Inspection and Evaluation of Spray Applied Fire Resistant Materials

An Online Continuing Education Course for Engineers

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Inspection and Evaluation of Spray Applied Fire Resistant Materials

Michael J. Rzeznik, P.E.

Introduction

As part of engineering assessments of existing buildings or commissioning and/or construction compliance surveys of new construction, engineers and architects are called upon to assess all aspects of a buildings design and construction. One critical aspect of this assessment is to evaluate the fire resistance rating of the buildings structural components. While physical testing of the fire resistance provided to building structural materials may not be the subject of all engineers or architects scope of work, it is critical that design professionals evaluating this aspect of a buildings design be familiar with the requirements for evaluating the quality and efficacy of the fire resistance methods employed in the building that they are assessing.

The focus of this course centers around passive fire protection of building structural members exclusively through the use of spray applied fire resistance materials (SFRM). This course is intended to briefly review some of the basic requirements associated with the application of SFRM, as well as some of the common construction deficiencies that an engineer or architect may encounter when performing assessments of existing buildings that use these materials.

The course is intended to summarize recognized inspection and testing requirements associated with protection for building structural elements, and provides useful guidance on how to identify code compliance issues during a brief building walk-through, or during a more thorough SFRM inspection or commissioning exercise. This course does not address more detailed inspection and testing methodologies that are available to professionals performing more detailed building surveys or forensic investigations.

A general discussion of the governing standard testing requirements in the United States is reviewed. Specific codes and standards that apply to the testing and installation of SFRM can vary from country to country, state to state, and city to city. Private entities, federal, state and local governments, insurance companies, and building tenants may also have their own standards that could be applicable to a building or portion of a building. Therefore, care should be taken to ensure an understanding of applicable code and standards requirements as they may impact each individual situation. For the purpose of this course, testing requirements of

the American Society for testing and Materials (ASTM) and Underwriters Laboratories (UL) directories, specifically those requirements applicable to SFRM, form the basis for the technical descriptions, unless otherwise noted. Another valuable resource and reference for aspects of testing and inspection of SFRM is Technical Manual 12-A, Fourth Edition, Standard Practice for the Testing and Inspection of Field Applied Sprayed Fire-Resistive Materials, an Annotated Guide, published by the Association of the Wall and Ceiling Industry (AWCI). Information provided in this course with regard to building code requirements, ASTM standard, and testing procedures may not be appropriate for all design and construction scenarios. Design professionals should utilize appropriate judgement and care when evaluating the appropriate design approach for their unique situation.

Passive Fire Protection

Building codes quantify the degree of fire protection afforded by various building elements based on how the protected assembly performs in carefully controlled laboratory tests. In the United States, fire resistance ratings for building construction assemblies such as floors, beams, columns and walls, are tested this way as a means of establishing a relative comparison as to the level of fire resistance provided by each assembly when compared to a standard fire exposure. The standard fire exposure utilized in the United States is the time temperature curve fire exposure used in the ASTM E 119 test, the Standard Test Methods for Fire Tests of Building Construction and Materials. Similar standard fire tests are used to evaluate the relative fire protection afforded for protection of openings used in such assemblies such as those required for doors, windows, joints, and through penetrations (fire stopping).

Columns, beams, floors, ceilings, and wall assemblies are given ratings based on their ability to withstand fire exposure in hourly increments ranging from one to four hours. Opening protective, such as dampers, doors, and windows, can be assigned ratings as short as 20 minutes, and as long as 3 hours.

It is important to recognize what the standardized laboratory tests are intended to indicate, and what they are not. Fire resistance rating testing results are specifically intended to be applicable to the structural assemblies' ability to resist the passage of fire, function as a barrier, and to otherwise support a prescribed load, throughout the fire endurance test. The test fire exposure is not intended to be representative of all fire conditions. Variables associated with actual fires, including fire load, fuel distribution, fuel type, ventilation, compartment size and configuration, all impact actual fire effect on building structure, and are too numerous to capture in a single laboratory test. Laboratory tests do, however, provide a consistent means with which to gauge relative fire endurance of assemblies under test fire conditions.

SFRM

Fire protection ratings for structural members can be provided inherently within the construction materials selected, such as in the case of concrete or reinforced concrete. However, for noncombustible steel frame construction, application of direct applied materials or membrane applied protection systems are required to achieve the thermal protection from fire.

Direct applied materials include spray applied fire resistance materials (SFRM), trowel applied mastic coatings, thin film intumescent fire resistive materials (TFIFRM), and masonry and concrete. Membrane enclosure systems generally consist of gypsum wallboard, mineral board, fiber board, plaster and lathe systems, and various batting and/or blanket wrap-type material assemblies.

SFRM is a material that can be directly applied to building structural members, with the intent of increasing the structural member's ability to resist the thermal effects of heat generated by fire. Assemblies that successfully achieve given fire resistance ratings must be constructed in the field using all design aspects of the assembly tested in the laboratories. In the instance of structural members protected by SFRM, this includes achieving the proper thickness, density, and adhesion/cohesion bond strength of applied materials. The mixing and application method used for the product, the environmental considerations, such as temperature and humidity, at the time of application and during the curing process, and proper preparation of the steel substrate are all important contributors to proper and successful application of SFRM materials.

The deliberate care and detail used to prepare a structural member for a laboratory fire test is much different than the field conditions and reality associated with construction sites. For laboratory tests, highly skilled laborers are used for preparation of the structural test assemblies to ensure that the tests perform as expected. The process and cost associated with the testing process can be quite expensive, and a test failure as a result of improper application would be particularly upsetting. Unfortunately, on the construction site, the skill level and training of the installers is not as easy to control, which can result in quite a variation in how the SFRM is prepared and applied. In some instances, construction schedule can also be seen as more critical than installation quality, which can also lead to a less than perfect application process. Furthermore, in the laboratory the environmental conditions, specifically temperature and cure times, are much easier to manage. On the construction site environmental conditions cannot be controlled, and cure times may not be fully adhered to in many instances. For these

reasons, field verification of SFRM installation is critical to the building commissioning process for new construction.

Inspection criteria for SFRM is primarily driven by manufacturer's requirements, minimum criteria associated with a selected assemblies approved testing and listing laboratory, applicable building codes, and ASTM testing standards. The primary inspection and testing standards, applicable to SFRM in buildings are ASTM E 605 and ASTM E 736. Other ASTM tests for SFRM, such as tests for compressive strength, deflection, and air erosion are generally applied to manufacturer's products, the results of which are shared in product data sheets.

The ability of SFRM to protect structural members to which they are applied depends on the method of application, the type of material used, as well as the preparation of and application of the material to the substrate. The material, geometry, and weight per unit length of the structural material also contribute to the fire resistivity of the assembly. SFRM materials generally consist of either cementitious, gypsum, or mineral-fiber based products. Each of these material compositions possesses differing characteristics that impact the ability of the assembly to provide thermal installation during a fire event.

Spray applied fire resistance material (SFRM) has three attributes that are particularly important to assess during building construction, commissioning, or detailed inspection. Specifically, these attributes are thickness, density, and adhesion/cohesion (also referred to as bond strength). In the following sections, we will review some of the basics attributes of each of these elements, and describe the testing and evaluation processes of each. Testing for SFRM density requires use of laboratory equipment for proper density measurement. Adhesion and cohesion testing also requires some special equipment, training, and may also require time that may not necessarily available if access to the building and/or time is limited. Because of this, if the nature of the assessment being done is limited in scope such as a property condition assessment, including these types of assessments into the report may not be practical. However, a visual evaluation of SFRM thickness is something that can be performed to a limited degree when conducting a building evaluation when members protected by SFRM are readily observable. Such a spot check survey would not comprise the requirements of a full SFRM thickness evaluation, but can be effective in identifying bare steel and similar conditions.

Thickness

ASTM E 605 Standard Test Methods for Thickness and Density of Sprayed Fire-Resistive Material (SFRM) Applied to Structural Members (ASTM E 605) is the minimum standard for evaluating the thickness and density of applied SFRM that has been applied in the field. With

regard to SFRM thickness, this standard provides specific guidance with regard to properly measuring thickness and evaluating compliance with the required fire proofing material thickness laid out in the fire proofing assembly selected for installation.

SFRM material thickness must comply with requirements laid out using the design teams selected fire resistance rated assembly within specific tolerances, or otherwise the system as installed will not achieve the required rating provided by the testing and listing agency, and may not perform as intended in the event of a fire situation. Appropriate SFRM thickness is critical to mitigate transmission of heat from a fire to the protected structure.

During the application of SFRM, calibrated and graduated thickness gauges should periodically be being used by trained SFRM application staff to ensure that minimum thicknesses are being achieved and to mitigate the need for patching. The thickness gauge should be calibrated, and consist of a needle for penetrating the SFRM, as well as a sliding disk oriented perpendicular to the needle. ASTM E 605 requires that the gauge be graduated to take measurements in a minimum of 1/16-inch intervals. The disk should be capable of being reliably and mechanically held in place after inserting the pin into the SFRM to allow the measurement to remain unchanged as the gauge is removed from the sample. This will increase the level of consistency and accuracy in the measurements. During the application process the technician should be careful to ensure that no bare spots exist.

For post installation SFRM inspections or evaluations, identical graduated test gauges will be used to measure and record SFRM thicknesses. In instances where the applied SFRM is too dense for a hand-held depth gauge to be used, small diameter holes can be drilled into the material, and a standard depth gauge can be used by inserting the depth gauge into these holes. As is the case when any breach is made in the coverage of SFRM applied to structural members, the holes made to take these measurements must be filled and patched with SFRM once the testing is complete.

Application of SFRM to structural members cannot be assumed to be consistent during the construction process. Differences in the quality of the application can include environmental conditions, such as temperature and humidity, as well as a few other variables such as quality of the mixed product, skill of the laborer, and the physical ability to apply the material to the substrate. These challenges would make single point thickness testing inaccurate, and similarly would make limiting testing to a single location within the construction not representative of a quality installation. Therefore, the post-application thickness testing procedure developed by ASTM E 605 requires that thickness tests be conducted at random locations so that the consistency of SFRM application can be gauged in various locations for each protected

structural member type throughout the building. The standard requires random test locations in one bay per floor or one bay for every 10,000 square feet for structural members, whichever is greater, for each protected structural member type. This testing frequency is identical to that required by IBC, though IBC also requires that not less than 25% of structural members per floor be tested.

It should be noted that many local codes and standards have adopted ASTM E 605 as written, while others have included modifications. For example, the International Building Code (IBC) has modified the testing frequency requirements of ASTM E 605 as it applies to floor, roof and wall assemblies. IBC requires the thickness of SFRM on these assemblies to consist of not less than four measurements for each 1,000 square feet (93 m^2) of the sprayed area or portion thereof, for each story. Local building codes sh ed with regard to the method and testing frequ ickness testing process requires between 18 a locations along each of the randomly selected kness measurements is different depending or lumn test location would require 24 minim -beam would require 18 individual measurem

For example, for a beam ired circling around from one side of the bea

1. Underside of t
2. Middle of the
3. top of the bott
4. flange tip,
5. underside of th
6. opposite flange
7. top of the opposite bottom flange,
8. middle of the opposite web, and
9. Underside of the opposite side of the top flange.

Once these initial measurements are taken, an identical series of measurements must be taken 12 inches from that point. For columns, additional points located at the tips of and on top of the top flange would provide the balance of test measurements required for evaluating thickness of SFRM on columns. This series of 18 measurements for beams and 24