

Fire Engineering®

New Technology to Improve Firefighter Safety & Efficiency

by Jerry Knapp

From the personal protective equipment e-Newsletter, sponsored by



As your truck turns the corner, you see fire pushing out one window of a single-family house and heavy smoke turning to fire out a second window. It is 0232 hours, the house is in a good neighborhood, two cars and three bicycles are in the driveway, and a kids' playhouse and a street hockey goal are near the garage.

Your halligan and flathead ax make quick work of the door. Using your thermal imaging camera (TIC), you lead your team in, up the stairs, and into the bedroom. You see the outline of a child; your partner quickly grabs her, and you exit the building.

Consider the technology you used at this fire: a halligan, a tried and trusted tool; and the TIC, which allowed you to see through the smoke to make the rescue--unimaginable just 10 years ago. You needed both tools to succeed at this call. Imagine if you had neither.

This is the fire service of today, a mix of super technology and trusted tools. How will we get to tomorrow if we don't experiment with new technologies today?

Today we take for granted that interior firefighters have SCBAs and radios. In the 1970s, although we had a few masks on the rig, there was great resistance to their use because of the increased weight, decreased mobility, and decreased visibility. Similarly, radios were large brick-like devices that often were frowned on by "real firefighters."

We must constantly be willing to try new technologies. Some will fail, but we will never know unless we try. Others will take their place next to the TIC and halligan and become tools we cannot live without. As *Fire Engineering* reported in the May 2008 issue, NIST is experimenting with a variety of new technologies for the fire service funded by million-dollar grants. Often these technologies are years away from field testing and fire department use, but we need to keep experimenting. The goals are improved safety and fewer line-of-duty deaths.

Affordable Technology

Captain William R. Mora of the San Antonio (TX) Fire Department published a study on U.S. firefighter disorientation in July 2003. In a more recent publication, Mora summarized the value of company integrity relative to firefighter safety: "In the ongoing effort to prevent structural firefighting fatalities, assistance in the form of affordable and effective technology is now urgently needed. Studies have clearly shown that far too often, traumatic firefighter fatalities in structure fires were directly associated with a loss of visibility within the structure. The loss of vision was understandably also shown to have caused loss of company integrity. In fact, according to the U.S. Firefighter Disorientation Study, 1979-2001, company integrity was lost in 100% of 17 national disorientation incidents examined. It is important to note that maintaining company integrity is associated with effective fireground operations and is also widely regarded as the firefighter's safety net. Lose company integrity, and you not only lose the structure, you may also lose firefighters."

Read the [Worcester](#) and [Charleston](#) NIOSH reports if you have any doubt. Seeing and being seen during an aggressive interior fire attack or search and rescue can make the difference between life and death.

Consider also from an individual firefighter's perspective: Say you are inside a building. Suddenly, because of the heavy smoke condition, you cannot see other members of your company. What do you do? You obviously will move to a safer position, to find other members, or to get to a window or door. In a larger structure, such as a warehouse or furniture store, moving may actually take you away from your hoseline or your company members. If you were visible to your company members, a simple grab for your arm or foot may have made the difference between your survival or death. If you were able to hook up with another company member because you could see him or he could see you, you would have had a better chance of finding your way to safety. Seeing others and being seen improve your safety.

Crew Integrity

Remaining in contact with your company members is essential to crew integrity, efficiency, and safety. Verbal communication is one way to remain in contact but provides limited results in reduced visibility. Contact with a search rope or hoseline is effective, but has its obvious limitations, especially if you lose contact with the rope or hoseline.

Experiments with personal strobe lights, chemical light sticks, and light-emitting diodes show that they all offer some degree of visibility in smoke. Although under closer review, the aforementioned technologies present critical design limitations, which inevitably prevents optimal visibility of members in smoke.

The thermal imaging technology has been the most recent addition to our tools. Obviously, it is a huge leap forward but it certainly is not available to every fire department or every firefighter inside, and it even has limitations.

All interior firefighters carry a hand light, but it has limited use in medium or heavy smoke conditions. Like high beams on a foggy night, it does a good job at lighting up the smoke directly in front of you. Of course, this is a vital tool that has served well for decades, but you must direct it where you want better visibility and it takes away one hand from a firefighter who may need two hands for tasks such as victim removal. Personal lighting systems exist that are hands-free, be it as a right angle chest flashlight or a helmet-mounted light, and they help to improve immediate work area lighting.

The hand light has been especially useful in combination with retro-reflective trim. However, dense smoke conditions will obviously hamper the visibility/effectiveness of this reflective material-you need a high-powered focused light source pointed at the material for it to be visible.

In some instances with a moving body, the reflectivity of the material only lasts a few short seconds at best.

A PASS device can help you find and locate downed firefighters but it does not activate until a firefighter does so or is already down. The current audible PASS device helps in identifying that there is a problem. Experience has shown that it is not easy to locate the direction or source of the alarm in some open areas and balloon structures. You may be on the second floor and hear a PASS device going off in the attic when actually the firefighter in distress was in the basement.

Optically Enhanced Illumination

A promising technology that provides a way to identify firefighters inside even in dense, heavy smoke conditions is optically enhanced illumination, which is generated by an illumination technology known as electroluminescence, or EL. The military has used this technology for several years to identify airfields and way points for attacking or returning aircraft. This technology was especially beneficial when aircraft needed to locate landing zones in haze, fog, or sandstorms. If the military can benefit from this during low-visibility conditions, why can't the fire service?

Electroluminescence is an ambient light commonly found as an illuminating wire or in the form of an illuminating panel. EL is tunable to generate various light frequencies. The design modified for the fire service makes use of an EL panel embodied within a retro-reflective material. Most importantly, this illumination source operates at a specific wave length that intends to match the peak sensitivity of the human eye in night vision. Scientifically, our eyes, which operate differently in low light, are most sensitive at a 507 nanometer light frequency range. Visually, this frequency is a pleasant bluish green color. Because of the physiology of our eyes, this light color is visually sensed first, transmitted by the optic nerve and recognized by our brains before any other color.



(1) Although difficult to capture in a photo, this photo from a live burn training scenario shows how conspicuous the 507 nanometer color frequency is to the human eye in smoke. As light levels decrease and smoke levels increase, the band continues to be visible. (Photos by author.) Click to enlarge

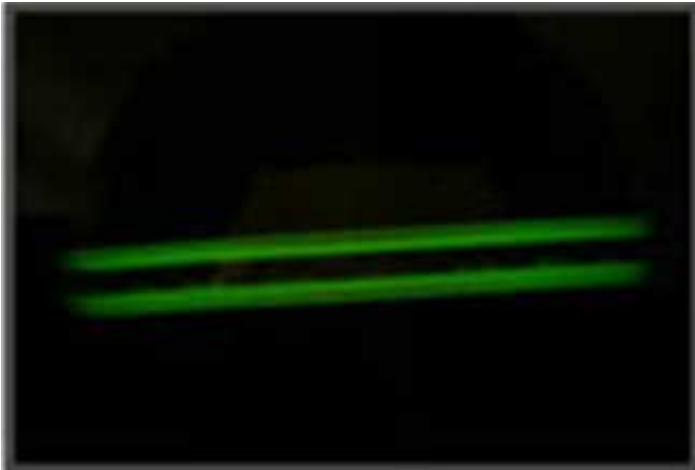
Combining Technologies

Firefighters need to be seen and recognized in several different types of visibility conditions. Generating light to be visible to others is certainly a huge benefit, but combining the use of various technologies maximizes visibility.

Fluorescent color, much like the existing trim on turnout gear, is considered a passive technology but offers good visibility in daylight and reduced light situations, maximizing available light and visibility factors.

Reflectivity, again, like turnout gear striping, is a passive technology but has micro-prismatic structures that enable it to reflect light when light is directed toward it. This is helpful in relatively clear atmospheric conditions, whereby light can easily reach the reflective material and reflect back.

Photoluminescence is considered a semi-active technology and is otherwise known as "glow in the dark material." This material charges specifically when exposed to ultraviolet (UV) light. After a full UV charge, which is achieved in a relatively short period of time, photoluminescent material can generate active illumination in the form of an "after glow" for up to two hours.



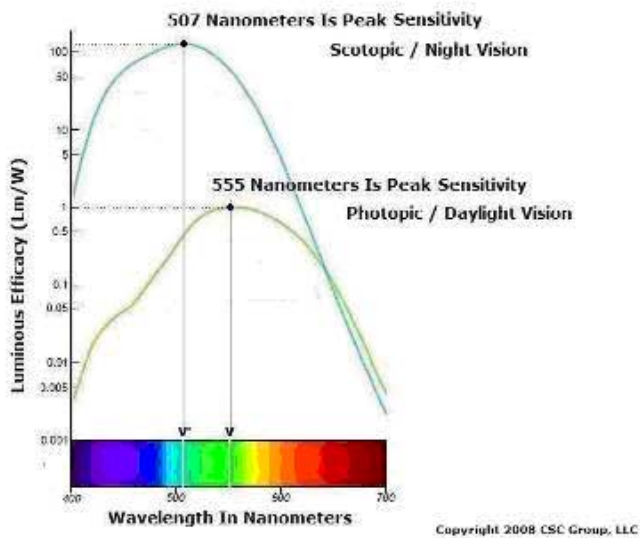
(2) The photoluminescent portion of a helmet-mounted visibility device. In this instance, the EL illumination panel is off and appears as the dark center area between the two parallel glowing lines. [Click to enlarge](#)

Electroluminescence is considered an active technology and is the key component to providing visibility in darkness and during smoky conditions. This active illumination technology is packaged within the mentioned conspicuity strip in the form of a custom manufactured electroluminescent (EL) lamp. In this instance the electroluminescent lamp provides active illumination through an electrical current generated from a battery source of two AA batteries. The electroluminescent lamp is designed to generate a light wave, which is tuned to operate within a frequency range that complements the peak sensitivity of the human eye in various levels of low light.

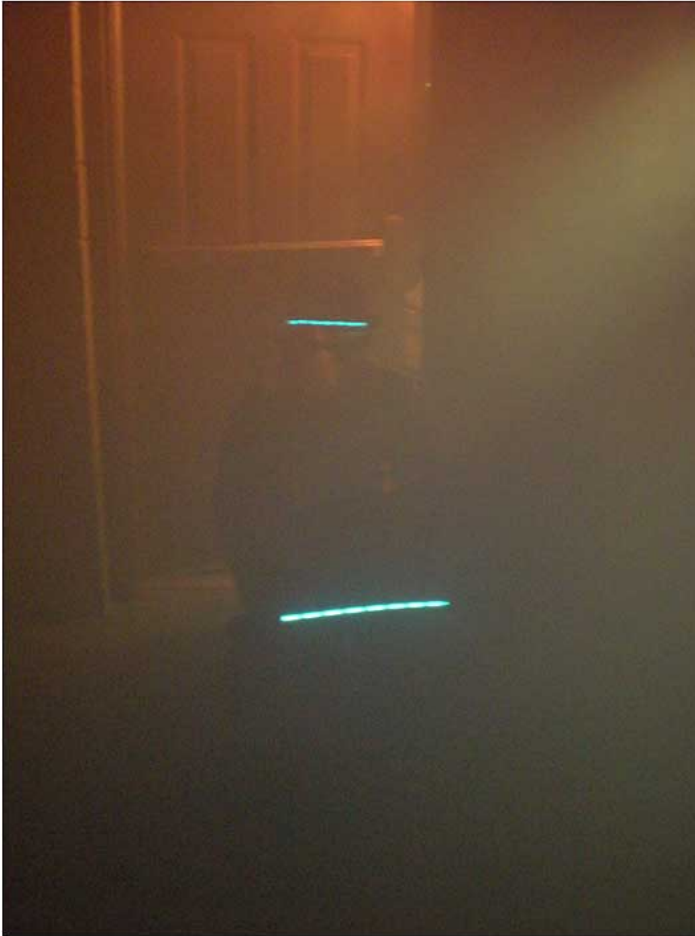


(3) The EL illuminated compared with the photoluminescence and other reflective materials on the helmet. [Click to enlarge](#)

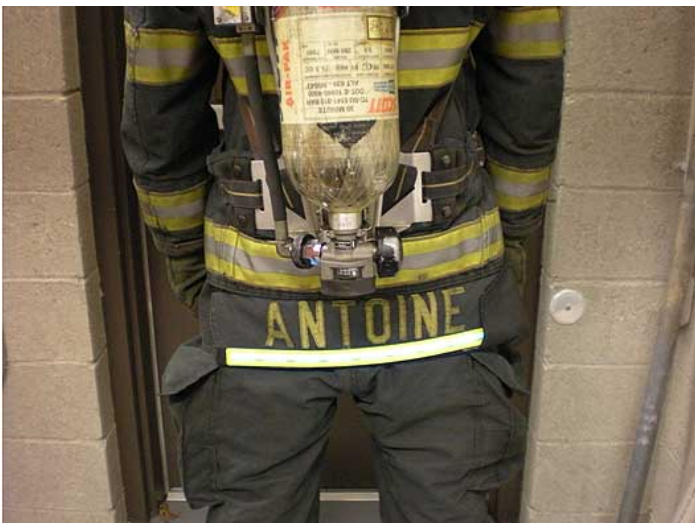
SPECTRAL SENSITIVITY OF THE HUMAN EYE



The ability to have a constant and active light source announcing your exact location to other firefighters has proven effective in training scenarios. How often in real-world situations, either during interior fire attack or search and rescue operations, have you bumped into another firefighter or attempted to occupy the space where he is simply because you could not see him? Your sense of touch is your only way to know where your partner is and what he is doing.



(4) This technology can be mounted on helmets, SCBA bottles, or even the trim of turnout gear. Look how effective it is in a smoke condition in low light. [Click to enlarge](#)



(5) The strip mounted on the coattail of the turnout gear. [Click to enlarge](#)

Applications

The real value of this new technology is to be the ability of interior firefighters to see where other firefighters are inside. The practical benefit of optically enhanced illumination is that it offers enhanced positional awareness. When a firefighter activates this optic sensitive device, it allows others to see him 100% of the time within practical ranges. Tests have shown that even in an extreme, heavy, dense smoke condition, when firefighters were unable to literally see their hand in front of the mask, this bluish green light was visible at about three feet because of the sensitivity of the eye and one's ability to easily recognize it.

The Seattle (WA) Fire Department tested a helmet band that uses EL technology under dense smoke conditions and reported the following: "As the firefighter in the zero-visibility room slowly moved along the measurement back to the door, every inch gained created a brighter illumination of the band to the firefighter on the outside looking in. It was measured that at 2 feet 9 inches, within a zero-visibility environment (thick black, underventilated, oxygen-controlled environment), visibility of the helmet band was adequate enough for a firefighter who would be looking for his partner, thus offering a reasonable outcome that someone could successfully be recognized without effort."



(6) EL on a helmet. The battery pack is on the left side of the helmet; a clip on the front of the helmet makes it adjustable and adaptable to many styles of helmets. [Click to enlarge](#)

An extreme, heavy, dense smoke condition is, of course, the worst-case scenario, and smoke conditions will vary throughout the firefighting operation. As the smoke condition lifts, the range of this optically enhanced illumination increases, further increasing the value of the visibility of personnel.

Active illumination maybe an effective way to identify FAST or RIT personnel. Also, during roadway operations, black turnout gear and retro reflective trim patterns (confusing to drivers) provide little safety. If a firefighter is equipped with this form of active illumination, drivers can see them in enough time to avoid a collision.

Optically enhanced illumination is being tested at several training academies and fire departments across the country. This new technology provides a unique and effective method to maximize our safety simply by making us visible to other firefighters during our most dangerous interior operations. It will be interesting to see how quickly the American fire service adopts it as an essential tool for our safety.

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Subjects: Firefighter safety technology, personal protective equipment (PPE)