UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
799 ROOSEVELT ROAD
GLEN ELLYN, ILLINOIS 60137

FEB 18 1992

MEMORANDUM FOR: Kent E. Walker, Chairman, TSI Investigative Task Force, OIG

THRU: Eugene T. Pawlik, Vice Chairman, TSI Investigation Task Force, OI:RIII

FROM: Joseph M. Ulie, Reactor Inspector, TSI Investigative Task Force Member, OI:RIII

SUBJECT: REPORT ON TECHNICAL ISSUES RELATED TO THE THERMO-LAG FIRE BARRIER SYSTEM

On February 4, 1992, members of the Thermal Science, Inc. (TSI) Investigative Task Force conducted investigative interviews relative to the Thermo-Lag 330-1 Fire Barrier System. During these interviews, the task force members were provided information that raised new concerns on two facilities regarding their (Washington Nuclear Project, Unit 2 (WNP2) and Comanche Peak) compliance with 10 CFR Part 50, Appendix R. In addition, other technical concerns were raised during an investigative task force visit to WNP2. The concerns identified during the investigative task force visit were discussed with Mr. John Hanson while onsite and again on February 18, 1992, during a telecon discussions between Mr. Hanson and myself. I emphasized to Mr. Hanson that fire barrier configurations found to be inoperable require interim action in accordance with plant technical specifications or administrative procedures, as applicable. These concerns are described below:

Washington Nuclear Project, Unit 2

During an investigative interview, task force members were informed that WNP2 Thermo-Lag Fire Barrier System configurations deviated from the TSI manual, "TSI Technical Note 20684, Thermo-Lag 330 Fire Barrier System Installation Procedures Manual - Power Generating Plant Applications." The task force members were told that according to the TSI installation procedure, the prefabricated panels were to cover all four sides of the cable tray. However, the task force members were informed that in the cable spreading room, the top portion of certain cable tray panel configurations were not always installed but that the uncovered tray areas had been filled with trowelable grade Thermo-Lag material to 1/2 inch above the top of the tray cables. This included a cable tray designated Division 2, which WNP2 has designated as the division to be protected by a fire barrier. The task force members were informed that the cable tray loading varied and the cable trays could have been filled with

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Thermo-Lag material that exceeded the 1/2 inch thickness. The cable tray loading may include power cables, which would have ampacity derating considerations potentially not evaluated by WNP2. The task force members were concerned that excessive amounts of Thermo-Lag material may adversely affect the seismic and cable ampacity derating factors used by the licensee for cable trays that are less conservative than had been previously calculated. The cable ampacity derating issue has particular importance since the licensee had previously informed the NRR Technical Task Force (reference memo dated December 11, 1991, L. Plisco/S. West to F. Miraglia, "Fact Finding Visit to Washington Nuclear Project, Unit 2") that the WNP2 design does not include sufficient margin to accept additional cable derating without adversely effecting cable performance.

While onsite at WNP2 on February 6, 1992, the task force members observed Thermo-Lag protected cable trays that were covered in the top portion of the trays with trowelable grade, spray-on or roll on Thermo-Lag materials. These cable trays were located in the cable spreading room. Without a destructive test or further review of licensee documentation, the task force members were unable to determine the adequacy of the material thickness but believe further review is necessary.

In addition, other Thermo-Lag protected cables in cable trays considered intervening combustibles (cable jackets) were also covered with the Thermo-Lag trowel grade, spray-on or roll on material. As noted above, excessive amounts of Thermo-Lag material may adversely affect the seismic and cable ampacity derating factors previously calculated. These issues need to be reviewed by appropriate NRC staff.

In another instance, the task force members were informed of Thermo-Lag installers deviating from the TSI installation procedure for the three-hour Thermo-Lag fire barrier system. It was described that the installers placed scrap Thermo-Lag panels of various sizes on top of pre-installed cable tray one-hour fire barrier panels, then troweled around the scrap material and covered the entire assembly with an additional layer of stress skin. The task force members were told that this occurred in locations where multiple cable trays were grouped in a vertical configuration near each other. The task force members were concerned that the above described as-built fire barrier configurations were not substantiated by either fire test or engineering analysis.

During the WNP2 site visit, a Thermo-Lag Fire Barrier System installer involved in constructing Thermo-Lag fire barrier assemblies during plant construction was questioned about the above claim. The installer indicated that approximately 1' X 3'

scrap Thermo-Lag Fire Barrier System prefabricated panel pieces were pre-buttered and installed on top of pre-existing one-hour fire barrier panels to complete the construction of three-hour fire barrier systems. However, he commented that he was not aware of any smaller scrap Thermo-Lag pieces being used to complete fire barrier installations.

In addition, other technical concerns were observed during the WNP2 site visit that included the following:

- On the 572' elevation of the reactor building, structural steel supports that support Thermo-Lag fire barrier systems were unprotected, and therefore, exposed to a fire. In a TSI letter of October 5, 1991 to the NRC (Page 5), the vendor specified that all structural steel supports forming a part or supporting the Thermo-Lag 330 Fire Barrier System should be protected to provide fire resistance equivalent to that required by the barrier.

- "V" stiffener ribs on one-hour prefabricated panels located in the cable spreading room were observed to be oriented in the perpendicular and parallel directions along the bottom section of the cable trays. TSI Technical Note 20684 installation procedure fails to address this detail. However, the NRR Technical Task Force identified that the Comanche Peak installation specification required the prefabricated panel "V" stiffener ribs be oriented perpendicular to the cable tray on the top section to prevent sagging, and parallel with the tray on the bottom section (Reference: L. Plisco/S. West memo to F. Miraglia dated December 24, 1991 (Page 8), "Fact Finding Visit to Comanche Peak, Unit 1"). In addition, the Thermo-Lag Fire Barrier System installer interviewed on February 6, 1992, also confirmed that the "V" stiffener ribs were suppose to be perpendicular to the cable tray for the top Thermo-Lag panel.

- Stress skin and "V" stiffener ribs on one-hour prefabricated panels also located in the cable spreading room were found on the outside rather than on the inside. Sections I.B.I(a) and II.1.1.2 of TSI's Technical Note 20684, Revision V, specifies that stress skin shall be on the inside. With regard to the "V" stiffener ribs, as mentioned above, the TSI installation procedure does not address this detail; however, information learned from the above mentioned Thermo-Lag material installer during the WNP2 visit indicated that the ribs were supposed to be installed on the inside of the fire barrier.

Comanche Peak

During an investigative interview, the task force members were informed about a TSI Flexi-Blanket thermal barrier material being used to satisfy NRC fire protection requirements that was not known whether fire test data or adequate engineering analysis existed to support as-built configurations. These fire barrier configurations were described as Flexi-Blanket material wrapping groups of cable trays and cabling in various locations of the plant. No further specific information was attainable during the interview.

I recommend these issues be transmitted to Frank Miraglia, Deputy Director, Office of Nuclear Reactor Regulation, for his referral to the appropriate NRC review organization.

ORGANIZATION:	THERMAL SCIENCE, INCORPORATED ST. LOUIS, MISSOURI
REPORT NO.:	99901226/91-01
CORRESPONDENCE ADDRESS:	Mr. Rubin Feldman, President Thermal Science, Incorporated 2200 Cassens Drive St. Louis, Missouri 63026
ORGANIZATIONAL CONTACT:	Mr. Rubin Feldman, President (314) 349-1233
NUCLEAR INDUSTRY ACTIVITY:	Thermo-Lag fire barrier materials and related installation training services
INSPECTION CONDUCTED:	December 16-20, 1991

SIGNED: R C Wilson — 3/6/92

Richard C. Wilson, Team Leader — Date
Reactive Inspection Section No. 2
Vendor Inspection Branch (VIB)

OTHER INSPECTORS: Randolph N. Moist, VIB

APPROVED: for Gregory C Cwalina — 3/6/92

Chris A. VanDenburgh, Chief — Date
Reactive Inspection Section No. 2
Vendor Inspection Branch

INSPECTION BASES:	10 CFR Part 21, 10 CFR Part 50, Appendix B and 10 CFR Part 50.48
INSPECTION SCOPE:	To review Thermal Science, Inc.'s program for supplying Thermo-Lag fire barrier materials and related services for fire protection applications in nuclear power plants
PLANT SITE APPLICABILITY:	Numerous.

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1 INSPECTION SUMMARY

1.1 Nonconformances

1.1.1 Nonconformance 91-01-01 (Open)

Contrary to Criterion V, "Instructions, Procedures, and Drawings," of 10 CFR Part 50, Appendix B, Thermal Science, Inc.'s (TSI's) documented instructions and procedures used for NRC licensee purchase orders invoking 10 CFR Part 50, Appendix B, did not require maximum weight and minimum thickness measurements of prefabricated panels and conduit sections during final inspection (Nonconformance 91-01-01. See Section 3.3 of this report).

1.1.2 Nonconformance 91-01-02 (Open)

Contrary to Criterion V, "Instructions, Procedures, and Drawings," of 10 CFR Part 50, Appendix B, TSI failed to comply with its documented instructions and procedures when conducting tests intended to qualify fire barriers for commercial nuclear power plants. (Nonconformance 91-01-02. See sections 3.4, 3.5, 3.7, and 3.8 of this report.)

2 STATUS OF PREVIOUS INSPECTION FINDINGS

The NRC had not previously inspected TSI.

3 INSPECTION FINDINGS AND OTHER COMMENTS

3.1 Entrance and Exit Meetings

In the entrance meeting on December 16, 1991, the NRC inspectors discussed the scope of the inspection, outlined areas of concern, and established interfaces with TSI's management and staff. In the exit meeting on December 20, 1991, the inspectors discussed their findings and concerns with TSI's management and staff.

3.2 Inspection Scope

TSI manufactures Thermo-Lag patented heat blocking and fire retardant materials. Major applications include aerospace, oil drilling, commercial nuclear reactors, and tank cars. TSI employs between 50 and 100 personnel in a 60,000 square foot building. Commercial nuclear power plant sales grew to about half of TSI's business in the mid-1980s, and have declined to a very low current level. Only the Thermo-Lag 330 product line is supplied for commercial nuclear plants, usually in the form of panels or pre-cast conduit sleeves and trowelable mastic. TSI performs on-site training and certification of installation personnel provided by the licensees. TSI also supplies fire

endurance qualification and ampacity derating test reports, and installation procedures manuals.

The NRC inspectors reviewed TSI's program for supplying Thermo-Lag 330 materials and related services both generically and against the requirements of numerous licensee purchase orders. The inspection was restricted to documents and personnel at TSI, and the inspectors did not review any site documents.

3.3 Manufacturing Process

TSI mixes Thermo-Lag 330 material in batches of 20,000 pounds maximum, with 10,000 pounds typical. Material is mixed for specific orders, rather than to maintain an inventory. Tests performed on each batch of material include a drop test and a mandrel bend test which verifies that a thin sample is essentially cured within 72 hours at 77°F and 50 percent humidity. The bulk material is loaded into drums or five gallon pails labeled with batch tickets that are coded to show constituent materials. TSI either ships the containers of material to a plant site, or uses them to fabricate flat panels or preshaped conduit sections.

The panels are cured in a large oven at 120 to 180°F for 15 to 30 days, based on in-process moisture measurements. The measurements are performed on a sample of panels using TSI Test Procedure A-29, Revision 0. A moisture content of less than ten percent is required. Although the procedure's purpose states that it applies to panel coatings, TSI's QC manager stated that it is used for Thermo-Lag 330 panels. Numerous thickness measurements are made after drying and before final QA acceptance testing. High and low spots are corrected.

Minimum thickness limits for panels and conduit sections are 0.500 inch for a one hour fire rated panel and 1.000 inch for a three hour fire rated panel. These thicknesses are intended to provide the minimum mass of material necessary to ensure the fire rating of the panel. Maximum thickness is not usually specified in Purchase Orders (POs) and is not usually certified, even though an overly thick section could affect ampacity deratings. TSI provides customers a weight sheet dated June 7, 1986, with guaranteed maximum weights for prefabricated conduit and panel sections that can be used by the customer for seismic calculations (such as cable tray hanger load). The maximum weights for flat panels are 3.5 lb/ft^2 for a one hour panel and 7.0 lb/ft^2 for a three hour panel. Minimum weights are not guaranteed.

Thickness is verified using TSI Test Procedure A-33, Revision 0, which specifies 18 measurements per panel. Weight is verified using an unnumbered TSI test procedure titled "Panel Weight Determination." Even though TSI performed thickness and weight

measurements to TSI test procedures, the NRC inspectors found no procedure requiring performance of the measurements. TSI's president and QC manager stated that they were not aware of any TSI procedure that required that thickness and weight measurements be performed. These values are important to safety because thin sections may not provide assured fire barrier capability, and overweight sections could exceed cable tray and conduit support capabilities. Criterion V of 10 CFR Part 50, Appendix B requires that activities affecting quality be prescribed by documented instructions or procedures. For safety-related procurements, TSI's failure to specify a requirement for performing thickness and weight measurements is designated as Nonconformance 91-01-01.

TSI's inspector signs off on the maximum weight and minimum thickness verifications on a form titled, "Thermo Lag Prefabricated Panel Q C Form." The material batch number and stress skin lot number are written on the panels and on tags attached to the panel stress skins.

The NRC inspectors reviewed shipping invoice No. 18802 under Texas Utilities (TU) Generating Co. Purchase Order (PO) No. 665-71871, Supplement 10, dated December 7, 1989, for Thermo-Lag prefabricated panels without the normal stiffener ribs. TSI personnel stated that panels without the ribs are intended for use only when attached to steel structural supports in the plant, where the stiffening capability of the ribs is not needed. No records of other shipments of panels without ribs were observed by the inspectors.

The NRC inspectors asked about a "cure accelerator." The QA manager advised that an accelerator is available which promotes early mechanical setup and is useful in cold weather. The accelerator actually does not affect drying or curing. Like the Thermo-Lag 330 materials, it is water-based. TSI does not use the accelerator in poured panels, but it can be used in spray or trowel applications and has been provided to customers. TSI's QA manager stated that an Underwriters Laboratories Inc. (UL) fire test showed that the accelerator has no adverse effects. TSI stated that UL fire tests also showed no problems with the topcoat material that TSI provides for weather resistance. The NRC inspectors did not review the UL test reports or form any conclusions regarding the use or effects of the accelerator.

The NRC inspectors asked how the six month shelf life is established for bulk Thermo-Lag 330 material in containers. TSI's QC manager stated that the bulk material's shelf life starts on the day the material is shipped to the customer. The policy is to not manufacture any material with shelf life limitations until a customer order is received. TSI can perform thermogravimetric analysis on samples returned by customers to determine if the material is still usable, because the subliming material has a

relatively low volatility temperature. TSI's Bills of Lading specify that bulk material must be stored above 32°F and below 100°F at all times, and shipments are accompanied by a pail containing a temperature recorder.

The NRC inspectors showed TSI's QA manager paragraph 6.6.6 of TU's Comanche Peak nuclear plant procedure ECC 10.07, Revision 3, dated March 5, 1989, regarding the plant's criteria for repair of surface cracks or pinholes in prefabricated panels. The only criterion listed was for the width of the defect, with no repair required for less than 0.050 inch. Surface patching was specified for larger cracks or holes. There were no depth or length criteria. TSI's QA manager could not provide a basis for this procedure. He indicated that the paragraph needed more context to be meaningful, including the definitions for surface cracks and pinholes. The inspectors did not pursue this matter further.

3.4 Quality Assurance Program

TSI'S Nuclear Quality Assurance (QA) Program Manual, Revision X, dated January 12, 1987, governed its 10 CFR Part 50, Appendix B, quality assurance program. TSI Quality Control Operating Procedures Manual, Revision X, dated September 22, 1986, implemented and supported the Nuclear Quality Assurance Program Manual. The implementing procedures controlled activities affecting quality during raw materials receiving inspection and the manufacture of the Thermo-Lag 330 materials.

TSI has applied its Nuclear QA program to all Thermo-Lag 330 materials shipped to commercial nuclear power plants, regardless of what QA requirements were specified in the PO or whether the procurement was by the licensee or by another party. TSI personnel stated that the principal improvements related to the nuclear QA program are care of manufacture, records, traceability, and material purity. Although TSI's procedures make provision for procuring raw materials in accordance with 10 CFR Part 50, Appendix B, TSI personnel stated that all of their procurements have been commercial grade.

The NRC inspectors verified the implementation of TSI's QA program by reviewing selected criteria from 10 CFR Part 50, Appendix B, including nonconforming materials, identification and control of materials, handling, storage and shipping of materials, control of measuring and test equipment, and control of purchased materials. TSI did not manufacture any Thermo-Lag 330 materials during this inspection.

To verify traceability, the NRC inspectors selected batch numbers from TSI Certificates of Conformance (COCs) for selected materials (Thermo-Lag bulk material, prefabricated panels and conduit sections) that were shipped to commercial nuclear power plants. The NRC inspectors traced the batch numbers back to the batch

mixes, including the lot numbers of the raw materials used. The NRC inspectors concluded that TSI had adequate quality control records and procedures for demonstrating the traceability of raw materials purchased from suppliers used in manufacturing Thermo-Lag 330 material.

The NRC inspectors selected measuring and test equipment that TSI used to verify the adequacy of the purchased raw materials, batch samples, and finished prefabricated panels (fire endurance test instruments were not reviewed, except as noted in the next paragraph). The inspectors concluded that TSI's calibration program, QC records, and procedures were adequate to perform and document the testing. In addition, the NRC inspectors verified that the calibration of measuring and test equipment was traceable to the National Institute of Standards and Technology.

The NRC inspectors briefly addressed the calibration of thermocouples used in American Society for Testing and Materials (ASTM) Standard E 119 fire endurance type qualification tests. The thermocouples that monitor specimen temperature are replaced with each specimen, and new units are obtained with current supplier calibrations. However, the thermocouples that monitor furnace temperatures are never calibrated after installation and TSI has no procedure specifying calibration. Since these chromelalumel thermocouples are exposed to flames reaching about 2000°F and remain in the furnaces for years, their ability to maintain calibration is questionable. Criterion V of 10 CFR Part 50, Appendix B requires that activities affecting quality be prescribed by documented instructions or procedures. TSI's failure to maintain calibration of the furnace thermocouples forms a portion of Nonconformance 91-01-02.

The NRC inspectors asked how TSI controls the calibration of its test and measuring equipment at nuclear power stations. The QC manager indicated that TSI has no inspection function or acceptance function at any site; therefore, any TSI test and measuring equipment at a site is not under TSI calibration control.

The NRC inspectors verified that TSI had a nonconformance program in place. In addition, the NRC inspectors reviewed several nonconformance notices and verified that TSI closed the notices on a timely basis and took adequate corrective actions.

The NRC inspectors verified that TSI had 10 CFR Part 21 procedures in place and met the posting requirements of 10 CFR Part 21. No notifications had been submitted to TSI's clients. Within the scope reviewed the inspectors did not identify any concerns with TSI's program for satisfying 10 CFR Part 21.

TSI's QA manager stated that about one dozen licensees had audited TSI's QA program. The NRC inspectors reviewed records

of audits that TU performed at TSI between 1982 and 1989. TU's audits did not identify any major concerns with TSI's QA program.

TSI had not audited its material suppliers. TSI obtains commercial COCs and performs infrared spectroscopic analyses on all lots of material purchased for Thermo-Lag 330 use. The NRC inspectors verified that TSI had receiving records, QC reports, and COCs for the lot numbers selected for subliming powder and stress skin procurements. In addition, the NRC inspectors verified that a certified material test report from the mill was in the data package for the lot number selected for the stress skin.

Based on the observations reported above and the file review of POs for six commercial nuclear power plant sites, the NRC inspectors concluded that TSI's QA program for supplying Thermo-Lag 330 material was adequate with the exception of the two nonconformances cited in this inspection report.

3.5 Customer Purchase Order (PO) Requirements

This section of the inspection report addresses PO contractual requirements on TSI as observed by the NRC inspectors, with the exception of the on-site support requirements discussed in the next section. The content of TSI's Certificates of Conformance is also addressed.

The NRC inspectors reviewed records for all of the POs in TSI's files for Thermo-Lag 330 material for the following six commercial nuclear power plant sites:

Callaway Nuclear Power Generating Plant
Comanche Peak Steam Electric Station
Perry Nuclear Power Plant
River Bend Station
Susquehanna Steam Electric Station
Washington Nuclear Project, Unit-2 (WNP-2)

Site selection was based primarily on Thermo-Lag site problems reported in NRC Inspection Reports, NRC Information Notices and Licensee Event Reports. The inspectors were also interested in whether different PO QA criteria affected what TSI supplied, and had asked TSI to prepare a list of plants that specified various criteria including 10 CFR Part 50, Appendix B. TSI was unable to complete the list by the end of the inspection, partly because a typical plant file included either numerous POs or numerous PO change orders.

3.5.1 Commercial Grade PO Requirements

Procurements for the listed plants began between 1981 and 1984. For four plants (all except Comanche Peak and WNP-2) the initial procurements were by the architect-engineer or another contractor

to the licensee. By the mid-to-late 1980s all six licensees were procuring directly from TSI. All of the procurements were commercial grade except for Comanche Peak, where all of the POs reviewed (except those for on-site services) invoked 10 CFR Part 50, Appendix B.

The typical PO covered both bulk material and prefabricated panels and conduit sections. Certification that the materials meet specified criteria, including TSI's QA/QC program, was often required. Material certifications are of limited value because the qualification type tests covered fabricated installation designs, not generic materials or the prefabricated panels and conduit sections supplied by TSI. Other criteria that some POs specified are identified below in the COC discussion.

The Callaway nuclear plant provided an example of a requirement for material certification. Daniel PO No. 7186-NS-87593, dated February 7, 1984, invoked Bechtel Specification No. 10466-E-097, "Technical Specification for Furnishing and Installation of Fire Barrier Materials for the Standardized Nuclear Unit Power Plant System (SNUPPS)," Revision 0, dated October 11, 1983. Section 4.1.b of the specification required the following: "Manufacturer's certification showing material has been tested and is qualified for use as 1-hour and 3-hour rated barriers by the applicable standards or codes."

The NRC inspectors also obtained a copy of a February 7, 1984, letter to Daniel from TSI's national sales manager which stated: "This will advise you that TSI's THERMO-LAG 330 Fire Barrier Materials Systems meets [sic] all the prerequisites delineated in the reference specification." The NRC inspectors also noted that the PO invoked no QA requirements on TSI (except repetition of the cited requirement to submit material certification), and that TSI's COC merely certified that the materials "meet TSI's manufacturing and written quality control specifications."

The inspectors reviewed Stone & Webster Engineering Corp. (S&W) PO No. 12210-30454, dated September 24, 1984, for the River Bend Station. The technical and QA requirements were specified per S&W Nonengineered Item Data Sheet 211.161, which described the materials and specified thickness ranges for prefabricated panels. One hour panels and shapes were to be 1/2 inch -0.00, +0.125 inch and three hour to be 1 inch -0.00, +0.250 inch. The NRC inspectors observed a TSI COC dated March 14, 1985, which certified only a 1.00 inch minimum thickness for a three hour panel.

2.5.2 Comanche Peak 10 CFR Part 50, Appendix B PO Requirements

The NRC inspectors found that POs for TU (the licensee for Comanche Peak) appeared to impose two types of additional requirements on TSI beyond the scope of the typical PO. First, TU's PO

invoked the safety-related QA requirements of 10 CFR Part 50, Appendix B, on TSI's scope. Second, TU's POs imposed a specification which appeared to impact TSI's responsibilities for the applicability of qualification test reports and installation procedures to the plant installations of Thermo-Lag material.

The NRC inspectors reviewed TU PO No. CPF 1557-S, dated April 19, 1982. The PO and its supplements specified materials and technical assistance services for a Thermo-Lag 330 subliming coating envelope system for the Comanche Peak nuclear power plant. The PO specified that all materials and services must be in strict compliance with TU Specification 2323-MS-38H, "Cable Raceway Fire Barriers," Revision 1, dated April 2, 1982, (prepared by Gibbs and Hill, Inc.) and any subsequent revisions. Although the specification is labeled "Non-Nuclear Safety Related QA Program Applicable," the PO specified that "work performed herein shall be performed as applicable in compliance with T.S.I. Inc.'s nuclear quality assurance program manual" as qualified by the licensee. The PO also specified that "services shall be accomplished in accordance with T.S.I. Inc.'s written quality assurance program conforming to the requirements of ANSI [American National Standards Institute Standard] N45.2 [and] 10CFR50, Appendix B ... as applicable, subject to verification by [TU's] quality assurance department." The PO stated that the provisions of 10 CFR Part 21 may apply.

Specification 2323-MS-38H placed broad requirements on the vendor (and, in some cases, the "vendor/applicator"). Section 3.1.1 defined the vendor/applicator scope to include "the design, furnishing, quality assurance/quality control, and performance testing of all materials and components required for the cable raceway fire barriers." Section 3.3.1 required the vendor to "guarantee the satisfactory material performance, and installation instructions and procedures of all cable raceway fire barrier materials furnished." Section 3.4.1 invoked (without distinguishing between vendor and vendor/applicator) NRC Branch Technical Position APCSP 9.5.1, which included criteria for the design and qualification of fire barriers.

Section 3.7.1.1 of specification 2323-MS-38H required the vendor to "supply documented tests of product performance referencing the materials used, the type of installation and the method of application as a basis for meeting the requirements specified herein." Section 3.10.4 requires submittal for approval of "Certified test results which demonstrate that all fire barrier arrangements have been tested in accordance with the requirements of" the specification. These requirements contribute to the basis for Nonconformance 91-01-02 as defined elsewhere in this inspection report.

TU exercised its contractual right to approve documents, as evidenced by a TU letter to TSI dated June 22, 1989, subject:

"Notification of Document Status" for PO No. 665-71871, which showed general approval of six Industrial Testing Laboratories, Inc. (ITL) test reports; another test report; two TSI Technical Notes regarding thermal and dynamic loads and ampacity rating; and documents titled, "Determination of Chloride, Fluoride, Sodium and Silicate concentrations in Thermo-Lag 330-1 Subliming Coating," and "Summary of Ampacity Derating Tests." The NRC inspectors noted, however, that TU's letter did not address installation procedures or drawings.

By reviewing TU source inspection reports, the NRC inspectors verified that TU exercised its contractual right to perform source inspections prior to shipment, although TU sometimes waived that right. TU's source inspections included verification of thickness and weight measurements.

The NRC inspectors reviewed a November 10, 1989, TSI internal memorandum for PO No. 665-71871 to all quality control and production personnel. TSI's QC and production managers issued the memorandum to implement an agreement between TU and TSI to add additional steps to TSI's inspection program. Specifically, in addition to the normal 18-point thickness inspection of prefabricated panels, the memorandum specified additional thickness checks to be made along the panel edges to identify undesirable compressions. The weight of each prefabricated panel would also be recorded by the QC inspector on his acceptance tag (this was normally a go/no go signoff).

The NRC inspectors found another example of TU invoking Specification 2323-MS-38H. TU's PO No. 8 0029731, dated October 30, 1991, procured safety-related replacement parts from TSI. The PO invoked Pre-Engineered Item Data Sheet # NES0011, which stated in Section 1.2 that "products listed in the purchase order are identical to those products previously tested and supplied in accordance with TU Electric Specification 2323-MS-38H Revision 1."

The NRC inspectors noted that the Comanche Peak site used a Thermo-Lag installation procedure designated as "TU Electric - Generating Division, Engineering and Construction, Construction Department Procedure ECC 10.07, Application of Fire Protection Materials (for example, Revision 3 dated May 5, 1989)." This procedure did not reference any TSI documents, but did reference licensee drawings for Thermo-Lag installation details. Thus, despite the wording of Specification 2323-MS-38H, the NRC inspectors saw no evidence that TU relied upon TSI to guarantee the completeness of TU installation procedures. However, the inspectors did not review site records that might clarify this issue.

3.5.3 Certificates of Conformance (COCs)

The typical COC stated "this will certify that the materials listed above [or below] under purchase order number _____ meet

TSI's manufacturing and written quality control specifications." The COC also listed the materials shipped, showing product type, quantity, and batch or lot number; date; bill of lading number; and truckline. Each COC was signed by TSI's manager of quality control. Many COCs named TSI's QA manual and cited a specific controlled copy that had been issued to the customer. For Comanche Peak only, the COCs generally stated that 10 CFR Part 50, Appendix B and ANSI N45.2 applied.

The NRC inspectors observed numerous variations of the typical COC format. Often the materials were certified as being identical to those that had been qualification-tested (although the tests qualified only specific configurations). Some COCs named specific criterion documents, such as ASTM Standard E 119 and American Nuclear Insurers (ANI) Bulletin 5-79, with words such as, "when used in approved configurations." Additional standards addressed in this manner were ASTM E 84, "Surface Burning Characteristics of Building Materials," ANSI A2-1, and NRC Regulatory Guide (RG) 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel." Some COCs stated that the requirements of the PO were met. Some stated, under "product description," a 1.00 inch minimum thickness for three hour panels.

TSI also provided some Certificates of Analysis. Those observed covered density, pH, and sometimes leachable chloride content for material batches. TSI's QC manager told the NRC inspectors that TSI discontinued chloride analysis of Thermo-Lag material on November 20, 1989, because the leachable chloride limit never approached the 200 ppm limit specified in RG 1.36. Since that date TSI's COCs and COAs have not specified individual batch chloride tests, and TSI now recommends that customers desiring the analysis obtain it from another source.

3.6 On-Site Responsibilities

3.6.1 Discussions with TSI personnel

TSI usually contracts to perform on-site training of installation and quality control personnel provided by the licensee. TSI informed the NRC inspectors that it does not perform, inspect, or approve installation work. Occasionally, as at the WNP-2 and Comanche Peak plants, TSI personnel have been on-site for cumulative periods of more than a year. TSI's QA manager noted that such extended residence was sometimes the result of a licensee ensuring that a TSI representative would be available for training several groups of craftspersons, and that the representative might perform additional duties such as inventory monitoring. In this regard, the NRC inspector noted in the WNP-2 file an inventory list signed by the representative whose living expenses were billed to the licensee over an extended period.

TSI's QA procedures provide for the position of Manager of Field Service Operations, whose responsibility includes "exercising technical control over product application activities at the client nuclear plant site" (procedure NQAP 3-1, section 3.3.3). TSI's QA manager stated that TSI has never had a field service manager.

TSI regards training as a best-effort activity. Although trainees must pass a test, TSI stated that trainee retention is beyond TSI's capability. TSI stated that personnel to be trained are normally experienced in heating, ventilating, and air conditioning (HVAC) installations. Often on newer plants they are the personnel who installed the plant HVAC, penetration seals, and pipe wraps. Although TSI stated that many were journeymen and master craftsmen, TSI does not select the personnel or specify selection criteria.

The documentation of TSI's on-site training is poor. Prior to the inspection TSI provided to the NRC a two-page training outline that contained no installation information, but merely named various applications (such as "prefabricated panel design for junction boxes - installation of one hour fire barrier design"). During the inspection, the TSI QA manager provided a new informal "Applicator Training Program Lesson Plan." In addition to simply naming the applications covered, the new plan also named aspects of each installation (such as "spacing of tie wire, barding and fasteners" and "joint filling and sealing"). TSI still provides no written training documentation covering concerns such as those noted in the following paragraphs. The TSI position is that the customer's installation procedures, supplemented by hands-on training of customer-selected personnel in the general nature of Thermo-Lag 330 installations and the customer's QC inspection of the plant installations, should be sufficient to ensure adequate installation.

TSI routinely supplies customers with TSI Technical Note 20684, "Thermo-Lag 330 Fire Barrier System Installation Procedures Manual - Power Generating Plant Applications." The latest version is Revision V, November 1985. This document, and its predecessors, were approved for insurance purposes by ANI. TSI stated that the document has not been revised since ANI suspended its approval activities. However, as a result of discussions with the NRC a new revision is scheduled for issue by January 31, 1992. Examples of planned additions cited by TSI were specifying curing time, redefining how to seal joints and cut the stress skin, and adding a note to wear goggles.

TSI personnel characterized Technical Note 20684 as a generic document, and frequently referred to it as an application guide. TSI stated that architect-engineers or licensees provided the plant-specific installation manuals. TSI might be asked to comment on a plant-specific manual, and would comment on whether a

configuration had been tested. TSI stressed that this would be an opinion, not a responsibility; even if a similar configuration had been tested, analysis would be required. TSI considers Technical Note 20684 to be accurate, and as complete as necessary when supplemented by training of competent crafts personnel.

The NRC had previously informed TSI that Technical Note 20684 did not cover certain important installation characteristics, such as which side of a panel should be scored or V-grooved for bending, when pre-buttering would be necessary for joints, and the maximum allowable thickness of material. TSI responded that these matters were all covered in hands-on training. During this inspection the inspectors noted a deficiency in Technical Note 20684. The second and third paragraphs of Section 1.0, page II-2, specifies that scored corners and joints of Thermo-Lag panel sections are to be filled with trowel grade material after the panel sections are tied or banded around a cable tray. However, at that stage it would be impossible to fill the seams with trowel-grade material. These types of deficiencies allow plant installation configurations that may not be represented by qualification type test specimens.

3.6.2 PO Requirements for On-Site Responsibilities

The NRC inspectors' review of files for the six plant sites generally supported the position presented by TSI personnel. POs were non-safety related and contained no QA or QC requirements for on-site work; often the PO specified that site procedures would govern. Certain POs for Comanche Peak were particularly limiting, containing statements such as "neither TSI nor the TSI loaned employees were providing engineering services in connection with the work of the loaned employees, and TSI had no responsibility or liability for the installation or design of Thermo-Lag material." Some POs specified additional requirements for on-site assistance by TSI, as described below.

For Comanche Peak, TU PO No. CPF 1557-S, dated April 19, 1982, and its supplements specified both materials and technical assistance. The PO specified compliance with Gibbs and Hill Co. Specification 2323-MS-38H, "Cable Raceway Fire Barriers," Non-Nuclear Safety Related, Revision 1, dated April 2, 1982, and any subsequent revisions. Paragraph 3.3.1 required the vendor to guarantee satisfactory material performance and installation instructions and procedures for all cable raceway fire barrier materials. Paragraph 3.10.4 required the vendor to submit drawings, documents, and procedures with its proposal, for approval.

For WNP-2, PO No. 37115 dated July 28, 1982, specified training services. It also required that the TSI technical service representatives "shall assure the raceways coated with Thermo-Lag meet the requirements as previously tested (sample articles) by TSI Inc." It also specified TSI support of the owner's commitments

to ANI with respect to the use of Thermo-Lag materials, and that daily working direction would be provided by the owner's construction manager. There were no QA or QC requirements.

Also for WNP-2, Contract No. C20610, as proposed to TSI in 1986, required TSI "corporate approval of specific configurations of Thermo-Lag application to steel penetrating the fire barrier to assure compliance with tested configurations" and to "perform regular inspections of installation and provide Certificates of Conformance to 'three-hour' fire protection requirements at the completion of installation." TSI's June 10, 1986, letter to WPPSS took the following exceptions: "TSI is not an approving authority for Nuclear Power Generating Plants. TSI will provide, however, a Certificate of Conformance, when required, with regard to compliance of the installed configurations with those previously tested" and "Regular inspections of the installation can be provided by our field service engineer while onsite at WPPSS. A Certificate of Conformance can also be provided to the test configurations following procedures delineated in TSI's Quality Assurance/Quality Control Operating Procedures Manual. After the completion of the installation, additional inspections can also be arranged in accordance with a mutually agreeable schedule and at our standard Field Service Engineering rates." WPPSS's letter to TSI dated June 13, 1986, transmitted an executed original of the contract, and stated that the TSI exceptions were acceptable and TSI's letter would be retained in the contract file along with the unmodified contract. These WNP-2 provisions, if implemented, appear to comprise limited exceptions to TSI's general policy limiting on-site support.

For Susquehanna, Contract No. 8856-F-56718, dated October 15, 1981, specified that a TSI field service representative would be required on-site for approximately 12 weeks. Schedule A to Technical Services Agreement 8856-FTSA-22, dated November 12, 1981, specified that TSI must "provide all necessary technical and professional services required to support and document the installation of" TSI's Thermo-Lag 330 subliming coating system on electrical raceways in accordance with Bechtel Technical Specification 8856-E-E61, Revision 1, dated November 12, 1981. Schedule A also required TSI to furnish "all personnel and test equipment necessary to document and monitor the application of T.S.I., Inc.'s QA/QC program and application procedures." The NRC inspectors noted that Section D.1.(b) of Schedule A identified TSI's QA program manual as the "application procedures." The only QA requirements were for TSI's program.

TSI's QA manager stated that TSI did not supervise or perform any quality control functions or installation at Susquehanna. The NRC inspectors found only one invoice, Number FS-104 dated November 16, 1981, for field services; the span was 12 days. Although the invoice did not indicate what services were provided, TSI's QA manager stated that the service was limited to training on

setting up spray equipment and on the proper method of spraying Thermo-Lag on stress skin. The contract also stated under the warranty clause that the buyer assumed all responsibility and risks for proper application, safety, and use of the material. Based on this information, the NRC inspectors concluded that TSI's role at the Susquehanna site appeared to be limited to non-safety related training services.

For Callaway, PO No. 7186-NS-87593, dated February 7, 1984, from Daniel International Corp. specified field services, with no QA or QC requirements. Daniel was the construction contractor, although documents indicated that Thermo-Lag installation was actually performed by Owen-Corning Fiberglas Corp., Power and Process Contracting Services. TSI furnished an installation procedure, TSI Technical Note 11266 titled "Installation Procedures for the 'Ready Access Designs' of the Thermo-Lag 330-1 Subliming Fire Barrier Systems" to Union Electric Co. (the licensee) as a guide for use in installing Thermo-Lag materials at the Callaway plant. Bechtel (the architect-engineer) personnel changed the TSI Technical Note number from 11266 to C-1001 and made numerous pen and ink changes in the procedure. Daniel Field Change Request (FCR) No. 2FC-3247-E, incorporated a marked copy of the technical note which had been reviewed and signed by TSI's QA manager on March 19, 1984. Bechtel indicated their review and approval on March 20, 1984, by initialing the changes in the application guide and the approval block of the FCR. TSI's QA manager stated that TSI's role in producing this plant-specific installation manual remained advisory, and TSI did not assume responsibility for the manual's application, as described above.

Based on the file reviews and discussions with TSI personnel reported above, the NRC inspectors concluded that TSI appeared to satisfy its contractual requirements for on-site support at the commercial nuclear power plants reviewed during the inspection. However, the support actually provided, as described by TSI, essentially placed full installation responsibility on the licensee and its contractors. TSI clearly resisted customer attempts to increase TSI's role.

TSI's installation guide lacked considerable detail necessary for installation; TSI stated that it accepted only an advisory role in applying qualification tests to plant installations; the content of training provided by TSI was not documented; TSI had no prerequisites for the selection of installation or site inspection personnel; and TSI did not appear to be involved in determining if the inspection personnel received any training. Thus, TSI did not appear to exercise control over installed Thermo-Lag 330 fire protection systems except for the material itself.

2.7 Qualification Type Testing

ASTM E 119 fire endurance qualification type tests have been performed on several Thermo-Lag 330 installation designs at TSI and elsewhere. This inspection only addressed testing at TSI, which is performed under the observation of Industrial Testing Laboratories, Inc. (ITL) as addressed in Section 3.8 of this inspection report. The NRC inspectors did not witness any qualification testing. TSI personnel described test preparations as follows.

Either the customer (licensee or architect-engineer) or TSI prepares the test plan. TSI and the customer also determine the general design of the test specimen and the location of thermocouples. The test plan does not give full details of the test specimen construction; as-built information may be sketched in the daily work sheets for the test. TSI personnel stated that prior to 1986 ANI approved the test plans, witnessed the test specimen construction and installation, witnessed performance of the tests, and approved the test report for insurance purposes. Customers have also witnessed testing.

The test specimen is assembled by a TSI crew of manufacturing personnel assigned to the test, using materials selected from the QA-approved inventory (which normally is quite small, since materials are basically mixed and fabricated to order). No attempt is made to select worst-case or other specific characteristics. TSI builds the test specimens in a small area near the test furnace. TSI maintains current calibrations of data logging instruments, as described in the QA program section of this inspection report (section 3.4). TSI has two furnaces. Usually the larger and better-instrumented furnace is used for nuclear tests.

Section 3.8 of this inspection report describes the NRC inspector's review of two qualification test reports, dated 1987 and 1990. Neither test plan fully described the design of the test specimen. For example, only a few dimensions were specified, and filling of joints was not described in detail. Some, but not all, of the omitted information was provided in as-built specimen descriptions in the daily record sheets appended to the test report. Criterion V of 10 CFR Part 50, Appendix B requires that activities affecting quality be prescribed by documented instructions or procedures. For safety-related procurements, TSI's failure to adequately specify specimen construction in the qualification test plans forms a portion of Nonconformance 91-01-01.

TSI also has performed ampacity derating tests. The customers designed the tests and supplied the cable samples. TSI has not performed ampacity derating calculations, but under a present contract from Gulf States Utilities is arranging for a [illegible] capability to perform them.

TSI maintains a complete set of qualification type test reports, both ITL and others, arranged chronologically in a file cabinet.

3.8 Industrial Testing Laboratory Role

TSI has stated that several ASTM E 119 type qualification tests of Thermo-Lag installation design specimens have been conducted under the independent auspices of Industrial Testing Laboratories, Inc. (ITL) of St. Louis. For example, a TSI document titled "Synopsis on the Thermo-Lag 330 Fire Barrier System for Power Generating Plant Applications, 10 February 1987," summarizes and references various tests. It makes the following statement regarding fire endurance tests on page two: "The above tests were performed under the supervision and total control of an ANI accepted third party, independent testing laboratory, Industrial Testing Laboratories, Inc., who also published the test results."

In order to assess the scope of ITL's efforts, the NRC inspector interviewed an ITL representative (a professional engineer) together with TSI's president. Although it has not performed fire barrier endurance tests, ITL has conducted numerous tests, including flame tests, for a wide variety of customers. ITL first tested Thermo-Lag material for aerospace applications in the late 1950s. ITL is listed on TSI's Approved Vendor List based on performance history, with no record of an audit. Criterion V of 10 CFR Part 50, Appendix B requires that activities affecting quality be prescribed by documented instructions or procedures. For safety-related procurements, TSI's failure to audit ITL forms a portion of Nonconformance 91-01-02.

The TSI president stated that TSI has an oral agreement with ITL that specifies rates but not work scope. Criterion V of 10 CFR Part 50, Appendix B requires that activities affecting quality be prescribed by documented instructions or procedures. For safety-related procurements, TSI's failure to contractually specify ITL's role in fire endurance qualification tests forms a portion of Nonconformance 91-01-02.

ITL does not participate in preparation or approval of the test plan, the design of the test specimen, or the location of thermocouples. ITL does not witness the construction of the test specimens, and at TSI's option may or may not witness installation of the specimen into the furnace. The ITL representative stated that he does not compare the test specimen dimensions with the test plan or daily work sheets. ITL also does not review calibration records for the test instrumentation.

ITL's role is observing the actual performance of the test. The ITL representative stated that he reviews the criteria documents including the test plan, discusses the text with the test supervisor to ensure understanding, witnesses performance of the test,

signs the daily work sheets, and collects and issues the raw data to ITL, TSI, and TSI's customer. The ITL representative stated that his role in the test ended with issuing the raw data; his function was to witness the test and verify that it was conducted as it was supposed to be, according to the test plan and other criteria documents. He was never involved in issuing a test report. TSI's president stated that TSI writes the test report text, types the report including the raw data, and obtains its customer's approval. The report is then given to ITL for what was described as a minimal review, and issued by ITL.

The NRC inspector questioned the ITL representative and TSI's president concerning a 1990 fire endurance test that had been observed by the ITL representative interviewed. The inspector noted that the raw data package highlighted an out-of-limit temperature that was not correspondingly emphasized in the draft test report (the actual number was included in the typed data, but its significance was not noted there). The ITL representative stated that his activities would not include such a comparison. TSI's president stated that the discrepancy would be identified in TSI's review of the draft report and corrected before issue.

In reviewing a typical fire endurance test report, ITL Report No. 87-5-76 dated June 1987, the NRC inspector commented that the report's appearance suggested that ITL's role may have been greater than it really was. For example, the cover sheet bears ITL's name and logo, but not TSI's. The title page is similar, except that it does identify TSI by name and address as the "test location." It also bears an ITL disclaimer concerning the use of the report, and the only approval signature is that of ITL's director. A reader would not know that the report had actually been written and typed by TSI, or that ITL's role in the test was essentially limited to witnessing data acquisition. The ITL representative and TSI president did not dispute these comments.

The inspectors found only one requirement for test laboratory independence in the files reviewed during the inspection. TU PO No. CPF 1557-S invoked Gibbs & Hill Specification 2323-MS-38H, Revision 1, which stated in section 3.7.2.1 that "fire and hose stream tests shall be performed and documented by a recognized independent testing laboratory." The specification in section 3.4.1.4(b) also invoked NRC Branch Technical Position APCSP 9.5.1, which defines a fire barrier rating in hours as established by a nationally recognized testing laboratory. The NRC inspectors were unable to determine an NRC requirement was actually violated in this regard. However, the inspectors believe that the appearance of the test reports and the representation of them as ITL reports could be misunderstood by users.

3.9 Conclusions

Section 3.3 of this report cites Nonconformance 91-01-01 concerning TSI's failure to procedurally require minimum thickness and maximum weight measurements for prefabricated, safety-related panels and conduit sections. Sections 3.5, 3.7, and 3.8 provide a basis for Nonconformance 91-01-02 involving TSI's failure to adequately control qualification testing for NRC licensees such as Texas Utilities, as identified in section 3.5.2.

Based on the file reviews and discussions with TSI personnel reported above, the inspectors found no other violations of NRC requirements for supplying materials and qualification documentation to commercial nuclear power plants. However, the inspectors were also concerned by the limited scope of installation support that TSI provides to its customers, as discussed in Section 3.6.

4 PERSONNEL CONTACTED

Thermal Science, Inc.:

* + R. Feldman, President
* + R. A. Lohman, Manager, Quality Assurance
* + B. E. Evans, Manager, Quality Control
* + M. G. Murphy, Administrator

Industrial Testing Laboratories, Inc.:

D. Wylan, Staff Consultant

US NRC:

\+ C. A. VanDenburgh, Section Chief
\+ L. R. Plisco, Section Chief
\+ K. S. West, Senior Project Manager

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* Attended the entrance meeting on December 16, 1991
\+ Attended the exit meeting on December 20, 1991