UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

December 15, 1992

NRC INFORMATION NOTICE 92-82: RESULTS OF THERMO-LAG 330-1 COMBUSTIBILITY TESTING

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to alert addressees to the results of Thermo-Lag 330-1 combustibility tests conducted for the NRC by the National Institute of Standards and Technology (NIST). It is expected that recipients will review the information for applicability to their facilities and consider actions as appropriate. However, suggestions contained in this information notice are not new NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

As part of a small-scale testing program of Thermo-Lag 330-1 fire barrier material, NRC staff had NIST perform combustibility tests using the following standards: (1) American Society for Testing and Materials (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 Rates for Materials and Products using an Oxygen Consumption Calorimeter." NIST documented the results of these tests in Attachment 1, "Report on Test FR 3989, Analysis Of Barrier Material For Noncombustibility," of August 31, 1992.

Based on the ASTM E-136 testing standard, the NIST tests revealed that Thermo-Lag 330-1 fire barrier material is combustible. This testing standard prescribes the material as combustible if three out of four samples exceed any of the following criteria: (1) the recorded temperature of the specimen's surface and interior thermocouples rise 30 °C [54 °F] above the initial furnace temperature; (2) there is flaming from the specimen after the first 30 seconds of irradiance; or (3) the weight loss of the specimen during testing exceeds 50 percent and either (a) the recorded temperature of the surface and interior thermocouples at any time during the test rise above the furnace air temperature at the beginning of the test or (b) there is flaming of the specimen. Each of the four Thermo-Lag specimens tested exhibited a weight loss of greater than 50 percent and exhibited flaming beyond 30 seconds.

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NIST performed the ASTM E-1354 calorimeter test on four Thermo-Lag specimens, subjecting them to an irradiance of 75 kW/m^2 [6.6 BTU/ft^2-s]. The total amount of heat released from the Thermo-Lag exceeded that released from Gypsum board and was about equal to the heat released from fire-retardant plywood.

Discussion

Section 50.48(a) of Title 10 of the Code of Federal Regulations requires that each operating nuclear power plant have a fire protection plan that satisfies General Design Criterion (GDC) 3, "Fire protection," in Appendix A to 10 CFR Part 50. GDC 3 requires that "structures, systems, and components important to safety shall be designed and located to minimize, in a manner consistent with other safety requirements, the probability and effects of fires and explosions. Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room."

NRC-approved plant fire protection programs referenced by the plant operating license and Section III.G, "Fire protection of safe shutdown capability," of Appendix R to 10 CFR Part 50, require one train of systems necessary to achieve and maintain hot shutdown conditions from either the control room or emergency control stations to be free from fire damage.

Section III.G.2 of Appendix R permits separation by a horizontal distance of more than 6.1 meters [20 feet] with no intervening combustibles or fire hazards as one of several methods to ensure that cables and equipment and associated circuits of redundant safe shutdown trains located outside containment are maintained free from fire damage. If this method is used, fire detection and automatic fire suppression must be installed in the area of the redundant safe shutdown trains. Some licensees use Thermo-Lag fire barrier material to enclose intervening combustibles to achieve 6.1 meters [20 feet] of separation free of intervening combustibles between the redundant safe shutdown trains.

Section III.G.2.f of Appendix R allows licensees to separate cables and equipment and associated circuits of redundant trains inside noninerted containments by installing a noncombustible radiant energy shield as one of several methods to achieve required fire protection for these circuits. Some licensees use Thermo-Lag to construct radiant energy heat shields inside containment.

Related Generic Communications

Attachment 2 is a list or recently issued generic communications concerning Thermo-Lag 330-1 fire barrier systems.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Original signed by
Brian K. Grimes

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Ralph Architzel, NRR
(301) 504-2804

Patrick Madden, NRR
(301) 504-2854

Attachments:
1. Report of Test FR 3989, Analysis Of Barrier Material For Noncombustibility
2. List of Recently Issued Generic Communications Concerning Thermo-Lag 330-1 Fire Barrier Systems
3. List of Recently Issued NRC Information Notices

* See previous page for concurrence

SPLB:DSSA MWidmann* 11/04/92	SPLB:DSSA RArchitzel* 11/04/92	TechEd JMain* 11/05/92	OIG GMulley* 11/05/92
SPLB:DSSA CMcCracken* 11/05/92	DD:DSSA GHolahan* 11/10/92	D:DSSA AThadani* 11/08/92	C/OGCB:DORS:NRR GMarcus* 11/25/92
DORS:NRR BGrimes 12/10/92			

DOCUMENT NAME: 92-82.IN

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SPLB:DSSA	DD:DSSA	D:DSSA	C/OGCB:DORS:NRR
CMcCracken*	GHolahan*	AThadani*	GMarcus GHM mkm
11/05/92	11/10/92	11/08/92	11/20/92
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SPLB:DSSA MWidmann 11/4/92	SPLB:DSSA RArchitzel 11/4/92	TechEd JMain 11/5/92	OIG GMulley 11/5/92 No objections per telecon w/ L. Norton
SPLB:DSSA CMcCracken 11/5/92	DD:DSSA GHolahan 11/10/92	D:DSSA AThadani 11/9/92	C/OGCB:DORS:NRR GMarcus 11/ /92

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U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Gaithersburg, MD 20899

REPORT OF TEST

FR 3989

on

ANALYSIS OF BARRIER MATERIAL FOR NONCOMBUSTIBILITY

by

Vytenis Babrauskas

August 31, 1992

Submitted to:

Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Washington, DC 20555

Purpose of test

Tests were conducted to determine if material submitted qualifies as noncombustible.

Material tested

The test material comprised board stock supplied by the Nuclear Regulatory Commission (NRC) to the National Institute of Standards and Technology (NIST). Two variations of board stock were supplied: nominal 1/2" and nominal 1" thick boards. The thickness of the boards is intended by the manufacturer to have a certain 'plus' tolerance, but a zero 'minus' tolerance. Thus, the boards were generally thicker than the nominal 12.5 and 25 mm values, but with substantial variation from point to point on the board. The nominal 1" stock contained a stainless steel wire mesh on both sides of the board, while the nominal 1/2" stock contained only wire mesh on one side of the board.

With the exception of removing the wire mesh (in those instances where stated, below) and cutting specimens to size, NIST did not alter or modify the specimens.

Definition of noncombustibility

The Uniform Building Code (International Conference of Building Officials, Whittier, CA, 1991) defines noncombustible as follows (pp. 29-30):

> "Sec. 415. NONCOMBUSTIBLE as applied to building construction materials means a material which, in the form in which it is used, is either one of the following:
>
> (a) Material of which no part will ignite and burn when subjected to fire. Any material conforming to U.B.C. Standard No. 4-1 shall be considered noncombustible within the meaning of this section.
>
> (b) Material having a structural base of noncombustible material as defined in Item (a) above, with a surfacing material not over 1/8 inch thick which has a flame-spread rating of 50 or less."

We note that U.B.C. Standard No. 4-1 is functionally identical to ASTM E 136 [1]. The other two U.S. model building codes, BOCA National and Southern Standard, use essentially identical definitions for noncombustibility.

To explain in more detail, U.S. practice provides for two different ways by which a product can be qualified as noncombustible. Part (b) was originally developed to make certain that conventional gypsum wallboard would be allowed as noncombustible. To qualify under part (b), two tests must be run: an ASTM E 136 test on the substrate material and the ASTM E 84 Steiner Tunnel on the complete product, including its thin surface layer. Part (b) cannot be successfully applied to a product unless the material comprising all of its thickness, save the topmost 1/8", can pass the ASTM E 136 test, while the top layer cannot. In the present case, the steel mesh layer is accepted to be noncombustible. Thus, for the test specimens submitted, part (b) is not applicable. Only testing of the bulk board stock material needs to be done, and this must be done using the ASTM E 136 test.

For reference, a specimen is recorded as passing the ASTM E 136 test if:

> "...at least three of the four specimens meet the following conditions:

The recorded temperature at the surface and interior thermocouples do not at any time during the test rise more than 54°F (30°C) above the furnace temperature at the beginning of the test,

There is no flaming from the specimen after the first 30 s, and

When the weight loss of the specimen during the testing exceeds 50%, the recorded temperature of the surface and interior thermocouples do not at any time during the test rise above the furnace air temperature at the beginning of the test, and there is no flaming of the specimen."

To examine the submitted specimens for noncombustibility, the standard procedure as described above was conducted. To obtain additional information, some supplementary tests were also conducted to better assay the behavior of the material. The standard procedure was conducted for NIST under contract by United States Testing Company, Inc. Their results are described below, while their report submitted to NIST is appended to this Report. The supplementary tests were conducted in our own laboratories.

Standard tests

Specimens of the nominal 1" board stock were submitted to the United States Testing Company, Inc. for testing according to ASTM E 136 procedures.

The material FAILED the test, since, for all 4 specimens tested, the percent weight loss was greater than 50% and flaming continued in excess of 30 s.

The report received from the testing laboratory is attached as the Appendix to this report.

Supplementary tests

The report from an ASTM E 136 test is recorded simply in pass/fail terms. To derive additional insight into the behavior of the material, it is possible to conduct tests which provide a quantitative measurement scale. Such a test is available in the form of the ASTM E 1354 test [2]. This is a heat release rate (HRR) test and, as such, it provides time-resolved information on the combustion of a specimen. In engineering terms, specimens which are 'noncombustible' are those which show low heat release. This concept has not yet been introduced into the U.S. building codes, but it is in the process of being approved for use in Canada [3] and U.S. usage is expected to come shortly thereafter. The tentative decision in Canada is to use a test irradiance of 50 $kW \cdot m^{-2}$. Work has also been done at NIST on the development of this concept, with most of the studies being conducted at a 75 $kW \cdot m^{-2}$ irradiance [4]. This heat-release-based approach conceptually simplifies the treatment of combustibility, since a special two-part testing approach, necessary for the conventional method to properly characterize gypsum wallboard, is no longer necessary. With this heat-release based approach, a single method is adequate to characterize all materials, including gypsum boards.

For the supplementary examination of the subject material, tests were conducted at both 50 and 75 $kW \cdot m^{-2}$ irradiance levels. The specimens were cut from the nominal 1/2" board stock to a size of 100 mm by 100 mm. The actual thickness of the board stock was found to be approximately 18 mm. In all cases, the prescribed edge frame was used, since the material substantially intumesces.

The test conditions and the test results are given in Table 1.

Table 1. Results obtained in supplementary tests

Test no.	Test condition	Irradiance $kW \cdot m^{-2}$	Peak HRR $kW \cdot m^{-2}$	Total heat in 600 s $MJ \cdot m^{-2}$	Total heat in 900 s $MJ \cdot m^{-2}$
5489	grid used; wire mesh up	50	74	—	34.1
5490	grid used; wire mesh up	50	83	—	44.1
5491	grid used; wire mesh down	50	74	—	28.2
5492	grid used; wire mesh down	50	76	—	25.9
5466	grid not used; wire mesh up	75	120	28.5	—
5486	grid used; wire mesh up	75	107	46.9	—
5487	grid used; wire mesh down	75	110	38.9	—
5467	grid used; wire mesh down	75	100	35.3	—

It is intended in the ASTM E 1354 test that the specimen surface condition be approximately planar. Thus, with intumescing or deforming specimens, the testing laboratory needs to use a restraint grid described in the standard or, if necessary, an alternate restraint technique to ascertain that specimen deformations are not excessive. The notation "grid used/not used" refers to the restraint grid specified in ASTM E 1354. In the present case, the test board stock had a wire mesh which can be considered as also serving some restraint function. Thus, various combinations of standard grid and wire mesh topside/bottomside location were tried to determine if there was a systematic effect of the restraint condition used. The notation "wire mesh" refers to the wire mesh which comes as part of the subject test specimen.

Interpretation of results

The above findings must be interpreted in the light of the performance of materials accepted for use as noncombustible. By examining the published data it can be seen that the following performance for gypsum wallboard (unpainted, both regular and Type-X grades) is obtained.

Table 2. Published results on gypsum wallboard

Irradiance $kW \cdot m^{-2}$	Ref.	Peak HRR $kW \cdot m^{-2}$	Total heat in 600 s $MJ \cdot m^{-2}$	Total heat in 900 s $MJ \cdot m^{-2}$
50	[3]	70 - 103	—	4
75	[4]	97	4.2	—

The results of Table 1 can now be compared to those of Table 2 to determine more quantitatively the differences between the tested product and gypsum wallboard. There are two bases of comparison: the value of the peak HRR and the total heat released in the control period (600 s when testing at 75 $kW \cdot m^{-2}$; 900 s when testing at 50 $kW \cdot m^{-2}$). The value of the peak HRR for the tested board product is seen to be roughly similar to gypsum wallboard. The value of the total heat released, however, is more than 8 times higher. This quantitative measure is consistent with the qualitative observation in the E 136 test that "flaming continued for the remainder of the test."

As a result of the Canadian study, Richardson and Brooks [3] made a proposed recommendation that combustibility of materials can be grouped into categories, based on performance in the ASTM E 1354 test. In the highest category (#1), limits of 10 $kW \cdot m^{-2}$ on peak HRR and 5 $MJ \cdot m^{-2}$ on the total heat released would be set. This is intended to correspond to specimens which pass solely by means of the ASTM E 136 test. In the next category (#2), would be gypsum wallboard and other products which are currently qualified on the basis of the ASTM E 136 test for the core material, plus the ASTM E 84 test on the finished product. For category #2, the limits are taken at 100 $kW \cdot m^{-2}$ peak HRR and 25 $MJ \cdot m^{-2}$ total heat released. For the present test specimens, the total heat released exceeds 25 $MJ \cdot m^{-2}$ in all cases; thus, by the proposed Canadian criteria, the test material would not qualify to be rated in a class comparable to gypsum wallboard.

References

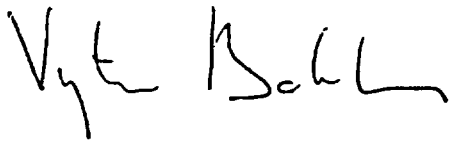
[1] Standard Test Method For Behavior of Materials in a Vertical Tube Furnace at 750 °C (E 136). American Society for Testing and Materials, Philadelphia.

[2] Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products using an Oxygen Consumption Calorimeter (E 1354). American Society for Testing and Materials, Philadelphia.

[3] Richardson, L.R., and Brooks, M.E., Combustibility of Building Materials, **Fire and Materials. 15**, 131-136 (1991).

[4] Babrauskas, V., North American Experiences in the Use of Cone Calorimeter Data for Classification of Products, pp. 89-103 in **Proc. of the Intl. EUREFIC Seminar 1991**, Interscience Communications Ltd, London (1991).

Prepared by:



Vytenis Babrauskas

APPROVED

Andrew J. Fowell
Chief, Fire Science and Engineering Division

List of Recently Issued Generic Communications Concerning Thermo-Lag 330-1 Fire Barrier Systems

1. Information Notice 91-47, "Failure of Thermo-Lag Fire Barrier Material to Pass Fire Endurance Test," August 6, 1991

2. Information Notice 91-79, "Deficiencies in the Procedures for Installing Thermo-Lag Fire Barrier Materials," December 6, 1991

3. Information Notice 92-46, "Thermo-Lag Fire Barrier Material Special Review Team Final Report Findings, Current Fire Endurance Tests, and Ampacity Calculation Errors," June 23, 1992

4. Bulletin 92-01, "Failure of Thermo-Lag 330 Fire Barrier System to Maintain Cabling in Wide Cable Trays and Small Conduits Free from Fire Damage," June 24, 1992

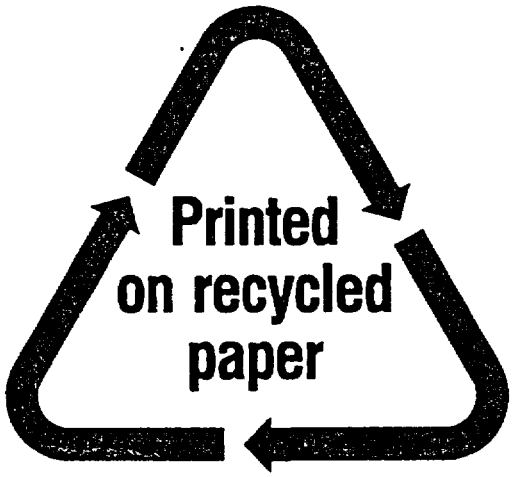
5. Information Notice 92-55, "Current Fire Endurance Test Results for Thermo-Lag Fire Barrier Material," July 27, 1992

6. Bulletin 92-01, Supplement 1, "Failure of Thermo-Lag 330 Fire Barrier System to Perform Its Specified Fire Endurance Function," August 28, 1992

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
92-81	Potential Deficiency of Electrical Cables with Bonded Hypalon Jackets	12/11/92	All holders of OLs or CPs for nuclear power reactors.
92-80	Results of Thermo-Lag 330-1 Combustibility Testing	12/07/92	All holders of OLs or CPs for nuclear power reactors.
92-79	Non-Power Reactor Emergency Event Response	12/01/92	All holders of OLs or CPs for test and research reactors.
92-78	Piston to Cylinder Liner Tin Smearing on Cooper-Bessemer KSV Diesel Engines	11/30/92	All holders of OLs or CPs for nuclear power reactors.
92-77	Questionable Selection and Review to Determine Suitability of Electropneumatic Relays for Certain Applications	11/17/92	All holders of OLs or CPs for nuclear power reactors.
92-76	Issuance of Supplement 1 to NUREG-1358, "Lessons Learned from the Special Inspection Program for Emergency Operating Procedures (Conducted October 1988 - September 1991)"	11/13/92	All holders of OLs or CPs for nuclear power reactors.
92-75	Unplanned Intakes of Airborne Radioactive Material by Individuals at Nuclear Power Plants	11/12/92	All holders of OLs or CPs for nuclear power reactors.
92-74	Power Oscillations at Washington Nuclear Power Unit 2	11/10/92	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit



Federal Recycling Program