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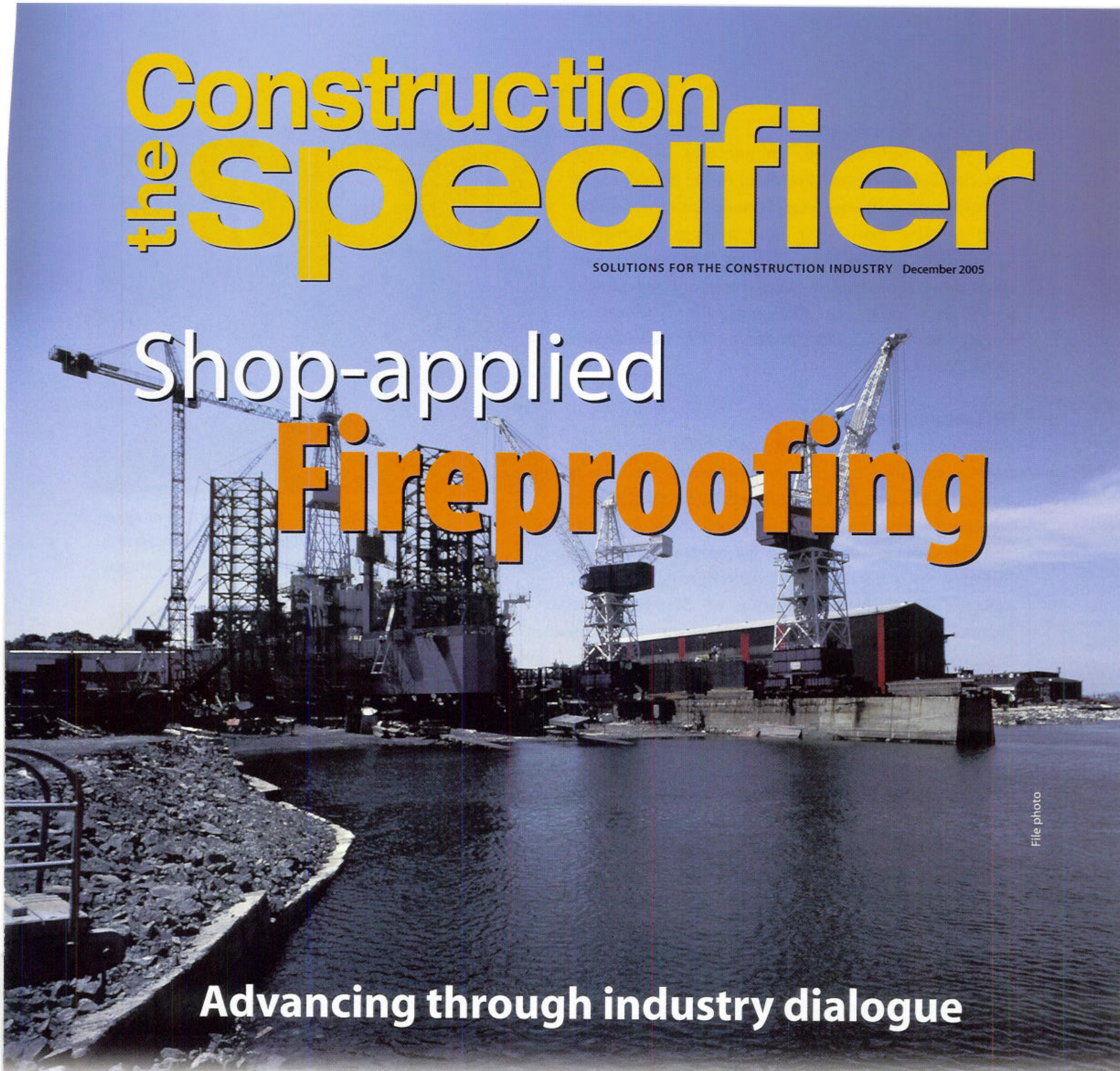
Shop-applied Fireproofing



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Advancing through industry dialogue

by Bill Dempster, CSI

Passive fireproofing plays a key role in protecting structural steel in commercial and industrial structures around the globe. Traditional passive fireproofing materials, such as cementitious sprayed mineral fiber and rigid board, along with intumescent thin-film paints, are routinely applied at the job-site following construction of the structural frame. Although application equipment, processes, and fireproofing materials have improved significantly over the past 35 years, there are still limitations and drawbacks with on-site application:

- weather and job-site conditions significantly impact the application and subsequent in-place performance of the fireproofing material;
- overall project completion is dependent upon the fireproofing schedule;
- various environmental, health, and safety concerns such as dust/chemical exposure, waste/overspray containment and site disruption; and
- the level and degree of quality control (QC) during application and inspection of in-place material.

For years, shop-applied, intumescent fireproofing materials have protected structures in the petrochemical and off-shore industries from extreme fire scenarios, but until recently, have never been used in commercial construction applications. Passive fireproofing and external pipeline coatings have evolved along parallel paths from field- to shop-application, addressing identical issues and experiencing similar technological development.

NIST recommendations

Following attacks on New York City's World Trade Center (WTC), and the Pentagon, in Washington, D.C., many owners, building officials, and regulatory agencies are taking a critical look at passive fire protection technologies and materials currently used in the commercial building industry. In a recent report investigating the WTC collapse, the National Institute of Standards and Technology (NIST) made 30 recommendations for improving the safety of buildings, occupants, and emergency responders.[1] Two of these specifically address the performance of on-site fireproofing applications:

NIST recommendation #6

NIST recommends the development of criteria, test methods, and standards:

1) for the in-service performance of
spray-applied fire resistive materials (SFRM, commonly referred to as fireproofing or insulation) used to protect structural components; and

2) to ensure that these materials, as installed, conform to conditions in tests used to establish the fire resistance rating of components, assemblies and systems.

NIST recommendation #10

NIST recommends the development and evaluation of new fire-resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection following major events. This could include technologies with improved adhesion, double-layered materials, intumescent coatings, and more energy-absorbing SFRMs. Consideration should be given to pre-treatment of structural steel members with some type of shop-applied fire protection to minimize uncertainties associated with field application and in-use damage. Where such an approach is feasible, only connections and any fire-protection damage during construction and fit-out would be needed to be field-treated.

Photo courtesy International Paint

Climate-controlled facilities apply plural-component epoxy coatings in an open-floorspace environment. The process is largely the same as applying corrosion-protection coatings, and allows for the use of multiple guns.

Lessons learned from the pipeline industry

The protection of buried steel pipe against external corrosion is mandated by the U.S. Department of Transportation (DOT) for safe and efficient transport of water, oil, gas, and other petroleum products. This is accomplished with protective coatings, in conjunction with cathodic protection (an electro-chemical technique).

From the end of World War II to the early-1980s, steel pipelines were primarily protected using thin, cold-applied tape or coal-tar enamel, commonly referred to as 'hot dope.' Surface preparation was minimal (or nil), with rudimentary application methods like wire brush-cleaning pipe and dope kettles heated with open-flame burners. While there have been several technological improvements, the process remained limited by a lack of quality-control measures, along with concerns over level of surface preparation, weather dependence, and fitness for use.[2]

As a result of leaking pipelines, and occasionally catastrophic pipe failure (sometimes caused by coating failure leading to premature corrosion), the industry moved toward more durable coatings applied in a plant environment. Plants are located within close proximity to the pipe mills, applying such systems as fusion-bonded epoxy, extruded polyethylene and polypropylene, polyurethanes, and multi-layer composite systems. Pipe can be coated regardless of outside weather conditions, often with greater production outputs than on-site application.

Today, plant-applied coatings are common to most new

Catastrophic pipeline failures forced the move to plant-applied coatings. Application can take place regardless of weather conditions, and often with greater efficiency. These techniques are now being adapted to the commercial sector and finding much success.

pipeline projects. These coating systems are designed specifically to withstand handling, transportation, construction, and weather damage. Project specifications are written to detail handling, transportation, and storage procedures, repair and joint-coating procedures, inspection in the shop and on the job-site, as well as quality control and quality assurance (QA) for plant application using current industry standards. Though the initial installation cost can be higher, extending the service life of the pipeline by two years or more could potentially save millions of dollars.[3]

Fire protection of petrochemical structures

The knowledge and experiences gained from protecting pipelines has been applied by the petrochemical industry to protect offshore rigs from fire. The severe conditions of an offshore environment demand a much higher performance level than traditional passive fireproofing materials can provide. Typical requirements include:

- thermal resistance to hydrocarbon fuel fires;
- resistance to explosive force;
- resistance to moisture, salt air, and chemicals;
- high adhesion to steel substrate;
- resistance to mechanical damage during installation;
- weatherability and ultraviolet (UV) light resistance; and
- long-term corrosion resistance.

Considering the locations and construction practices for offshore facilities, large-scale application on-site is impractical, necessitating the use of fabrication shop-applied coatings. Many passive fireproofing materials cannot meet the above requirements, necessitating the development of 100-percent solid epoxy intumescent coatings. Correctly formulated, epoxy-based intumescent materials can retain their fire-performance capabilities over many years with minimal maintenance. This is one of the primary reasons why epoxy intumescent materials have largely displaced cement-based fire protection products for the offshore oil and gas exploration and production industry.

Returning to shore

Although an offshore environment is more severe than a typical commercial building application, the expectations for long-term thermal and corrosion protection of a structural building-frame are similar. Given recent global events, the potential for catastrophic incidents in urban locations has risen, requiring blast-resistance and thermal performance under very severe fire conditions. High adhesion, moisture-resistance, and tougher mechanical resistance help ensure that in-place fireproofing will maintain integrity for the design life of the building.

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While offshore environmental conditions are usually more severe than those a commercial building will face, long-term thermal and corrosion-protection issues are similar.

conventional passive fireproofing material and thin-film intumescent paints:

1. Application is completed in controlled temperature and humidity conditions. This results in a consistent application, but also extends the weather window. Application can be carried out year-round, when conditions at the job-site may be unsuitable for fireproofing application.
2. Coating application is properly controlled and inspected during the process, considering surface preparation, material thickness, equipment efficiency, and application consistency. All activities are documented by auditable QA and QC procedures.
3. In-place material performance is enhanced, resulting in long-term protection and lower maintenance costs.
4. Structural steel is erected faster, resulting in efficient follow-up scheduling of building trades. Project completion is no longer dependent upon the fireproofing application.
5. Job-site disruptions are reduced, with fewer on-site trades, equipment/floor preparation, tarping, and other measures.
6. Job-site exposure to, and disposal of, fireproofing-related dust, solvents, and mineral fibers, is reduced.

In Europe, Asia, the Middle East, Australia, and New Zealand, fabrication shop-applied fireproofing is not limited to petrochemical structures, but is an established commercial building practice. Examples of commercial projects using shop-applied intumescent fireproofing include London, England's Millennium Dome and Wembley Stadium, along with the Jinmao Mansion in Shanghai, China.

Advantages of shop-applied fireproofing

Fabrication shop-application of epoxy intumescent technology has the following advantages over

The shop-application process

Fireproofing is applied in climate-controlled coating facilities located at the steel fabrication shop. Personnel at these facilities are trained in applying plural-component epoxy coatings in a high-production environment. The dedicated floorspace is wide open, with unobstructed access to the steel sections, permitting multiple-gun application for greater production output. The application process is fairly straightforward and similar in scope to most corrosion-protection coating systems:

1. Abrasive cleaning of fabricated steel, to a minimum SA 2-1/2, near-white metal finish.

2. Application of primer if required.
3. Masking of connection areas and end-joints. Generally, 152 to 305 mm (6 to 12 in.) is sufficient for end-joints.
4. Single-pass application of epoxy intumescent fireproofing material, using special plural-component spray equipment. A second pass can be required to achieve higher hourly ratings. Back rolling is necessary when an architectural texture and finish is required.
5. Application of topcoat if required. Topcoat can also be applied at the job-site following steel erection and fireproofing of field joints.
6. Inspection of the application process and fireproofing material as specified.
7. Movement of fireproofed steel sections from the floor to outside padded storage racks, or loaded onto trucks for transportation to job-site.

Epoxy intumescent materials permit a faster application process, due to quicker cure rates and thixotropic properties of the coating. A single pass can yield a film thickness of 2.4 to 3.2 mm (0.095 to 0.125 in.), sufficient for most one-hour fire ratings. Where additional thickness is required, a second pass can be applied within hours of the first coat. In a controlled-climate condition, the epoxy material can achieve full hardness within 24 hours, allowing the steel to be coated in one day and then moved out of the shop for storage, or direct shipment to the job-site.

Arrival on-site

Coated steel arrives from the steel fabrication facility and can be unloaded directly for erection or stored on-site. Steel is handled using nylon web slings, end hooks, or internal eye hooks to minimize potential damage to the fireproofing during handling and erection.

Welded field-joints and completed connections are inspected, then brush-cleaned and primed when necessary. The epoxy intumescent is then either spray- or trowel-applied to the specified thickness. Site touch-up areas are repaired in the same manner, although typically using trowel application. A topcoat layer can then be applied to the desired color or finish.

Notes

[1] See the *Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)* (NIST, June 2005).

[2] See "Heat Fused Polyethylene Coating: A synergistic approach to external pipeline protection" by William Dempster. Proceedings from the Pipe Protection Conference (The BHRA Group, London, England, September 1991).

[3] See "The Reliability and Economics of Polyethylene Coatings" by William Dempster. Proceedings from the Pipeline Reliability Conference (Houston, Texas, November 1996).

Additional Information

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Abstract

The harsh environmental conditions facing off-shore petrochemical structures and pipelines have long made shop-applied fireproofing a material option. Today, the advantages of this method are beginning to reach the U.S. commercial market as well. In addition to improved durability, coating facilities can often produce more efficiently, leading to cost savings.

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