THE HAZARDS OF MEMBRANE ROOF FIRES

BY FRANK C. MONTAGNA

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On arrival at the scene of a recent roof fire involving a multi-occupancy, one-story, noncombustible building that measured 550 feet by 750 feet, heavy black smoke was billowing down from the roof. It was the type of smoke you would expect to see rising from a pile of burning automobile tires. The occupants had reported a fire on the roof.

We checked for fire inside the building and found none. A 2½-

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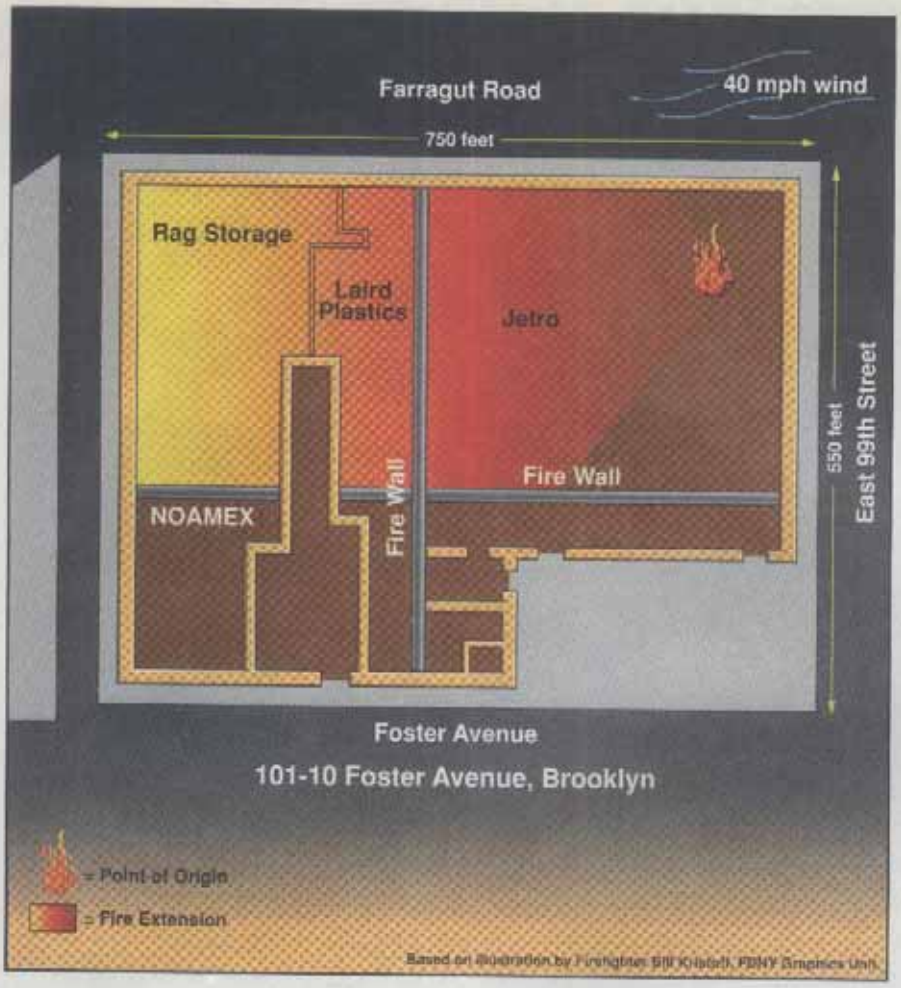
(Top) A firefighter watches as fast-moving membrane roof fire passes him. As the large fire front passes him, it leaves in its wake spot fires not unlike the aftermath of a brush fire. Note that the fire is contained by a small partition rising several inches above the roof. (Bottom) The fire ran the entire length of the 750-foot roof in about 30 minutes. (Photos by author.)



inch handline was stretched up the aerial ladder to the roof. There, on a roof larger than two football fields laid end to end, a 25- × 150-foot area on the southwest corner of the roof was burning. The flames leapt skyward some 15 feet above the roof, even though they were pushed eastward by winds gusting to 40 miles an hour. The handline's stream fell short of its mark. More line was needed. As the first units attempted to advance the handline, the area in front of the wall of fire appeared wet, and then suddenly ignited, doubling the size of the fire area. In a short time, the roofing in front of this new fire area looked wet. The fire proceeded in this manner, leaving in its wake a scorched rooftop sporting numerous small spot fires, not unlike the aftermath of a brush fire.

The firefighters could not catch up with the advancing roof fire. They had to settle for following behind it, extinguishing small smoldering fires left behind in the fiberboard insulation.

The Q-deck roof and supporting bar joist were not structurally compromised by the roof fire. However, several spot fires started inside the building, the result of the tar's melting, igniting, and dripping fire onto the well-stocked shelving units below. The sprinkler system contained these spot fires. Several interior handlines finally extinguished the fires.

Ultimately, the entire 750-foot length of the roof was consumed by the wind-driven flames. The flames had no problem jumping a partition that ran the width of the roof and extended three inches above the roof surface, but they did not jump a similar partition running lengthwise. I attribute this selective extension to the wind's direction and velocity.

THE ROOFING MATERIAL

The roofing material, the consistency of a bicycle's inner tube, was not glued down. It seemed to be stapled down. As the wind blew, it rippled like pond water on a breezy day. The driving wind ripped up portions of the burning roofing and insulation and blew them ahead of the main body of fire, creating a severe brand problem. At one point, the wind-driven brands were so plentiful that, at ground level, it was difficult to walk facing into the wind.

Multiple alarms were transmitted. Aerial platforms attempted to set up ahead of the advancing fire. The building's size, the high wind, and the speed of the advancing fire made these efforts ineffectual. The fire consumed the entire length of the roof within 20 to 30 minutes of my arrival. Video taken from a traffic helicopter was broadcast on the evening news. Those who saw that broadcast agreed that the fire looked like a gigantic brush fire. From my perspective, as mentioned above, the fire behaved in the same manner as a large brush fire.

This was my first experience with rubber membrane roofing, and it was not a good experience. I knew little about this type of roof when I arrived on the scene. The evening I spent fighting this fire taught me that this roofing burned quickly and presented a monumental extinguishment problem on a large roof. I decided to find out more about the roofing material. Unfortunately, not much has been written on this topic for the fire service.

SUGGESTED PROCEDURES

I realize that my experience may not be that of a typical flexible membrane roofing fire. The wind conditions undoubtedly dramatically affected the speed and direction of extension. The size of the building allowed a huge fire front, accompanied by tremendous radiant heat, to develop. My perspective on this category of fires is based predominantly on this one incident. Based on this experience, I offer the following for firefighters encountering a membrane roof fire.

- Before committing firefighters to the roof, check to make sure that the fire did not originate inside the building or spread into it. Fire inside the building can affect the roof deck as well as the roof supports.
- Find out what type of roof support system is under the roof. Is it Q-deck and bar joist or wood and joist or wood truss? Is the fire burning down into a wooden roof deck, or is liquid fire dripping through a metal deck onto the stock below? If fire is found burning beneath the roof and if the roof is supported by a lightweight wood or metal truss or a wooden I-beam, expect early roof failure, and exercise extreme caution if committing firefighters to the roof.
- Try to get large-caliber streams set up ahead of the fire area, but also consider what effect the weight of the water—applied by large-caliber streams—will have on the stability of the roof structure. To successfully stop and extinguish a spreading membrane roof fire, water must be put both on the burning roofing as well as on the roofing being preheated by radiant heat. Depending on the

amount of roofing already burning, this might encompass a large area. Set up aerial platforms well in advance of the spreading fire. Use their master streams to apply large quantities of water to the roof.

If possible, set up apparatus on two or three sides of the building. Successful and timely implementation of this tactic may prevent the preheated area from flashing over, thus stopping the fire's advance, but it must be done quickly and requires an early, heavy commitment of personnel and apparatus. If the fire spreads as quickly as the one described above, you will be hard pressed to get the apparatus in position and supplied with water in time to have the desired effect. Like a brush fire, this fire can pass you by as you are setting up your apparatus. Also, be aware that firefighters in an aerial platform ahead of the fire may be exposed to radiant heat, noxious smoke, and flying brands.

• If burning liquid tar is dripping into the occupancies below, inside lines will be needed to extinguish the resultant spot fires. The reach of a 2½-inch line could be useful in high-ceiling occupancies and in cooling a large area of roofing. If the occupancy is large, a heavy commitment of personnel will be needed to advance the line. The mobility of a 1¾-inch line might make it a better choice for extinguishing interior spot fires. If the roof's stability is in question, either from the fire below or the weight of the water on the roof, you may not be able to place lines beneath the involved area.

• Do not allow firefighters to operate in front of the advancing fire front. This type of roofing is often used on large-area roofs; it might be too time-consuming and therefore not practical to remove the roofing. While removing the roofing in front of the advancing fire could stop the fire's spread, having firefighters work in front of the spreading fire could be dangerous. Firefighters could be driven off the roof by a rapidly spreading fire. In one instance I heard of, a rapidly spreading membrane roofing fire forced a firefighter to jump off the roof.

• Consider that if a driving wind is not present, radiant heat might simultaneously preheat and ignite the roofing on all sides of the burning roofing and that the spreading fire might radiate about in all directions instead of just one direction as in the incident described above.

• On a Q-deck roof supported by bar joists, the roofing might well burn and leave the roof structure unharmed. That was my experience. After the membrane roof fire, most of the building's occupants were open for business the next day. I cannot imagine that being the case after an extensive roof fire in a wood-joist building or a building with a wooden roof deck. At the fire, the only occupancy to sustain substantial damage was a rag factory, which was damaged by the dripping, burning tar that burrowed into the high stacks of bundled rags, making them difficult to extinguish. In addition, the sprinklers thoroughly soaked the piles and made them swell and become unstable. From that point, everything you have read about absorbent stock came into play and turned the fire into a prolonged operation. The soaked bales pushed out an exterior wall, and the high stacks of baled rags threatened to collapse. Extreme caution was necessary. As a result, the operation continued into the next day.

• Consider letting the membrane roof burn off while concentrating firefighting efforts on the inside of the building and the exposures. Based solely on my one limited experience, this would not

(Top left) EPDM roofing held in place by a metal fastener. (Right) Mod bit membrane roof being torched in place. (Bottom left) Firefighters cutting a mod bit membrane roofing on a Q-deck roof. First, they cut the membrane, then they must cut and pull up the fiberboard insulation. It is an arduous, labor-intensive task. The fiberboard smoldered and spread underneath the membrane. Cutting and pulling over a large area was required to ensure extinguishment.

adversely affect the structural stability of the metal deck roof supported by metal bar joists. Despite our best efforts and five alarms, we did not stop the fire's spread on the roof. Letting it burn while protecting exposures and extinguishing interior spot fires might be as productive as or more productive than trying to extinguish a rapidly spreading membrane roof fire.

• Using inside lines to cool the underside of the roof deck at this fire stopped the melting and dripping of the flaming tar-like adhesive. [The result of applying streams from below is described by Francis L. Brannigan in *Building Construction for the Fire Service, Third Edition* (National Fire Protection Association), page 302; Figure 7-21 shows dripping tar being frozen by the application of water from below. The stream, in addition to freezing the dripping tar, will cool the underside of the roof deck, reducing the generation of flammable gases.]

• The day after the fire, roofers removing the burned fiberboard insulation found smoldering insulation that ignited when pulled up from the roof. At a recent fire involving a smaller membrane roof, smoldering insulation was found after the operation had been concluded. The fire, which had originated below the metal deck roof, ignited the insulation and tar on the roof. The membrane roofing, a type that looks similar to traditional built-up roofing, was not a significant factor at this fire. The insulation continued to smolder after the fire was extinguished. This insulation must be pulled up for some distance beyond the obvious fire area. The fire burrows underneath and into the insulation, consuming the adhesive and igniting the underside of the insulation. It can smolder there for some time. When exposed to air, the insulation flares up. In both cases, the quantity of water needed for complete extinguishment of the insulation was minimal. Depending on the size of the roof and the area affected, a substantial number of personnel may be needed to pull up the insulation; they must be careful not to cut the bar joists supporting the deck.

• There have been reports that cutting a membrane roof with a carbide-tipped saw will cause the blade to become gummed. I have spoken to several firefighters who have done that. Their experience was that the saw worked just fine and was not adversely affected by the membrane roofing.

• A week after the above membrane roof fire, roofers repairing the damaged roof ignited the new roof as they were torching a seam. This time, the resulting fire did not reach the magnitude of the previous one. The lack of high winds or the roofers' rapidly notifying the fire department may have made the difference.

• The torch work required to install or repair some flexible membrane roofing is a common source of ignition. We must consider the potentiality that flames may trap roofers on the roof. If this

should occur, we must concentrate our efforts on protecting and rescuing them.

Another thing to consider is that propane tanks and flammable adhesives are likely to be present on the roof. It may be necessary to direct cooling streams on exposed tanks or to remove them to prevent tank failure and the resultant release and ignition of the gas.

The above are suggestions, not dogma. Hopefully, testing will be done on this roofing material and the tests will provide more definitive information on what we can expect in a fire involving membrane roofs. Also, as others gain experience with membrane roofing and share their experiences, we will all learn.[4]

TYPES OF MEMBRANE ROOFING

The brief descriptions of various types of membrane roofing that follow are based on information from the Web page of the Single-Ply Roofing Institute (SPRI). All of the articles from which the information was taken tout the admirable qualities of this type of roofing and do not address the products from a firefighting perspective.

Traditional commercial roofing is composed of the familiar layers of felt and rolled asphalt. It is attached to the roof by a tar-like "glue." Over the years, the roof can accumulate several layers of this roofing. This type of roofing tends to crack over time from exposure to intense heat and cold. An alternative roofing material, called flexible membrane or single-ply roofing, is composed of a single sheet of flexible synthetic material (some are composed of several factory bonded layers). There are a number of different types of membrane roofs as well as various methods of fastening them.

According to the SPRI, the three major categories of membrane roofing, which have variations within each category, are thermoset, thermoplastic, and modified bitumen.

• *Thermoset.* Made from rubber polymers, the edges of this type of roofing are overlapped and sealed with an adhesive liquid or tape. One popular type of thermoset roofing membrane is ethylene propylene diene terpolymer, or EPDM. This was the roofing we encountered at the fire described above. It was like a large sheet of bicycle inner tube.

EPDM was initially used as a pond liner but was adapted for roof surfacing in the early 1970s. It stretches without tearing and handles extremes of temperature well. It "will remain flexible down to −49°F and resist heat up to 300°F without cracking or deforming." As Joe Bublick, a roofing contractor and builder in Toledo, Ohio, describes it: "EPDM also has a good fire rating, and is available in a fire-retardant-treated version ... I use it on flat roofs or low-slope roofs ... it can be covered with a wood deck on pressure treated sleepers, with outdoor carpet or Astroturf®, and even with concrete pavers .... EPDM can also be painted ...."[5] According to Bublick, the roofing comes rolled in 20-foot widths. It is fastened with a contact cement-like adhesive. The seams are fastened adhesive or seam tape. Another thermoset product is Hypalon®, a synthetic rubber roofing that cures after installation. Hypalon® seams are fastened by welding.

• *Thermoplastic.* This type of membrane is made from plastic polymers including polyvinyl chloride (PVC). The thermoplastic membrane seams are sealed with heat or chemical welding. This type of roofing material was used in Europe as early as the 1960s.

• *Modified bitumen.* This type of membrane or "mod bit" is a melding of new and old technology. Composed of asphalt flux, polymer modifiers, and fiberglass reinforcements, it can contain various fillers, fire retardant additives, and surfacing such as ceramic granules and metal foil skins. Used in Europe since the 1950s, modified bitumen roofing began showing up on roofs in the United States in the mid-1970s. The SPRI claims that by 1987 it could be found on 15 percent of commercial roofs and that by 1995 it was on 22 percent. It can be fastened, depending on type and application, by mopped hot asphalt, by adhesive, by torching the asphalt, by cold process adhesive, as well as by self-adhesive.

There are a number of ways of fastening membrane roofing to a roof deck including ballast, mechanical fasteners, and adhesive that can be asphalt or of a water or solvent base. Because of the variety of ways the roofing can be fastened, it is used on many different types of roofs. According to the SPRI, membrane roofing is suitable for flat, sloped, and domed roofs. It is used on industrial buildings, airports, huge factories, small strip malls, fast food and convenience stores, schools, museums, and hospitals. I have encountered it installed on newly constructed flat-roofed private dwellings. According to *BUILDINGS Magazine:* "...42% of owners with new buildings and 52% of those undertaking retrofit and re-cover projects ..." are choosing flexible membrane roofing.[1]

Although membrane roofing has been around for some time, it is new to me and to many fire service members with whom I have spoken. I fully expect that there will be more membrane roofing fires. Hopefully, my experience with this type of roof will not be the norm. The EPDM roof fire in the above incident spread much faster than the fire-rating tests would have indicated. Neither was that the experience of another firefighter who related his encounter with a membrane roof fire to me. At that incident, fire was venting from below the roof. He explained that the membrane roofing was slow to ignite but that once it ignited, it spread across the roof rapidly.

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Editor's note: Consider this: There are a variety of these types of roofs with a corresponding variety of fire ratings—they may be Class A- or B- or C-rated (based on test standards) or not rated at all. It is not possible to look at a roof and determine its fire rating. You must talk to the installing contractor and the building inspector to classify the roof as to its fire rating (or lack thereof). Also, be aware that the method of attachment and substrate (including insulation) affects the flame spread across the surface of the roof. The bottom line is, try to do as much research as possible while preplanning to anticipate the type of fire you may encounter, and be prepared to *commit the appropriate resources for the worst-case scenario.*

The fires described herein point to a glaring inconsistency between standardized tests, the building codes, and the actual performance of the roof material during fires. The existing test criteria and building codes must be reviewed and modified to reflect actual performance of the roofs in the field.

* * *

Since this fire, I have encountered other fires that involved roofing material that I believe were membrane roofs. The problem is

that I am not sure. It is easy to recognize the EPDM roof attached by metal fasteners, as was the case at the above fire, but the mod bit roof is not easy to identify. Mod bit can easily be mistaken for traditional built-up roofing. Even as you stand on the roof in daylight, it can fool you; at night in a smoke condition, it is almost impossible to positively identify.

One fire that I believe may have involved mod bit roofing proved difficult to extinguish. It was a fire in a commercial occupancy that was fought with an exterior attack after an attempt at interior operations failed. The burning roofing gave off unusual amounts of thick, black smoke. As the fire, which seemed to be burning underneath the roofing, burned, sections of the roofing's surface would flash over.

Several aerial platforms seemed to have no effect on the burning of the roofing. The membrane roof (if that is what it was) did a good job of keeping the water from reaching the subsurface fire and although it could extinguish the surface fires, they would reignite quickly if the stream was diverted or shut down. As the fire burned, segments of the roof burned through and collapsed. It seemed that the fire would go on forever, producing large quantities of the choking smoke. Finally, it was decided to just let the roofing burn off the building. This is not our usual tactic, but letting it burn, it was decided, would substantially shorten the duration of the fire and reduce the amount of smoke produced. The constant application of water seemed to only lengthen the time it took for the roof to burn off without substantially reducing the quantity of smoke produced. We monitored the flames and doused them with water when they threatened the exposures.

I was told of another fire on the top floor of a high-rise housing project. It had a concrete roof covered with membrane roofing (I don't know the type). During the fire, the roofman reported that the roofing was bubbling. Apparently, heat from the burning apartment was passing through the concrete roof, possibly through cracks resulting from the settling of the concrete, and heating the roofing. The roofing did not ignite, but imagine if it had. The roofman was on a roof above the reach of ladders. There was only one stairway and hence only one means of egress. What if the roofing had ignited, cutting him off from the bulkhead door? Where could he have gone for shelter as the roofing burned?

Another incident I learned of involved a wood deck roof and possibly membrane roofing. When fire units arrived at the scene, fire was showing on the roof. A check of the interior of the building revealed no fire in the building. This fire was confined to the roof. It burrowed under the roofing, breaking out here and there, seemingly unaffected by the aerial platform streams attempting to extinguish it. This fire became an exterior attack due to the absence of fire within the building. An attempt had been made to cut up the roofing and extinguish the hidden fire with handlines, but it was unsuccessful. Again, the membrane (if that is what it was) did a good job of keeping the water away from the fire and supplying fuel to the flames.

When do we need a protective line on the roof? When can the roofman expect the roof to flash over quickly? When should roof operations be suspended? These are all important questions for which I do not have definitive answers, but it is crucial that we learn the answers. We must be able to identify the type of roofing and then we must know its behavior when involved in fire. Will it

If you have had any type of fire experience with membrane oofing, please send to *Fire Engineering* a brief description of our observations, the tactics employed, and the effects of hose tactics. ■

h over? Will fire burrow under it? How do we find out, and at do we do in the meantime?

Tests should be done on the various types of membrane roofing their burning characteristics should be documented.

The presence of membrane roofing must be noted, the type of mbrane determined, and this information included in prefire nning. It is not likely that this information will be available or urate if the first time a firefighter sees the f in question is when it is burning. If you cover a membrane roof or a roofing erial you suspect to be membrane, try to l out who installed it. You may be able to ermine from the installer or the building ner or occupant what type of roofing was d.

Protective roof lines must be gotten to roof quickly if the roofing is membrane l roof operations are contemplated. owing the type of membrane and its avior when exposed to fire will assist in iding whether to operate on the roof. We not know if all membranes pose an sual hazard. Some certainly do; others y not. This must be determined by testing by relating fire experiences.

Membrane roof fires must be document- and the lessons learned at them dissemi- ed throughout the fire service. In this way, can include this information in our fire- und decision making.

Not all membrane roofing will cause prob- s, but some surely will, and we must ckly learn to identify the problematic es. A cautious approach to roof operations do or could involve membrane roofing is isable. The possible presence of mem- ne roofing is not a reason to suspend all f operations automatically, but it is a rea- to review tactics and ensure the safety of f firefighters.

Multiple points of egress should be pro- ed for firefighters operating on all roofs, because of the possibility of rapid fire ead, this is especially true of membrane fing fires. Aerial and portable ladders uld be positioned to provide this egress.

If the fire is burning up through the roof, a f line should be in place to protect the roof es from a fast-spreading roofing fire. It y be advisable to have a line on the roof as f-cutting operations are in progress. This l be a personnel-intensive job and will not ossible at all fires. In any case, at the first n that the roofing is becoming involved, f firefighters should be ready and able to exit the roof if there is no protective line or if the protective line is ineffective.

Until we learn what to expect from this type of roofing, we will continue to be confounded by how it behaves at a fire. Being surprised at a fire is a good way to get hurt. We were at one time surprised and confounded by trusses, and firefighters were injured and killed. Let's not be surprised by membranes. ■

Endnotes

1. For additional information on membrane roofs, see also "Venting Single-Ply Roofs," Tony Papoutsis and Scott Reichenbach, *Fire Engineering*, Feb. 1992, 29.

2. "Installing EPDM Rubber Roofs," Joe Bublick, *Journal of Light Construction*, Nov. 1996.

3. "Flexible Membrane Roofing Systems," *BUILDINGS Magazine* (Buildings Online), April 1996; http://buildings.com.