materials, covered Thermo-Lag with gypsum board, or performed engineering evaluations to qualify existing installations. One application remains to be evaluated by the licensee. The licensee has submitted an exemption request addendum for staff review.

Surry 1 and 2 - The licensee covered Thermo-Lag with Pyrocrete 241 in one application. For the remaining Thermo-Lag applications but one, the licensee performed engineering evaluations to verify compliance with Appendix R requirements. The licensee expects to complete all corrective actions by 1994.

Palisades - The licensee protected about 144 feet (44 m) of 1-hour conduits, 30 feet (9 m) of 3-hour conduits, and associated junction boxes with Thermo-Lag material. The licensee plans to remove the Thermo-Lag and either reroute the cables, replace the circuits with 1-hour fire rated cables, or embed the conduit and associated junction boxes in concrete. Modifications are scheduled to be completed by 1995 for the 1-hour barriers and by the end of the 1996 outage for the 3-hour barriers.

CPSES 1 - Between July and August 1993, TU Electric conducted 1-hour fire endurance tests to qualify upgrades for the Thermo-Lag fire barriers installed at CPSES 1. Only one of the tests met the temperature acceptance criteria approved by the staff. TU Electric has determined that the remaining configurations are acceptable on the basis of cable functionality evaluations. The staff is reviewing the fire test reports and the cable functionality evaluations.

LaSalle - In a letter of April 6, 1994, the licensee provided its plan for qualifying a 1-hour upgrade for a plant-specific Thermo-Lag fire

barrier configuration independent of the NEI program. The licensee will test an overlay material developed by Darchem Limited and Transco. (This fire barrier system is not currently used in any domestic nuclear power facility.)

STATUS AND RESULTS OF NRC AND INDUSTRY EFFORTS TO
RESOLVE THE THERMO-LAG TECHNICAL ISSUES

FIRE ENDURANCE TEST ACCEPTANCE CRITERIA

After the special review team identified the Thermo-Lag issues, the staff concluded that additional fire endurance tests would be needed to determine whether Thermo-Lag fire barriers were capable of meeting NRC fire protection requirements. The staff also determined that the existing staff guidance and criteria for fire tests should be clarified so that the testing errors identified by the special review team during its review of Thermo-Lag fire test reports were not duplicated during any new fire tests. Therefore, the staff clarified the guidance previously provided in Generic Letter (GL) 86-10, "Implementation of Fire Protection Requirements," April 24, 1986. The staff issued its clarified guidance with GL 86-10, Supplement 1, "Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Safe Shutdown Functions Within the Same Fire Area," of March 25, 1994. The clarified acceptance criteria are generically applicable to any fire barrier system. Future fire tests should be conducted in accordance with the guidance provided in GL 86-10, Supplement 1.

Early in the process of developing GL 86-10, Supplement 1, TU Electric and Tennessee Valley Authority (TVA) undertook fire test programs to support the licensing of CPSES 2 and Watts Bar Nuclear Power Plant (WBN), respectively. The programs were intended to qualify the Thermo-Lag fire barriers to be installed in the plants. Therefore, in parallel with its efforts to develop the generic guidance, the staff reviewed plant-specific acceptance criteria for CPSES 2 and WBN. Later, TU Electric applied the criteria approved by the staff for CPSES 2 to CPSES 1.

While it was clarifying its previous guidance, the staff also reviewed the various acceptance criteria that the NEI proposed to apply to the industry fire test program. In summary, the NEI criteria for conduit fire barrier test assemblies satisfied the staff guidance. However, the criteria the NEI applied to its cable tray tests specimens deviated from the guidance described in GL 86-10, Supplement 1. The staff informed the Commission of these differences in SECY-93-362. After meeting with the Commission and the Advisory Committee on Reactor Safeguards (ACRS), the NEI changed its criteria for the second phase of cable tray tests and installed thermocouples in the test specimens in accordance with the staff recommendations. However, contrary to the staff recommendations for tests intended to have generic applicability, the NEI chose to test the cable tray assemblies with cable fill. The staff is concerned that the use of cable fill could reduce the generic applicability of the NEI cable tray test results. The NEI is addressing this concern in response to the staff comments on its application guidance, which is discussed below.

FIRE ENDURANCE TEST PROGRAMS

Thermo-Lag Fire Barrier Tests

Since April 1992, a number of fire tests have been performed to resolve the special review team finding that the fire resistance ratings of Thermo-Lag barriers were indeterminate. TU Electric, TVA, the NEI, and the NRC conducted full-scale fire endurance tests of various cable tray and conduit Thermo-Lag fire barrier configurations. In addition to the full-scale qualification type tests, the staff also conducted small-scale fire tests of Thermo-Lag panels at the National Institute of Standards and Technology (NIST). Some fire barrier vendors and licensees are developing and testing hybrid fire barrier assemblies (Thermo-Lag fire barriers upgraded with non-Thermo-Lag materials).

Between May and December 1992, TU Electric conducted plant-specific 1-hour fire endurance tests to qualify the Thermo-Lag fire barriers installed at CPSES 2. TU Electric constructed the fire barriers for the first series of test specimens approximately as recommended by Thermal Science, Incorporated (TSI), the manufacturer of Thermo-Lag, in its installation procedures manual. (Thermo-Lag fire barriers constructed in accordance with TSI procedures have come to be known as "baseline" barriers.) Most of these test specimens did not meet the test acceptance criteria and, therefore, TU Electric and the staff considered these tests failures. On the basis of the results of these tests, TU Electric developed and tested upgraded specimens for the CPSES 2 Thermo-Lag fire barriers. (Thermo-Lag fire barriers constructed with upgrades have come to be known as "enhanced" or "upgraded" barriers). The upgrades consisted of reinforcement of barrier seams and joints and the installation of additional thicknesses of Thermo-Lag material (trowel-grade or manufactured overlays). On the basis of its review of certain CPSES 2 fire test reports and a field inspection of the fire barrier installations, the staff approved the CPSES 2 fire barrier program during its licensing review of CPSES 2.

The TU Electric fire endurance tests for CPSES 2 were important for the following reasons. The initial tests demonstrated that 1-hour baseline Thermo-Lag fire barriers did not meet generally accepted fire test acceptance criteria because the barriers burned through and barrier seams and joints opened during the fire exposure. The tests also demonstrated that 1-hour Thermo-Lag barriers could not withstand a solid hose stream test after being exposed to the test fire for the full fire rating period. On the basis of these test results, the NRC issued Bulletin 92-01 and its supplement which required the licensees to implement compensatory measures. The second series of tests demonstrated, however, that 1-hour Thermo-Lag barriers could be upgraded to achieve a nominal 1-hour fire rating. Note, however, that the TU Electric tests were determined to be an acceptable alternative to the generic acceptance criteria of GL 86-10, Supplement 1, based on the plant-specific criteria approved during the CPSES 2 licensing process. In addition, the CPSES 2 fire barrier designs included enhancements and upgrades, such as wire lacing, wire stitching, and internal banding. All of the improvements are suitable for new barrier construction, but some cannot be applied to existing fire barriers. This may influence the generic applicability of the CPSES 2 fire tests to existing Thermo-Lag fire barriers. TU Electric also constructed the CPSES 2 fire test specimens using Thermo-Lag panels that it had TSI

manufacture to more exacting standards than is common in the industry. The staff concluded that the Thermo-Lag materials installed at CPSES 2 were representative of the materials used to construct the CPSES 2 fire test specimens and were, therefore, acceptable for use at CPSES 2. As part of its review of the generic applicability of these fire tests under the NEI program, discussed below, the staff will consider the generic implications, if any, of the CPSES 2 Thermo-Lag material specifications.

Later, between July and August 1993, TU Electric conducted 1-hour fire endurance tests to qualify upgrades for the Thermo-Lag fire barriers installed at CPSES 1. The barrier upgrades were designed for application to existing Thermo-Lag fire barriers and generally are not considered as robust as those installed at CPSES 2. Only two of the test assemblies met the temperature acceptance criteria approved by the staff. The cables installed in the test specimens that exceeded the temperature criterion exhibited visible cable damage such as swollen and charred cable jackets. These CPSES 1 tests are significant because TU Electric has determined that the tested configurations are acceptable based on cable functionality evaluations. The staff is reviewing the fire test reports and the cable functionality evaluations and will issue its safety evaluation after completing its review.

Between December 1992 and April 1993, TVA conducted a series of full-scale 1-hour fire tests of Thermo-Lag conduit and junction box fire barriers that were constructed in accordance with TVA plant-specific installation techniques. The staff review of these tests is ongoing; however, on the basis of its observations of the tests and its preliminary review of the test reports, it appears that the TVA tests met the acceptance criteria of GI 86-10, Supplement 1. These tests were important because they were the first tests conducted without cable fill in the test specimens. Like the CPSES 2 test configurations, the TVA configurations use plant-specific construction techniques that may limit the generic applicability of these tests. TVA is planning a second series of 1- and 3-hour tests of plant-specific and generic cable tray, conduit, and box barriers. During a presentation at the NEI Industry Thermo-Lag Workshop on April 21, 1994, a representative of TVA stated that TSI was providing financial assistance for these tests and that two of the tests will involve a new 3-hour Thermo-Lag fire barrier upgrade that uses a new fire barrier material being developed by TSI. The staff expects TVA to submit its test plan in the near future.

The NEI test program for the qualification of Thermo-Lag fire barriers included two testing phases. Phase 1, completed in October 1993, included tests of 11 upgraded 1- and 3-hour Thermo-Lag fire barrier assemblies. The barrier upgrades were designed and funded by TSI. The baseline barrier installations for the test assemblies were generally conservative. For example, they used minimum thickness Thermo-Lag panels and minimum construction attributes. With the exception of 3-hour barriers for a mid-sized cable tray and small-diameter conduit and 1-hour barriers on small to mid-sized conduits, the Phase 1 test assemblies did not meet either the NEI or staff acceptance criteria. The 3-hour cable tray barrier upgrade is so substantial—an upgraded 1-hour Thermo-Lag barrier was installed over the baseline 3-hour barrier—that it is generally not considered practical for field installation. These NEI tests provided additional evidence that

Thermo-Lag barriers could be reasonably upgraded to achieve a nominal 1-hour fire resistive rating. These were also the first 3-hour fire endurance tests of Thermo-Lag barriers conducted after the special review team questioned the ability of Thermo-Lag fire barriers to achieve their intended fire ratings. The observed barrier performance, with the massive upgrades, indicated that resolving the fire endurance concerns with 3-hour Thermo-Lag fire barriers would be more difficult than for the 1-hour Thermo-Lag fire barriers.

During January and February 1994, the NEI conducted tests of 18 baseline and six upgraded fire barrier assemblies under Phase 2 of its program. (The NEI deferred four Phase 2 tests indefinitely.) On the basis of test observations, the staff found that the baseline and the upgraded 3-hour barriers did not meet either the NEI or staff fire test acceptance criteria. With the exception of a 1-hour rated baseline conduit box, the baseline 1-hour barriers did not meet the acceptance criteria. The upgraded 1-hour cable tray and conduit barriers, however, did appear to meet the criteria. The staff will review the Phase 2 test reports after they are submitted by the NEI. These NEI tests provided additional evidence that Thermo-Lag barriers could be reasonably upgraded to achieve a nominal 1-hour fire resistive rating, but that the solution for 3-hour barriers would be difficult.

During December 1993, the NRC staff conducted three full-scale fire endurance tests of 3-hour Thermo-Lag fire barriers (two baseline and one upgrade) to evaluate the performance of the barriers against the results of tests previously reported by TSI. The three tests were significant because none of them met the performance criteria originally applied by TSI or the criteria recommended by the staff in GL 86-10, Supplement 1. The staff informed the licensees of these test results in Information Notice (IN) 94-22, "Fire Endurance and Ampacity Derating Test Results for 3-Hour Fire Rated Thermo-Lag 330-1 Fire Barriers," March 16, 1994.

Fire barrier vendors and licensees have expressed interest in developing upgrades for Thermo-Lag barriers, using fire barrier materials other than Thermo-Lag. For example, during February 1994, the 3M Company conducted two developmental 3-hour fire tests to assess the effectiveness of a combined Thermo-Lag/Interam fire barrier system. According to the 3M Company, a 2-inch diameter conduit test specimen exceeded the average temperature criterion 2 hours and 49 minutes into the test, but did not exceed the single hot spot temperature limit. The 3M Company also reported that a 1½-inch diameter conduit exceeded the average temperature criterion 2 hours and 47 minutes into the test and exceeded the single point temperature criterion at approximately 2 hours and 57 minutes.

Commonwealth Edison Company (CECo) recently informed the staff that it intends to qualify 1- and 3-hour upgrades for plant-specific Thermo-Lag fire barrier configurations independent of the NEI program. CECO will test Thermo-Lag fire barriers that are upgraded using an overlay material developed by Darchem Limited and Transco. (This fire barrier system is not currently used in any domestic nuclear power facility.) The test program will be performed in three phases. The first phase will be 1-hour tests of cable tray configurations that are specific to LaSalle. The second phase will be a 3-hour test of a

Braidwood/Zion configuration. The third phase, which will include tests of other unique configurations, is under development.

On the basis of the tests results, the staff has concluded that it is feasible to upgrade existing 1-hour conduit and cable tray Thermo-Lag fire barriers to achieve a nominal 1-hour fire rating. The test results suggest, however, that 3-hour Thermo-Lag fire barriers provide only about 1 hour of fire resistance and that existing baseline 3-hour barriers cannot be reasonably upgraded using additional Thermo-Lag materials to achieve a 3-hour fire rating. The 3M Company test results and licensee plans to pursue hybrid barrier options suggest that hybrid fire barrier systems may provide solutions to some of the Thermo-Lag fire barrier issues, particularly as upgrades for 3-hour Thermo-Lag fire barriers. However, additional fire testing as well as evaluations of the weight (seismic) and ampacity derating aspects of such systems need to be completed before a final determination can be made.

Nuclear Energy Institute Application Guide

As part of the industry program, the NEI is developing guidance for applying the NEI, TVA, and TU Electric test results to plant-specific barrier configurations. By letter of March 4, 1994, the NEI submitted for NRC staff review a draft of the "Industry Application Guide to Evaluate Existing Thermo-Lag Fire Barrier Systems." This guide is intended to provide licensees with a systematic process, supported by fire test data, to evaluate installed Thermo-Lag configurations. The process will help licensees establish the expected fire resistive performance (or worth) of its existing Thermo-Lag fire barriers. According to NEI representatives, the guide will also provide information and data that licensees can use to determine if there is reasonable assurance that the barriers will provide sufficient fire resistance to ensure that one train of safe shutdown systems will remain free of fire damage.

The staff discussed the guide with NEI representatives during a public meeting on March 16, 1994. At this meeting the NRC staff expressed concerns about the technical basis for the NEI fire barrier acceptance criteria and the evaluation methodology proposed by the NEI for generic application. The application guide did not address ampacity derating or cable functionality evaluations for test assemblies that deviated from the acceptance criteria in GL 86-10, Supplement 1. By letter of April 7, 1994, the staff transmitted to the NEI its comments and questions on the draft application guide. In summary, the staff noted that the application guide is limited in that it does not clearly identify fire barrier designs that can fully perform the 1- and 3-hour fire resistive functions prescribed by current NRC fire protection requirements. The staff also requested information on (1) the NEI acceptance criteria for determining the fire rating of a barrier, (2) the bounding criteria for evaluating installed fire barrier configurations that were not fire tested, (3) the level of detail describing these configurations, and (4) the discussion of other alternatives that can be used by licensees to resolve the Thermo-Lag issue.

PERFORMANCE-BASED FIRE PROTECTION

Plant-Specific Approaches

The staff first learned of industry interest in applying performance-based approaches to addressing Thermo-Lag issues during a NUMARC-industry Thermo-Lag workshop on July 19, 1993. At the workshop, representatives of NUMARC and Gulf States Utilities discussed proposals for applying the PSA methodology to Thermo-Lag issues. The presenters estimated that, based on a PSA, only 5 to 10 percent of existing Thermo-Lag applications would need to be brought into full compliance with the NRC fire barrier requirements to provide reasonable assurance of safe shutdown capability in the event of a fire. Later (in response to the request for additional information discussed in Enclosure 1), the licensees for 21 plants stated that they intend to justify existing Thermo-Lag configurations by applying performance-based approaches that involve fire modeling and probabilistic risk and safety assessment techniques.

By letter of January 12, 1994, Florida Power and Light (FPL) submitted an outline of the performance-based approach that it proposes to use to resolve the Thermo-Lag issue at its Turkey Point and St. Lucie facilities. The staff met with FPL on March 10, 1994 and April 14, 1994, to discuss the proposal. The proposed approach is an integrated one that includes a traditional fire hazard evaluation based on combustible loading (the screening methodology), a performance-based fire growth assessment that uses a FPL-developed fire model, and a confirmatory risk assessment that uses a plant-specific PSA. If the postulated fire hazards assessment (screening) indicates that the fire severity for the area is less than one-half of the fire rating of the Thermo-Lag fire barrier installed in the area, then FPL considers that the barrier configurations provide an adequate level of fire safety for the area. For plant areas that do not meet the screening criteria, the fire model will be used to determine, on a more sophisticated level, whether or not a postulated fire could challenge the existing fire barriers. If so, FPL would upgrade the barriers in the area or take some other corrective action, such as installing an automatic fire suppression system, to provide an adequate level of fire safety. To provide further assurance that the barriers will provide adequate fire safety, FPL will perform a PSA for each area and assess the potential impact of the fire severity and actual fire barrier ratings on core damage frequency (CDF). FPL also proposed to reevaluate the Thermo-Lag fire barriers located in outdoor areas at Turkey Point. (Turkey Point is the only nuclear power plant with Thermo-Lag barriers installed in outdoor areas.) Where the barriers are located more than 50 feet from in situ fire hazards, FPL proposes to reduce the required fire rating of barriers from 1-hour to $\frac{1}{2}$ -hour. FPL submitted additional details of its proposed approach for staff review with a letter of April 29, 1994.

By letter of March 3, 1994, Florida Power Corporation (FPC) notified the NRC of their intention to use an alternate, performance-based approach in meeting adequate separation requirements for its Crystal River facility. In a letter of April 6, 1994, the NRC staff advised FPC to coordinate its efforts with the NEI petition for rulemaking (discussed below) and to consider options that do not involve rulemaking or exemptions to resolve the Thermo-Lag issue at Crystal River.

Generic (NEI) Approach

During a meeting on April 8, 1994, NEI representatives presented a general overview of a potential new strategy for resolving the Thermo-Lag issues. The strategy is a work-in-process of the NEI executive level working group on fire protection. Although the NEI did not specifically characterize its approach as performance-based, it contains elements common to typical performance-based approaches. The proposed process includes a number of paths that the NEI believes are available to licensees to reach compliance with NRC requirements for fire barriers. According to the NEI, the licensee should first determine whether or not an installed fire barrier is required by reevaluating the plant safe shutdown analysis, fire hazards analysis, fire modelling, and Individual Plant External Event Evaluation (IPEEE). If the licensee determines, or has already determined independently, that the fire barrier is required, the licensee would evaluate the fire barrier using the NEI application guide. If the fire test results in the application guide apply to the barrier and the installed configuration is acceptable, then the barrier is considered to meet Appendix R requirements. If the installed configuration is not acceptable, the licensee may choose from a range of options which include: modifications such as upgrading Thermo-Lag or removing and replacing it with alternate material; enhancing the fire protection defense-in-depth; or requesting an exemption. If the test results do not apply to the barrier, the proposed process suggests that engineering evaluations or fire tests be performed to justify the barriers.

During the meeting, the NEI representatives stated that its work on this approach was preliminary. The approach has performance-based elements that appear to be similar to those of the plant-specific approaches the staff is aware of. However, on the basis of the preliminary nature of the proposal, the staff cannot offer technical judgments on the approach at this time. During the NEI Thermo-Lag Workshop on April 20, 1994, representatives of NEI presented the proposed approach to industry. The level of detail of the presentation was about the same as that provided to the staff on April 8, 1994. The next senior management meeting is scheduled for May 19, 1994. The NEI will provide additional information during the meeting.

Generic (Rulemaking) Approach

In SECY-94-090, "Institutionalization of Continuing Program for Regulatory Improvement," of March 31, 1994, the staff provided the plan of action and framework for developing a performance-oriented and risk-based fire protection regulation through rulemaking. This rulemaking initiative, which is also identified in the Fire Protection Task Action Plan, stemmed from the periodic review of regulations and elimination of requirements marginal to safety (see SECY-92-263 of July 24, 1994). The staff is continuing with this effort in accordance with SECY-94-090 independent of the resolution of the Thermo-Lag issues.

The staff will provide additional information on its assessment of performance-based approaches in a separate paper.

COMBUSTIBILITY OF THERMO-LAG

Section III.G.2. of Appendix R provides three options for ensuring that one redundant train is free of fire damage in areas inside and outside of primary containment. Inside non-inerted primary containments, redundant trains can be separated by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards or by a noncombustible radiant energy shield. Outside primary containments, redundant trains can be separated by a horizontal distance of more than 20 feet with no intervening combustibles or fire hazards when fire detectors and an automatic fire suppression system are installed in the fire area. The Standard Review Plan defines noncombustible material, in part, as a material which in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

The responses to the 10 CFR 50.54(f) RAI, show that 18 units use Thermo-Lag as a radiant energy heat shield and one unit (WNP-2) uses Thermo-Lag to separate intervening combustibles.

During Thermo-Lag fire endurance tests the staff observed that the Thermo-Lag material ignites inside the ASTM E-119 test furnace within a few minutes of exposure to the test fire. The barrier material burns throughout the fire test and continues to burn after it is removed from the furnace. As part of its review of Thermo-Lag properties, the staff had NIST conduct the following combustibility tests: (1) ASTM E-136, "Standard Test Method for Behavior of Material in a Vertical Tube Furnace at 750 °C," and (2) ASTM E-1354, "Standard Test Method for Heat and Visible Smoke Release for Materials and Products Using an Oxygen Consumption Calorimeter." IN 92-82, "Results of Thermo-Lag 330-1 Combustibility Testing," informed the licensees of the test results.

IN 92-82 stated that on the basis of the ASTM E-136 tests, Thermo-Lag 330-1 material is combustible. IN 92-82 also stated that, on the basis of the results of the ASTM E-1354 tests, the peak and total heat release rates for Thermo-Lag exceeded those for gypsum wallboard and were about equal to those of fire-retardant plywood. The IN transmitted these results to licensees to consider the impact of using Thermo-Lag to enclose intervening combustibles to achieve a horizontal separation of 20 feet between redundant safe shutdown trains and to consider the impact of using Thermo-Lag inside noninerted primary containment as a noncombustible radiant energy shield.

The NEI developed the "Thermo-Lag 330-1 Combustibility Evaluation Methodology Plant Screening Guide." In the guide, the NEI responded to IN 92-82 and took the position that the ASTM E-136 test is a severe test protocol that is not fully representative of fire conditions in most areas of a nuclear power plant. The guide states that the ignition temperature of Thermo-Lag is approximately 1000 °F based on ASTM D-1929, "Standard Method of Tests of Ignition Properties of Plastic," and the minimum radiant flux for ignition is greater than 25 kW/m². On these bases, the NEI concluded that Thermo-Lag should be treated as a combustible only under selected applications as derived through application of the NEI screening method.

The staff is reviewing the NEI screening guide assisted by NIST. Resolution of the issue concerning the combustibility of Thermo-Lag and its use as a radiant energy shield and to separate intervening combustibles is being pursued in parallel with the effort addressing electrical raceways. The staff will inform the Commission of the results of its review.