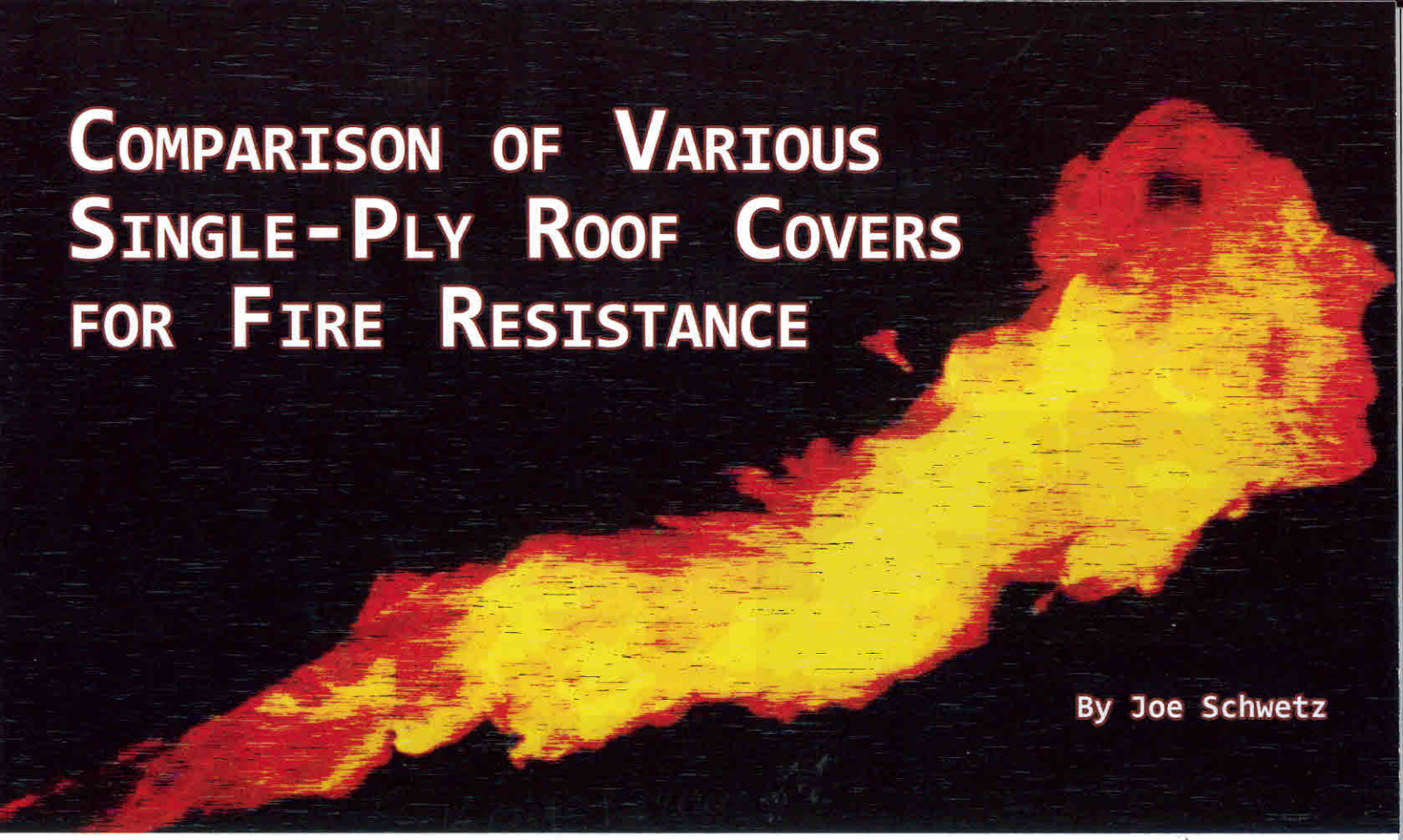
Comparison of Various Single-Ply Roof Covers for Fire Resistance



By Joe Schwetz

The use of controlled fire in domestic applications began approximately 500,000 years ago. This ability to use fire allowed humans to move from the warm tropical areas of the world to the colder climates of Europe, Asia, and the western hemisphere. Fire provided a means to warm the living areas, cook food, and provide light. Fire was instrumental in the development of everyday tools and goods from metals to pottery, which allowed for quicker advancement of mankind. As civilization moved forward, people started to develop densely populated cities, mostly for security reasons, often with individual buildings being connected or sharing common walls. Typically, these structures had beams made from wood, and the roofs were thatch or similar organic material. Chimneys were often generally short with large openings that allowed burning embers to travel to adjacent roofs, igniting the roofing and other materials. As one can imagine, with the lack of equipment or firefighting methods, fires in ancient cities were catastrophic, often resulting in complete destruction of cities.

In 1666, the Great Fire of London burned for five days, destroying approximately two-thirds of the city and leaving over 200,000 people homeless. From this event, the first fire departments and fire insurance companies were founded. The fire led to the first recorded use of pumps to fight fires, ladders to be used for fire suppression and rescue, as well as fire insurance. New building laws stopped the use of timber; required brick, stone, or masonry construction; and widened the streets to limit the damage from flying burning embers. In essence, London enacted the first fire code for buildings.

Fires were also very common in the early days of settlement in North America. In 1631, Boston banned the use of thatched roofs and wood chimneys after a serious fire; New York followed suit in 1648. After a devastating fire in 1653 in which a third of the families in Boston were left homeless, the city required every house to have a ladder and a 12-foot-long pole with a wet swab to extinguish burning embers on the roofs. There were additional requirements and restrictions enacted by the city but to no avail, as the city was devastated at least five more times by massive fires. Throughout the 1700s and 1800s and into the first third of the 1900s, massive, devastating fires continued to plague cities, causing a tremendous loss of life as well as extremely costly property damage.

The insurance industry, after massive fires and economic losses, was instrumental in the development of fire codes. One of the first fire codes used as a type of model code was developed by the national Board of Fire Underwriters, later renamed the American Insurance Association. After a number of fires with large loss of life, such as the infamous Triangle Building fire, the National Fire Protection Association (NFPA) began issuing pamphlets in the early 1900s describing the basic requirements for evacuating or safely exiting buildings. These pamphlets led to the development of the NFPA Building Exit Code, later renamed the Life Safety Code. The safety codes, along with the insurance-driven codes, eventually became the foundation for what is currently used in the International Building Code (IBC), the model code developed by the International Code Council (ICC), which has been adopted throughout the country. The International Building Code covers fire prevention in regard to building construction and design in great detail, while the International Fire Code addresses fire issues concerning operations in a completed and occupied building.

While fire, safety, and building codes in general have greatly improved over the years, losses from fire are still an ongoing issue. "In 2010, public fire departments responded to 1,331,500 fires in the United States," according to estimates based on data NFPA received from fire departments responding to its 2010 National Fire Experience Survey. An estimated 482,000 structure fires were reported to fire departments in 2010.

The NFPA estimates that these fires caused nearly $11.6 billion in property damage. Fires in structures resulted in $9.7 billion in property damage. Of the reported fires, the NFPA estimates there were 3,120 civilian deaths, with the vast majority occurring in residential fires. In addition to the civilian deaths, an estimated 17,700 people were injured in fires during 2010. This is an approximate 3.9% increase from 2009 and the highest total since 2005. (Information taken from the *NFPA Journal*, Sept./Oct. 2011, by Michael J. Karter, Jr.)

The information noted above from the NFPA reinforces the fact that while the frequencies of fires may be declining, there is still a tremendous impact due to losses from fires. Building codes and insurance requirements have been developed and implemented with the intention of minimizing fire loss.

One of the most vulnerable components of a building when exposed to fire is the roof. Roof systems can burn from within the building or from the topside down. Fires from within are more complex, with a multitude of building systems that may influence the fire. External fires affecting the roof are generally simpler, as there are fewer components within the roof system. Codes require that roofing systems be tested and classified to meet certain requirements, depending on the building use and occupancy.

There have been various forms of fire codes and insurance requirements for fire protection since colonial times. What was lacking for construction materials – specifically roofing products – was a method to

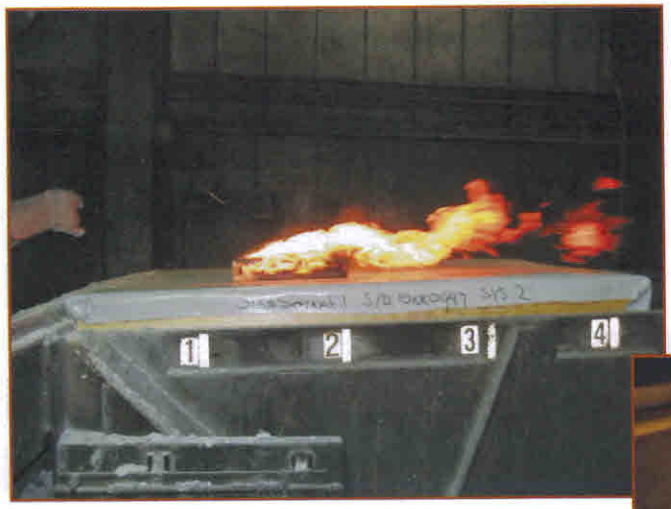


Photo 1 – Burning brand.

Photo 2 – Intermittent flame.

Photo 3 – Spread of flame.

test products when exposed to fire. It is believed that the first fire test for roofing products was developed by Underwriters Laboratories, Inc. (UL) in 1903. This UL test protocol standardized the evaluation of roof coverings' ability to withstand ignition, flame spread, and fire penetration from external fires. In 1910, a new standard developed by the NFPA was adopted that set classifications for roof covers. This standard had three tests: flame exposure, burning brand, and a radiation exposure. The standard also included an investigation to determine the quality of the raw material, weathering, and reparability of the roof coverings as applied to the roof system. There were continuing adjustments and refinements to the fire test standards and reporting up to 1955, when ASTM Standard E108, *Standard Test Methods for Fire Tests of Roof Coverings*, was adopted. The last major changes were made to the standard between 1970 and 1975, mostly with regard to format and test criteria, which are the basis for the current version.

ASTM E108, which is essentially the same as UL 790 and NFPA 256, evaluates the relative fire characteristics of roof coverings when exposed to external fire sources.

There are three classifications defined in the standard: Class A, Class B, and Class C. The Class A rating is for roof coverings that can withstand severe test exposure, afford a high degree of protection to the roof deck, will not slip, and do not generate any flying brand or embers. Class B ratings are for roof covers that can withstand moderate test exposures, in that they afford a moderate degree of protection to the roof deck, will not slip, and do not generate any flying brand or embers. Class C ratings cover light test exposures and afford a light degree of protection to the roof deck, will not slip, and do not generate any flying brand or embers.

This test standard measures the ability of the roof covering to protect or resist fire from penetrating from the topside of the test deck to the underside. The roof fire penetration tests include the burning brand test (*Photo 1*) and the intermittent-flame-exposure test (*Photo 2*). The standard also measures the distance a flame can spread along the top surface, the spread-of-flame test (*Photo 3*), a nonpenetrating test. If the intent is to test a roof covering over a combustible-type roof deck, then all three tests are done. When the roof deck is noncombustible, such as concrete or steel, or if a combustible deck assembly uses a specific type of gypsum board or similar approved thermal barrier, then only the spread-of-flame test is conducted.

The spread-of-flame test uses a constant flame source and a steady air movement to determine the potential for fire to spread across the surface of the roof cover. The maximum length allowed that still achieves a class A rating is six feet, class B is eight feet, and class C is 13 feet. In all cases, the fire cannot spread laterally to either edge of the test sample.

The main variables in the E108 test method are the components of the roof covering buildup and the slope of the deck. This test method provides a means for comparing roof-covering materials as tested according to the standard. There was some concern with the fire test standard as noted in the MRCA and NRCA report dated January 2006. Prior to this report, the MRCA and NRCA did a series of evaluations of aging on 109 polymer modified-bitumen roof systems. During the study, beginning in 1991, they realized fire resistance is an important attribute for roof covers. In 1996, the MRCA did a limited fire test program following the spread-of-flame method from ASTM E108. Four of the roof systems from the study were tested, with half passing. Based on the results, the MRCA conducted additional fire tests on aged materials in 2001, again to see if aged roof systems maintained their listed fire classification or rating. In this study, ten samples were taken from five different roof-covering categories: coated modified bitumen, granular-surfaced modified bitumen, PVC, TPO, and EPDM. All systems were believed to have been installed as classified fire-rated systems. From this round of testing, five of the test decks passed the spread-of-flame tests: both PVC systems, one from each of the modified bitumens, and one EPDM.

In an effort to better understand the failure of the rated EPDM and TPO materials, the MRCA and NRCA conducted additional fire test evaluations, this time with new and aged systems using these membranes. They wanted to see if the aged roofcover systems would maintain the listed fire classification, as well as verify that new roofcover systems would meet the listed ratings. This round of testing evaluated 34