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Introduction

We are fortunate this month that our guest editorial, by Vyto Babrauskas, addresses a key issue in fire protection: advances in smoke alarm technology.

This should also serve as a reminder to all of our readers that the editorial page always remains open for volunteers who would like to contribute ideas intended to help develop fire technology or improve fire safety.

This issue marks the end of the third year of the Fire Safety & Technology Bulletin. I do not want to miss this opportunity to wish all of our readers a Great and Happy New Year and a Wonderful 2009.

Marcelo M. Hirschler

Editorial

Smoke Detectors: Technologies Are NOT of Equal Value nor Interchangeable

By Vyto Babrauskas, Ph.D.

"Smoke alarms of either the ionization or the photoelectric type consistently provide time for occupants to escape from most residential fires." (NIST report Tech. Note 1455-1, February 2008). This message has been delivered to the American public by many institutions over the years, especially NIST. Unfortunately, the message is incorrect, misleading, and has been an active obstacle towards providing better life safety in American residences.

In slightly more detail, the traditional message has been saying that ionization detectors respond more quickly to flaming fires, photoelectric detectors respond more quickly to smoldering, but you don't know which type of fire you will have, so your odds are just as good with either technology. This statement is incorrect for two reasons:

(1) people do not have an equal need for being warned of smoldering, versus flaming fires; and

(2) there are huge differences between the warning time advantages in the two cases. So we need to consider these issues in more detail.

Smoke detectors (smoke alarms) by themselves do not put out fires, their only function is to sound an alarm. A person will most notably need warning if he is asleep. If the person is awake, he is both more likely to observe the fire without the benefit of a smoke detector, and he will also be in a much better position to safely make his exit.

Surprisingly, the US fire statistics reporting system (NFIRS) does not ask the question if the fire originated in a flaming or in a smoldering mode. But the experience of fire officials and fire researchers is that if a fire occurs when the occupants are asleep, it is much more likely to start out as smoldering rather than flaming.

Smoldering fires originate from cigarette ignitions, many electric wiring problems, and numerous types of furnace, fireplace, fluepipe, and chimney malfunctions. Conversely, flaming fires are most typically associated with activities of an awake, alert individual. These include cooking (by far the most common cause of all house fires, although a very high percentage of these fires are never reported), improperly fueling a fireplace, and actively using open flames in the household.

It is not uncommon for fire investigators doing a reconstruction test of a smoldering fire to find that an ionization detector will never sound, although the smoke has gotten so bad that a person cannot see their hand in front of their face. But when ionization detectors actually do work in a smoldering fire, the response is generally extremely slow. In the NIST study mentioned above, photoelectric detectors used with smoldering fires gave 31 minutes more warning, on the average, than did ionization detectors. By contrast, in the same study, for flaming fires, ionization detectors gave only 48 seconds more warning.

This is a huge disparity, and it does not justify the claim that neither type has an overall advantage. It is also not a new finding. In 1978, researchers at the Fire Research Station in England (Kennedy et al.) ran smoldering-fire tests and found that photoelectric detectors gave warning on the average 113 minutes before ionization detectors did. Another study (Schuchard, 1979) found that for smoldering mattress fires, photoelectric detectors sounded an alarm on the average 59 minutes quicker than did ionization detectors. A study organized by NFPA (Drouin and Cote, 1984) found a 68 minute faster photoelectric detector response in the case of a smoldering fire, but only a 12 second faster ionization detector response for flaming.

The latest results are from experiments by the National Research Council Canada (Su et al., 2008) involving 11 flaming house fires. These showed an average 16 s alarm time advantage for ionization detectors, compared to photoelectric. Thus, it is clear that photoelectric detectors will provide a huge advantage in smolder fires (30 minutes to 1 hour, or more), while ionization detectors provide a trivial advantage (a few seconds) in flaming fires.

By the way, proponents of ionization detectors sometimes argue that, even though the time advantage of ionization detectors for flaming fires may be very small, it is still an important advantage since flaming fires reach untenable conditions much more quickly. This is a specious argument, since it fails to take into account human behavior. In a real fire emergency, individuals do not behave in a robotic fashion, moving quickly and directly to the correct exit. Instead, they are most likely to engage in numerous activities before proceeding to the exit and may, even then, choose a poor exit. Minutes, not seconds, are generally likely to be needed before all the occupants of a house have successfully exited. In the context of that reality, a time difference of 12-48 seconds is very unlikely to make the difference between life and death.

The NIST policy of claiming that detector technologies are interchangeable, as far as occupant protection goes, is actually very old. Their original "Indiana Dunes" studies of 1975-77 contained the same conclusions. At the time, this was a reasonable conclusion, since (a) most houses did not have any detection and it was considered that any type of detector has to be better than nothing; and (b) during that era, battery-powered photoelectric detectors were not yet available, while battery-powered ionization detectors were. Since the initial push had to focus on retrofits, rather than new housing, it was essential to not discourage householders from installing ionization detectors. But battery-powered photoelectric detectors have now been available for more than two decades; consequently these original reasons have lost all of their validity.

An additional reason why photoelectric detectors should be preferred has to do with false alarms. A large fraction of fires that become serious involve homes where a smoke detector once existed, but was then disabled. This is most commonly due to excessive false alarms. A study in Alaska (Fazzini et al., 2000) found that false alarms are 9 times more likely to be experienced for houses with ionization detectors, as compared to photoelectric ones.

For a number of years now, consumers had the ability to buy a combination sensor detector, where both ionization and photoelectric detector elements are incorporated into one device. Theoretically, such a detector would be the ideal detection device. In actuality, this turns out not to be the case. Evidently most of the manufacturers made the unfortunate decision in designing these units to focus on false alarms rather than on detection time. The consequence is that these dual-mode detectors do not offer the early-warning advantage that they would be capable of, if appropriately designed.

It is sometimes argued that photoelectric detectors should not be promoted because their retail price is roughly double of the ionization detectors. This is not a reasonable claim, since even with the price premium, a photoelectric detector can easily be purchased for $20.

But the price difference is solely a chicken-and-egg question. Photoelectric technology does not require costlier parts to make the unit, nor is it more complex. But single-station ionization detectors currently outsell photoelectric detectors by around 20:1. Consequently, manufacturers charge more for photoelectric units, simply because the market is much smaller. Interestingly, in commercial occupancies, central-panel type smoke detectors are predominantly photoelectric, rather than ionization. But this does not have a large effect on fire fatalities, since, if an individual dies in a fire, this is overwhelming likely to be at home and not in an office, workplace, school, or other non-residential occupancy.

Very recently the situation is beginning to improve, due especially to the efforts of Jay Fleming, Deputy Chief at the Boston Fire Department. Chief Fleming found that there were recurring fire fatalities in Boston which could have been prevented had the occupants used photoelectric, instead of ionization detectors. Thus, for a number of years he campaigned to introduce requirements mandating photoelectric detectors.

Fleming's efforts are now starting to bear fruit, primarily in the Northeast. A number of jurisdictions have recently issued regulations which will require photoelectric technology. Details of these, along with an engineering analysis of problem will be given in a paper (Babrauskas, Fleming, and Russell) at the Fire and Materials 2009 conference in January (*see Calendar)*.