NUCLEAR ENERGY INSTITUTE

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June 28, 2004

Mr. Sunil Weerakkody
Fire Protection Section Chief, DSSA
U.S. Nuclear Regulatory Commission
Mail Stop O11-A11
Washington, DC 20555-0001

PROJECT NUMBER: 689

Dear Mr. Weerakkody:

During a recent public meeting on fire protection issue management we agreed to offer industry evaluation on the combustibility of epoxy coatings in nuclear plants. After considerable review, we recommend that this topic be closed for the following reasons:

- The use of epoxy coatings at nuclear plants do not, in general, present a significant fire risk and should be removed from further consideration as a generic fire protection issue.

- Generally, epoxy floor coatings should be considered non-combustible, since their combustible properties are less severe than other floor finish materials for which the NRC currently requires no evidence of test and listing by a recognized testing laboratory.

- Inspection guidance should reflect the fact that this is a low fire risk concern and is within the uncertainty band of the Fire Hazards Analysis.

- Only plants that have unusual epoxy coating configurations that substantially increase the fire hazard or are outside the plant licensing basis should be subject to inspection findings.

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We are enclosing a draft position paper that provides a basis for closure. We invite your comments or further discussion in order to resolve this issue in a manner appropriate to its low risk significance.

If you have any questions, please address them to either me (202-739-8080; am@nei.org) or Fred Emerson (202-739-8086; fae@nei.org).

Sincerely,

Alex Marion

Alex Marion

Enclosure

c: John Hannon, NRC
Dan Frumkin, NRC
NRC Document Control Desk

Industry Position Paper
Use of Epoxy Coatings

Purpose

The purpose of this paper is to document the industry postion and evaluation regarding the use of epoxy floor coating systems in nuclear power plants. Protective coatings (paints) have been used extensively in nuclear power plants to protect the surfaces of facilities and equipment from corrosion and contamination, from radionuclides (ALARA), and provide wear protection during plant operation and maintenance activities.

This position is necessary in order to:

- Supplement the NRC Summary Position provided to NEI on October 10, 2003, to include other considerations, including NRC guidance previously provided to the industry regarding interior finishes and the installation of combustible materials, and other fire protection information.

- Address the fact that since most epoxy floor coatings are self-leveling, the installed thickness of the coating in some localized areas, due to floor imperfections, settling, slope for drainage, etc., could potentially exceed the dry film thickness (DFT) that was actually tested for flame spread and/or could exceed 1/8 of an inch. In addition, the installed thickness could be increased due to repair and/or re-coating work.

- Ensure that floor protective coating systems are appropriately addressed in the approved fire protection programs.

Industry Position

Epoxy coating systems applied to concrete floors generally do not constitute a significant or unusual fire risk.

The use of epoxy coating systems on concrete floors is consistent with the previous industry guidance regarding the unrestricted use of interior finish materials, such as oil paint, vinyl tile, vinyl asbestos tile, and linoleum over concrete and concrete floors, which were historically acceptable for use as an interior finish regardless of thickness and/or flame spread characteristics.

Experience has shown that epoxy floor coating systems are difficult to ignite, will not sustain a flame capable of propagating fire, and are not likely to contribute to early fire growth. The self-leveling nature of the epoxy floor coating, repair and/or re-coat work, etc., are judged to be incidental for the locations where the thickness of an epoxy coating exceeds the nominal DFT of 1/8 of an inch, due to floor imperfections. The fire protection features (i.e., detection, suppression, barriers, etc.) already provided to satisfy GDC 3 and protect the in situ fire hazards are sufficient to minimize the probability and consequences of postulated fires in such areas. Therefore, such applications do not represent intervening combustible materials, do not increase the probability and consequences of postulated fire, and changes to the existing fire protection features are not warranted.

The contribution of epoxy floor coatings to the area fire hazards is considered to be negligible. Therefore, it is appropriate that they are excluded from station combustible loading calculations.

Licensees should ensure that the use of epoxy floor coatings is appropriately addressed in the fire protection program by:

- Confirming or revising the interior finish description in their Fire Hazards Analyis (or equivalent documentation) to incorporate or bound the epoxy coating systems used in their plant and the positions outlined above.

- Confirming or revising station procedures or policies to ensure that, going forward, the nominal DFT of the epoxy coatings used to coat floors within the power block are limited to a flame spread of 50 when tested in accordance with "Method of Test of Surface Burning Characteristics of Building Materials" NFPA No. 255 and ASTM No. E-84 or similar test, or a Critical Radiant Flux not less than 0.45 watts/cm^2 (Btu/ft^2 Sec) when tested in accordance with ASTM E-648 or NFPA No. 253.

Basis

1. A material having a structural base of noncombustible material, with a surfacing not over 1/8 inch thick that has a flame spread rating of not higher than 50 when measured in accordance with ASTM E-84, "Standard Test Method for Surface Burning Characteristics of Building Materials," is a noncombustible material (Reference 5).

2. Interior finishes that have a flame spread, smoke and fuel contribution of 25 or less when listed by a nationally recognized test laboratory, such as Factory Mutual or Underwriters Laboratories, Incorporated, are considered to be non-combustible (Reference 4).

3. The heat content value for epoxy floor coating is conservatively assumed to be 130,000 Btu/gallon, based on an NFPA Handbook value of 30.37 MJ/kg and an assumed density of 75 lb/ft^3 per field sample analysis at the Duane Arnold Energy Center. Given a conservative, manufacturer-recommended application rate of 50 square feet per gallon (i.e., approximately 30 mils thickness), then the estimated fire loading contribution to any plant area is approximately 2600 BTU/sq ft per coat (130,000 BTU/gallon and 50 sq ft per gallon). This equates to a fire severity of less than 2 minutes per coat, based on the linear relationship between fire load and fire severity indicated in the NFPA Handbook. Therefore, even conservatively assuming the epoxy floor coating, when fully cured, is combustible, the contribution to the overall fire loading in any area would be insignificant.

4. The thickness of epoxy floor coating systems used throughout the industry, when installed in accordance with manufacturer instructions, typically range from 3 to 50 mils. Therefore, the nominal Dry Film Thickness of the systems used throughout the industry is usually less than 125 mils or 1/8 inch. However, as indicated in the "Purpose" section, the actual thickness of a self-leveling epoxy floor coating in certain plant locations may exceed the nominal DFT that was tested.

5. As indicated on Attachment A, typical epoxy coatings used throughout the industry applied up to 50 mils nominal DFT demonstrate flame-spread values significantly below 50.

6. "No intervening combustibles" means that there are no "significant" quantities of in-situ materials that will ignite and burn located between redundant shutdown systems. The amount of such combustibles that has significance is a judgmental decision, and this judgment should be made by a qualified fire protection engineer and documented for later NRC audit. (Reference 4).

7. The ASTM E-84 tunnel test was designed for testing ceiling and wall products and did not provide the type of test data necessary for evaluating flooring materials. As a result, the tunnel test was replaced by the flooring radiant panel test as the preferred method for evaluating flooring materials, and the federal government (GSA, DOD), AIA, and other specification generating groups have been eliminating any reference to ASTM E-84 as a requirement in regard to Interior Floor Finish materials.

The most appropriate test for evaluating the flame spread of floor coverings is the "Standard Method of Test for Critical Radiant Flux of Floor Covering System Using a Radiant Heat Energy Source" (ASTM E-648 or NFPA 253), which evaluates the tendency of a floor covering material to propagate flame across its surface in a relationship to a given energy source over a period of time. The test recognizes two classes of interior floor finishes, Class I, with a minimum critical radiant flux of 0.45 watts per square centimeter, and Class II, with a minimum value critical radiant flux value of 0.22 watts per square centimeter. For example, NFPA 805 states that interior floor finishes shall be in compliance with NFPA 101 requirements for Class I interior floors. Therefore, interior floor finish materials having a Critical Radiant Flux of 0.45 watts/cm^2 (Btu/ft^2 Sec.), when tested in accordance with ASTM E-648 or NFPA No. 253, are assumed to be equivalent to materials having Class A flame spread index (i.e., 25 or less)."

8. When determining the flame spread rating of an epoxy floor coating via the tunnel test:

   - The assemblies are tested in a ceiling configuration, and

   - The specimen tested consists of epoxy coating are applied to a thin (i.e., ¼ inch) inorganic cement board, as opposed to the minimum 5 inch thick concrete floor that is typical in the power block of a nuclear plant.

   Therefore, the actual flame-spread characteristics of the epoxy coating when applied to the concrete floor are less severe than that determined by the test.

9. The historical acceptability of thin interior finishes over concrete floors (i.e., vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile, etc.) <u>without evidence of test and listing by a recognized testing laboratory</u> is consistent with the insignificance of the hazard. Specifically, a thin combustible finish applied to a non-combustible substrate presents little fire hazard because the substrate will not ignite and will absorb heat during the early stages of fire development.

10. Application of a thin finish material applied to concrete floors distinguishes the expected behavior of these coatings in a fire event from that of electrical cables, hydraulic fluids and miscellaneous ordinary combustibles materials that commonly exist throughout the plant.

Applicable NFPA Guidance

NFPA Handbook, 16th Edition

Interior finish is considered to be the materials and combination of materials that form the exposed interior surface of walls and ceilings in a building. The types of interior finish materials are numerous and include common construction items such as plaster, gypsum wallboard, wood, plywood paneling, fibrous ceiling tiles, plastics, fabric, and a variety of wall coverings. Ordinary paint, wallpaper, or other similar wall coverings not exceeding 1/28 in. (0.9 mm) in thickness are not generally included as interior finish, except where deemed to be a hazard by the authority having jurisdiction.

Interior floor surfaces are considered to mean the exposed floor surfaces of buildings and include floor coverings such as carpets and floor tiles which may be applied over, or in lieu of, a finish floor. In accordance with Chapter 10, requirements for interior floor finish are applied where floor finish requirements are specified elsewhere in the Code for specific occupancies or where there is a floor finish of unusual hazard. Thus, unless the authority having jurisdiction determines that the material used poses an unusual hazard, floorings and floor coverings are excluded from interior finish requirements but are required, where so specified in the Code, to comply with special interior floor finish provisions.

Surface finishes should be considered with recognition of the substrate material to which they are attached. A thin combustible finish applied to a non-combustible substrate presents little fire hazard because the substrate will not ignite and will absorb heat during the early stages of fire development.

NFPA Handbook, 19th Edition

Experience has shown that traditional floor coverings, such as wood, vinyl tile, and linoleum, are not likely to affect early fire growth. In most instances, there will be little gain in safety achieved by regulating traditional floor coverings.

NFPA 101-2003

NFPA 101, the "Life Safety Code," addresses those construction, protection, and occupancy features necessary to minimize danger to life from fire, including smoke, fumes, or panic. In accordance with Chapter 10, requirements for interior floor finish shall apply where floor finish requirements are specified elsewhere in this Code for specific occupancies or there is a floor finish of unusual hazard. With respect to NFPA 101, a nuclear power plant is considered a "special purpose industrial occupancy" and, in accordance with Chapter 40, there are no requirements or limitations for the "interior floor finish."

NRC Regulatory Guidance

NRC Regulatory Guide 1.189: Section 4.1.1.1, "Interior Finish," of Regulatory Guide 1.189 states:

"Interior finishes should be non-combustible. Materials that are acceptable for use as interior finish without evidence of test and listing by a recognized testing laboratory are the following:

- Plaster, acoustic plaster, gypsum plasterboard (gypsum wallboard), either plain, wallpapered, or painted with oil-or water-base paint
- Ceramic tile, ceramic panels; Glass, glass blocks
- Brick, stone, concrete blocks, plain or painted; Steel and aluminum panels, plain, painted, or enameled; and
- Vinyl tile, vinyl-asbestos tile, linoleum, or asphalt tile on concrete floors.

Suspended ceiling and their supports should be of noncombustible construction. Concealed spaces should be devoid of combustibles except as noted in Regulatory Position C.6.1.2 (Control Room Complex). In situ fire hazards should be identified and suitable protection provided.

The Regulatory Position above is based on GDC 3, 10 CFR Part 50 Appendix R, APCSB 9.5-1, and CMEB 9.5-1.

> Note: A random sample review of floor coverings typically specified for commercial applications indicates that a large percentage of vinyl tile, vinyl asbestos tile, and linoleum have a flame spread rating over 50, and that the actual thickness often exceeds 1/8 of an inch (without considering the additional thickness due to the adhesion material, when applicable).

Note: Previous NRC regulatory guidance does not differentiate between interior finishes applied to walls and ceilings and those applied to floors. However, as discussed above, the fire behavior of materials in floor configurations is less severe than fire behavior of the same materials in wall and ceiling configurations.

Federal Register

The NRC published its basis for the acceptability of combustible materials used by licensees in fire-rated barriers in the proposed rule, "Elimination of the Requirement for Noncombustible Fire Barrier Penetration Seal Materials and Other Minor Changes," in the Federal Register (64 FR 44860) dated August 18, 1999. As part of the basis for acceptance, the NRC staff addressed an apparent conflict with GDC 3 as follows: "Although GDC 3 states that noncombustible and heat-resistant materials must be used whenever practical, GDC 3 does not preclude the use of combustible materials. In fact, combustible materials are installed in nuclear power plants. In general, when these materials are incorporated as integral components of the plant fire protection program, including the fire hazard analysis, they are acceptable."

Other Considerations

The walls, floors, and ceilings of the power block at each station are completely constructed with non-combustible materials (i.e., concrete, concrete block, and steel). In addition, the significant in situ (i.e., fixed) fire hazards are analyzed in the Fire Hazards Analysis (FHA) to ensure each area is suitably protected by specific measures such as fire detection, fire suppression and fire containment. A review of the NRC fire protection guidance outlined above indicates that interior floor finishes similar to epoxy coatings (i.e., paint, vinyl, linoleum, and asphalt tile, etc.) over a non-combustible substrate did not constitute a significant or unusual hazard and was historically acceptable without test data and/or listing by a recognized testing laboratory.

Epoxy floor coatings at Duane Arnold Energy Center (DAEC) have been found via field sampling to range in thickness from .003 to .071 inches (90% of samples) with a few outliers having thicknesses up to 0.182 inches. These floor coatings include the Sherwin Williams Armorseal 650 product, which has yielded flame spread indices of 25 (one coat of Armorseal 650 over one coat of Armorseal 33 primer) and 110 (two coats of Armorseal 650 over one coat of Armorseal 33 primer). These coatings have, on occasion, have been subjected to dropped heated material from welding operations. These occurrences have created burn marks on the floor consistent with the size of the welding and cutting byproducts.

However, experience has shown that these scorched areas self-extinguish within a short period of time and do not propagate.

Since the epoxy floor coating systems are not considered combustible, they are typically not protected with a tarp or other barrier during hot work operations. As a result, epoxy floor coating systems installed at other nuclear plants, on occasion, have also been subjected to dropped heated material from welding operations, and experience has shown that the systems do not readily ignite and do not propagate fire.

References

1. July 25, 2003, letter from DAEC to NRC, Response to NRC Unresolved Item 50-331/03-02-03(DRS): Epoxy Floor Coatings.

2. Bodycote ASTM E-84 Surface Burning Characteristics of "Armorseal 650," dated May 21, 2003

3. Hardwood Plywood & Veneer Association Laboratory and Testing Service Test Number T-10951, "Report on Surface Burning Characteristics Determined by ASTM E 84 Twenty Foot Tunnel Furnace Test Method, One Coat Armorseal 33 Primer With Two Coats of Armorseal 650.

4. NRC Generic Letter 86-10, Questions 3.6.1 and 3.6.

5. NRC Regulatory Guide 1.189

6. NFPA Handbook (16th and 19th Editions)

7. NFPA 101 - 2003.

Attachment A

Typical Floor Coatings Used in US Nuclear Power Plants

Coating / System	System DFT (mils)	Flame Spread Index Per ASTM E-84
Carboline SL-CS7	26 to 38	15
Carboline SL-CS10	16 to 25	15
Carboline SL-CS10 (clear sealer only)	~2	5
Keeler and Long 3200 (not self-leveling)	3 to 5	0
	18	10
Keeler and Long 3400 (not self-leveling)	25	20
Keeler and Long Kolor-Poxy Self-Leveling Floor Coatings (5500 Series).	15	13
	25	19.5
	50	37
Sherwin & Williams ArmorSeal 650	10 to 20	20 (2)
Sherwin & Williams Armorseal 550	10 to 20	20 (1)
Keeler & Long 7700 – Kolor-Quartz Floor Coating	25	23.5
Keeler & Long H-Series Hydropoxy Enamel	8	<2

Notes:

1. There is no available test data to determine the Armorseal 550 surface burning characteristics. However, a comparison of the Material Safety Data Sheet's (MSDS) indicate that the physical properties of Amorseal 650 and 550 are similar. Therefore, for the purpose of this evaluation, it is assumed that the surface burning characteristics of Sherwin William's 550 are consistent with Sherwin William's 650.

2. Based on Ref. 2.