PennWell®

Fire Engineering®

TRAINING DIGEST

PPE: Survival on the Fireground

Today's structural firefighting gear offers unparalleled thermal protection and safety. Although it is the finest quality given today's technology, it is not impervious to failure under catastrophic conditions. In this guide, Karen Owens gives a detailed step-by-step process for removing compromised gear and assessing and treating firefighters with burn injuries. Firefighters often underestimate respiratory injuries that can occur during overhaul. Jeffrey Herbert provides life-saving information regarding serious respiratory hazards that exist during overhaul. Eric Schmidt offers a realistic view of donning gear in context and provides an excellent four-stage training process.

FIREFIGHTER BURN INJURIES

By **KAREN OWENS**

SCENARIO: AT THE station, you are completing dinner when you hear the announcement over the radio: "Dispatch from Broad Street Command, please upgrade this incident to a working fire. We have heavy smoke and fire from A/B corner with an unknown number of occupants still inside."

From this initial dispatch information, you know that you are the first-in medic unit, and you prepare for your response to the incident. Although you are prepared to handle the potential patient care issues, you also begin preparing to conduct rehab at the incident. As you arrive on scene, you are contacted by Operations, who radios you: "Medic 1 from Operations, please place your unit at the corner of Broad and E. Main Street, and meet me face-to-face for your assignment."

During your face-to-face, Operations advises that personnel are still searching for potential trapped occupants and that you should set up rehab until there is a known number of victims. You also prepare to treat victims suffering from burns, smoke inhalation, injuries from fallen debris, and other issues. You also consider the need to assist firefighters in rehab efforts (i.e. cooling off, rehydrating, and so on).

You then realize that you are not prepared for the next radio transmission: "Mayday, Mayday, Mayday—Truck 6 Firefighter Jones operating interior Division 1—I have been separated from my company and become trapped during a partial collapse in what I believe is the A/D corner. I currently have three-quarters of a tank of air supply left. I am requesting activation of a RIC [rapid intervention crew]."

Command: "Command to Firefighter Jones, I copy the Mayday and will send the RIC. Try to remain calm and conserve your air. Command to Dispatch, strike an additional alarm."

Command: "RIC from Command, deploy immediately into the structure for a collapse trapping a firefighter."

RIC: "RIC, understood. Deploying with a crew of three to Division 1 through side A for firefighter rescue. Command from RIC, we have rescued the firefighter and are removing him through the side A door. He appears to be conscious but severely burned; have the Medic Unit standing by."

Command: "Command copies. Medic 1 from Command, report to side A of the structure for patient care."

You gather your bag and quickly approach the front door just as the RIC is leaving the structure with the injured firefighter. As personnel put him on the ground, you notice the firefighter has lost his gloves and has visible burns on his hands, and his coat appears to have become undone. You cannot be sure if that occurred during the rescue or prior to the incident. Regardless, you recognize that this may lead to additional injuries.

THE GEAR

Patient burns require many considerations during treatment. When those burns occur to a firefighter dressed in full turnout gear, not only must you deal with the emotions of treating a fellow provider, but you must also deal with the issues that will arise from the personal protective equipment (PPE) that he is wearing.

Turnout gear provides a protective and heat-resistant barrier for a firefighter in an active fire environment. However, it is only designed to provide protection for certain temperatures for a certain time period. In some situations, turnout gear may be unable to tolerate certain conditions, leading to injuries to the firefighter wearing the gear.

Turnout gear is comprised of three protective layers, which follow:

:: Outer shell—provides heat and flame resistance while also providing protection to the two inner layers.

:: Moisture barrier—provides protection from moisture being absorbed through the gear while allowing perspiration to escape. It also allows for the release of

body heat, decreasing the amount of heat buildup within the gear.

:: Thermal layer—provides protection to the firefighter from transfer of thermal heat from the fire.

Although each turnout gear layer is important in providing protection during firefighting operations, it can drastically change your approach to patient care.

THE COOLING PROCESS

Training tells us that when an individual is suffering from a burn, the first thing you must do is stop the burning process[1]; this means limiting the size, depth, and severity of the injury by flushing the injury with water or, as taught to children in schools across the country, "Stop, Drop, and Roll." Unfortunately, when the patient is a firefighter encapsulated in turnout gear, the cooling methods must change significantly. Because of the thermal layer's design and composition, flushing a firefighter with water, physically patting him down, and compressing his gear may actually cause more significant burns. The air pockets, when functioning appropriately, do not effectively conduct heat, providing adequate protection during firefighting operations. However, when the air is compressed, either by force of water or compression of the air pockets, the thermal layer successfully conducts heat, leading to steam burns or thermal burns on the patient. Quickly remove the gear from the firefighter in a manner that will not cause you or the patient any additional injuries. Not only will this remove the heat source from the firefighter, but it will also allow you to better assess and treat injuries.

Table 1. Steps in Removing Heated Turnout Gear[2]

1. Loosen the SCBA shoulder straps.
2. Open the front jacket flap while unclasping/unzipping the coat.
3. Open the coat, and roll it and the SCBA over the shoulders and off the arms.
4. Remove the gloves, and finalize removal of the coat.
5. Unclasp the pants, and remove the suspenders, letting the pants fall.
6. Roll the pants over the boots, and assist in removal of the boots.

* This is just one method of gear removal. The overall goal is to carefully remove the gear without compression or water application.

In the scenario, your patient is not able to stand to assist in turnout gear removal; this can make for an easier task. When a patient is unable to stand, you can cut off and remove the turnout gear with trauma shears. Remember, if not already completed, removing self-contained breathing apparatus (SCBA) is also necessary. If the firefighter can stand, remove the turnout gear carefully. The process is thorough, but each step limits the potential of injuries caused by the gear. Table 1 lists steps to remove turnout gear.

When removing turnout gear, also conduct a visual inspection. Look for damaged areas or gear that is on fire. Also consider where the firefighter was in the building and any potential hazardous materials that may be on the gear. Also, when coming off an ambulance, you may not have the essential equipment to assist in removal of the superheated gear. Patient care gloves will not provide sufficient protection from the heat radiating off the PPE. Always wear firefighter gloves when removing the turnout gear. If firefighter gloves are not available, use RIC members or other firefighters to assist in gear removal.

After removing the SCBA and turnout gear, you begin to assess the firefighter's injuries. During your initial assessment, you realize that you know the patient. He is a rookie, just out of school, who also pulled some hours on your medic unit. Although this realization shakes you, you have to focus on treating him, regardless of the emotions.

ASSESSING THE INJURIES

After removing the turnout gear, your firefighter patient now becomes just like every other burn patient you encounter. You must reassess to ensure that the burning process has stopped and all areas are sufficiently cooled. The process of cooling thermal burns may change, depending on the substance that caused them. Treatment of thermal burns caused by a flame should follow a process of wetting down, smothering, and then removing the clothing.[3] Treating thermal burns caused by a semisolid (i.e. grease, wax, tar, and so on) follows the process of cooling with water without removing the substance. (3) After ensuring that the burned areas are appropriately cooled, you can begin your assessment.

Overall, assessing your burn patient is done the same as for any other trauma patient. Start with your initial assessment (airway, breathing, circulation) and

continue through with a hands-on assessment, looking for any injuries or issues. You still treat life threats as you come to them, but recognize that the burns may be the life threat you have to focus on.

Once you have found the patient's injuries and have treated any life threats you can, focus on your assessment and treatment of the burns. When assessing burns, you must determine the severity of each burn. Burn severity is based on six factors, which follow:

:: Agent or source of burn.

:: Body region affected.

:: Burn depth.

:: Extent of the burn.

:: Patient's age.

:: Patient's medical history. (3)

The source of the burn is important to know because it can also lead to other issues that may arise during your response. Patients with chemical burns must be decontaminated (if they are not already). Patients with electrical burns may have internal injuries far more significant than external wounds. When considering the body region burned, you must again remember that any burn to the face or airway is a life threat. Those injuries will compromise the airway because of swelling and physical damage. You should also consider that burns to the hands and feet may limit mobility of the appendages. Other regions of concern include the genitalia, which can increase the chance of introduction of bacteria, and circumferential burns, which can compress the area, leading to decreased circulation. (3) Circumferential chest burns are also significant because they limit the patient's ability to expand the chest for deep breaths.

When determining burn depth, three categories are considered: superficial, partial thickness, and full thickness. Characteristics of these depths are listed in Table 2.

You also need to determine the extent of the burn and the area of the body impacted by the injury. The "Rule of Nines" is the best method to determine the

Table 2. Burn Depths

Depth of Burn	Characteristics
Superficial	Epidermis is damaged, reddened skin, pain at injury site.
Partial Thickness	Epidermis and dermis are damaged, intense pain, white to reddish skin, blisters.
Full Thickness	All layers of the skin involved; dry, leathery skin (dark, white, or charred color); little to no pain.

percentage of body surface area involved. It states that each major body area represents nine percent of the body. A great percentage of burned area means that the patient is at a more significant risk of infection and possible death. The patient's age and other illnesses and injuries may also impact his ability to fight infection.

Your assessment of the injured firefighter determines that he has partial and full thickness burns on his hands and partial thickness burns on his chest. You classify him as a high-priority patient with critical burns and prepare to treat him as such. Your driver then asks what you need.

TREATING THE INJURIES

With burn classification and assessment complete, you must now focus on the treatment of the burns themselves. Since cooling is finished, remove any clothing that is still around the wound. Also remove any jewelry that is around the injury site. Swelling could easily prevent removal of rings and bracelets later. Remember that jewelry may also still be hot or warm to the touch, so remove it with caution.

Cover burns with a dry, sterile dressing, secured tightly to the injury. Because the burn has damaged the skin, a protective barrier between the underlying muscle and tissue preventing the introduction of bacteria into the body is essential. Using dry, sterile dressing is important because moist environments generate a larger bacterial environment. When dressing hand and toe burns, wrap each finger and toe separately.

As a basic life support provider, focus on airway management in addition to dressing wounds. Airway management includes high-concentration oxygen

through a nonrebreather mask or bag valve mask; when possible, use humidified oxygen. If protocols allow, consider using a more advanced airway such as the supraglottic airway device when the situation presents. Many burn patients, especially those showing smoke inhalation or airway compromise, are likely to have carbon monoxide (CO) poisoning. High-flow/high-concentration oxygen is the treatment for CO exposure; patients with significant CO poisoning may require hyperbaric oxygen (HBO) treatment. As CO symptoms correlate very poorly with poisoning, field assessment of patients using a pulse CO-oximeter (an oximeter capable of measuring blood levels of CO) or an exhaled breath CO monitor can help determine if your patient requires transport to an HBO-capable facility.

ADVANCED LIFE SUPPORT (ALS) TREATMENT CONSIDERATIONS

ALS burn treatment includes additional considerations to assist the patient, which fall under the following categories.

Airway management. Because of the high probability of airway swelling, consider early intubation. This ensures that even when swelling of the trachea occurs, the airway is open. If the airway has been compromised prior to the ALS provider's arrival, consider a surgical airway. Remember that airway access is the highest priority during treatment of this or any patient.

Fluid resuscitation. Because of the heat from the burn, there is a great need to support fluid replacement during treatment and transport. Establish at least one large bore IV (preferably two). Use lactated ringers, normal saline, or another crystalloid solution during initial resuscitation.[4] If IV access is unobtainable because of the severity of injuries, then consider intraosseous (IO) access, and follow local protocols.

Pain management. With IV access established, be aggressive with pain management. With the administration of any narcotic, remember to closely monitor your patient for any changes.

Cyanide. Cyanide (CN) is a poisonous gas released during incomplete combustion of virtually any occupied structure. Survival of victims pulled from structure fires in cardiopulmonary arrest who receive a cyanide antidote are dramatic—in some studies, exceeding 50 percent. As there is no rapid and reliable field or

hospital test for CN exposure, administer a CN antidote to patients (including firefighters) pulled from a structure with known fire smoke exposure in an enclosed space and showing evidence of airway compromise and significant hemodynamic instability (cardiac or respiratory arrest or unconsciousness with profound hypotension).

Conventional CN antidote kits have included three drugs given in sequence: amyl nitrite, sodium nitrite, and sodium thiosulfate. The first two agents work by inducing a chemical change in the blood (methemoglobinemia) that limits oxygen-carrying capacity. In the presence of CO, as often seen in smoke inhalation, this additional oxygen debt can be catastrophic. A newer antidote, hydroxocobalamin does not rob the body of oxygen but binds with CN to form vitamin B_{12}, a harmless by-product excreted in the urine. Fire victims' health drastically improves with use of hydroxocobalamin.

PATIENT TRANSPORT

Once the patient is packaged, transport becomes the priority. Transport burn patients to the local burn center as per local protocols. When transport time is delayed or made even longer, consider air transport.

While transporting the patient, remember to monitor vitals, airway, and interventions. Ensure that IV access is maintained, pain is successfully managed, and no additional problems arise prior to arrival at the receiving medical facility.

You have finally transferred care of the firefighter over to the local burn center. You have cleaned your truck and, on the way back to your station, you visit the first-due's firehouse and inform the rookie's crew that the doctor said the rookie was stable. You see the visible relief on their faces.

When an individual suffers burns, your treatment of his injuries is based on the assessment, the same as with any injury. Burns can be significant, but the focus is still on life threats. A burn pre-sents issues with airway, breathing, or circulation; those issues become priority during treatment. Once those issues are treated and stabilized, treatment can extend to other areas of the patient.

Calls can be complicated when the patient you are treating is a member of the

emergency services field. On completion of any call involving fellow providers, remember to consider the need for critical incident stress debriefings to assist in dealing with the emotions associated with the situation. Ensuring a thorough assessment and appropriate care of the injuries is important in ensuring the call's overall success.

ENDNOTES

1. American Academy of Orthopaedic Surgeons. *Outdoor emergency care book,* 4th Edition, 2005. Jones and Bartlett: Massachusetts.
2. Brown, P.L. Doffing superheated turnout gear. www.fireengineering.com, June 16, 2008.
3. Limmer, D. and O'Keefe, M.F. *Emergency Care, 10th Edition*, 2005. Prentice Hall: New Jersey.
4. Caroline, N. *Emergency Care in the Streets: Trauma Medical,* vol. 2, 2007. Jones and Bartlett: Sudbury: MA.

KAREN OWENS is the emergency operations assistant manager for the Virginia Office of EMS, where she has been employed since 2001. She oversees the emergency operations training programs including MCI management, terrorism awareness, and vehicle rescue. Owens has a BA in psychology and an MA in public safety leadership. She is a Virginia certified firefighter and has been a Virginia EMT-B instructor since 2002.

Originally published April 1, 2011

Fire Dex®

Protection for the Heat of the Battle™

Fire-Dex

FX-R

ULTIMATE IN PERFORMANCE

FX-A

LEGACY OF DEPENDABILITY

FX-M

PROVEN PERFORMANCE. MODERN STYLE.

chieftain

By Fire Dex

CLASSIC ECONOMICAL GEAR

INDUSTRY BEST LEAD TIMES

PINPOINT ORDER ACCURACY

Fire Writer 2

PRODUCTION EXCELLENCE

TURNOUT GEAR - BOOTS - HELMETS - GLOVES - EMERGENCY RESPONSE APPAREL

DuPont™ Nomex® | DuPont™ Kevlar®

The best coming TOGETHER to rise to any challenge

STRUCTURE FIRE OVERHAUL: RESPIRATORY HAZARDS AND PERSONAL PROTECTIVE EQUIPMENT

BY **JEFFREY L. HERBERT**

EVEN AFTER THE main fire is extinguished, firefighters still face many hazards in overhaul operations. However, the greatest danger is also the one that is largely ignored—poisonous gases resulting from incomplete combustion that exhausted firefighters may breathe in. In addition to examining these invisible dangers firefighters face during overhaul and the respiratory protection equipment available, this article will discuss the results of a Phoenix, Arizona, firefighter survey concerning the use of personal protective equipment (PPE) during overhaul.

(1) Even after the fire is extinguished, the burned fuels may still release toxic gases. [Photos by Paul Ramirez, Phoenix (AZ) Fire Department, unless otherwise noted.]

During active firefighting, visibility is often zero, the structure's tenability is decreasing, and the environment is hot. The fire department thus focuses on safety and training. In the operational phase following fire extinguishment, overhaul, the emphasis on rescuing civilians and putting out the fire has passed. In practice, overhaul is a transitional phase. Although many physical hazards exist during overhaul, common sense, experience, and awareness of your surroundings usually mitigate these dangers.

However, a serious respiratory hazard exists during overhaul, and firefighters often give this hazard low priority.

Firefighters know they can't survive if they breathe in superheated air or toxic gases released by fire, but they often forget that the heated fuels from the fire are still releasing toxic gases during overhaul. Firefighters often talk about carbon monoxide (CO), and they all know the feeling of a CO headache, but what other toxins are they inhaling? Air-monitoring studies have proven that CO and other hazardous gases exist in a structure after a fire. Many of them are undetectable without monitors and are more dangerous than CO. The type and concentration of the gas depend on the fuels involved. Depending on air currents, the hazard also extends beyond the immediate structure. This area of occupational health and safety has received little attention; therefore, firefighters do not know all they should know about what they face after the fire is out.

SCBA

Wearing a self-contained breathing apparatus (SCBA) during this operational phase virtually eliminates the respiratory hazards. Positive-pressure SCBAs provide a protection factor exceeding 10,000.[1] This means that compared to the air outside of the mask, contaminants breathed in are reduced more than 10,000 times. However, often firefighters reserve wearing the SCBA for active firefighting.

The air-purifying cartridge respirator is also used for respiratory protection in the fire service. It can be attached to the SCBA face mask, eliminating the cumbersome air bottle, but it provides a protection factor of approximately 50.[2] What commonly occurs is that someone passes out a box of N-95 masks, which are perceived as protection from the dust and light smoke encountered during overhaul.

(2) Phoenix Fire Department members wear full PPE, including SCBA, while performing overhaul on a single-story residence.

However, in the National Institute for Occupational Safety and Health (NIOSH) N-95 filter classification, N means "Not resistant to oil" and 95 means that the mask is 95 percent effective against particles larger than 0.3 microns.[3] Particles sized between one and five microns can enter the upper airway, particles sized between 0.1 and 1.0 microns can enter the lower lungs and alveolar ducts, and particles larger than five microns will fall out of the air. As an illustration, tobacco smoke particles range in size from 0.01 to 1.0 microns, and oil smoke ranges from 0.03 to 1.0 microns. So depending on particle size, the N-95 masks may or may not filter these smoke particles suspended in the air.

Additionally, the naked eye can see only particles sized 10 microns or larger, so the dust seen in the overhaul environment would not enter the upper airway even without the N-95 mask. Finally, firefighters need to realize that the toxic gases are not particulates, and the N-95 masks offer zero protection against them.[4]

The best information available on the chemical hazards of overhaul come from two studies published in 2000 and 2001, both conducted by the Phoenix Fire Department and the University of Arizona. The 2000 study, "Characterization of Firefighter Exposures During Overhaul," by Dawn Bolstad-Johnson, et al, monitored the air in 25 structures while firefighters were performing overhaul. (2) This was the first study of its kind, and in researching this article, I have found that many recent sources mentioning the chemical dangers of overhaul cited this work.

The study "demonstrated that maximum concentrations of contaminants in the overhaul atmosphere exceeded occupational exposure limits and could therefore result in adverse health effects in firefighters without respiratory protection. In a variable number of fires, concentrations of acrolein, CO, formaldehyde, and glutaraldehyde exceeded their respective ceiling values; concentrations of sulfur dioxide exceeded the STEL value; and concentrations of coal tar pitch volatiles (PNAs) exceeded the OSHA PEL, ACGIH TLV, and NIOSH REL." (2, 638)

The study noted that "among the fires sampled, there was tremendous variation in concentrations of the sampled contaminants. This variation may be explained by the diverse nature of each fire, including contents, number of rooms, commercial building vs. residential, etc." (2, 638)

A limitation of this study is that the researchers could not always get to the incident and begin monitoring as soon as overhaul began, so the amount of each toxic gas reported may have been higher before monitoring commenced. (2, 640)

TOXIC GASES

The chemicals identified in this study illustrate the severity of the hazards posed by inhaling them. Acrolein is a suspected human carcinogen; the French used it as a chemical weapon during World War I. The Environmental Protection Agency (EPA) states, "Acute inhalation exposure to high levels [10 parts per million (ppm)] of acrolein in humans may result in death. Effects on the lung such as upper respiratory tract irritation and congestion have been noted at acrolein levels ranging from 0.17 ppm to 0.43 ppm."[5]

(3) Toxic gases are released when household items burn. In homes dating from the early 1970s and earlier, popcorn ceilings may contain asbestos particles.

Carbon monoxide is the leading cause of accidental poisoning deaths in America. This odorless, tasteless, and colorless gas is known as the "silent killer." The Centers for Disease Control and Prevention estimates that CO poisoning claims nearly 500 lives and causes more than 15,000 visits to hospital emergency departments annually. Early symptoms of CO poisoning such as headaches, nausea, and fatigue are often mistaken for the flu, because the deadly gas goes undetected in a home. Prolonged exposure can lead to brain damage and even death.[6]

Hydrogen cyanide, another toxic gas present in the overhaul environment, is produced by the incomplete combustion of natural fibers (e.g., wool, silk) and synthetic polymers (e.g., polyurethane, nylon) widely used in insulation, cushioning, carpets, building materials, and home furnishings. Each year, an

(4) An air-purifying respirator provides only a fraction of the respiratory protection your SCBA offers. (Photo by author.)

estimated 20,800 residential fires are attributed to mattresses, pillows, and bedding materials, all of which are highly likely to contain synthetic materials that release hydrogen cyanide when they smolder (http://www.cyanidepoisoning.org).

J. Curtis Varone, in "Cyanide Poisoning: How Much of a Threat?" (*Fire Engineering*, September 2006, 61), noted the following after the cyanide poisoning of a firefighter: "What the Providence (RI) Fire Department learned in March 2006 was that not only is hydrogen cyanide a product of combustion but it may also very well be the most deadly product of combustion and the one firefighters should be concerned with above all others when fighting fires."

In 1987, the EPA classified formaldehyde as a probable human carcinogen under conditions of unusually high or prolonged exposure. Since that time, some studies of industrial workers have suggested that formaldehyde exposure is associated with nasal cancer and nasopharyngeal cancer and possibly with leukemia. In 1995, the International Agency for Research on Cancer (IARC) concluded that formaldehyde is a probable human carcinogen. However, in a reevaluation of existing data in June 2004, the IARC reclassified formaldehyde as a known human carcinogen.[7]

Glutaraldehyde vapor in the air can cause teary eyes, a burning nose, a sore throat, coughing, and a headache. These effects can occur when the amount of glutaraldehyde in the air is about 0.1 ppm (the legal exposure limit is 0.2 ppm). Repeated exposure to glutaraldehyde can cause asthma. Asthma has occurred even in people exposed to low levels of glutaraldehyde (0.05 ppm). Glutaraldehyde is now being tested to see whether it causes cancer in animals that breathe its vapor.[8]

OTHER TOXIC MATERIALS

Toxic gases are not the only respiratory hazard that exists during overhaul. While firefighters are exposing concealed spaces such as the area behind walls, doorjambs, and attics, they are inhaling asbestos fibers, lead from paint, and respirable dust. Samples of each of these were detected in the overhaul environment in the Bolstad-Johnson study. Although single events pose a danger, the health problems that these substances can cause need to be considered not only as a one-time exposure but also on the basis of their long-term effects. Additionally, based on the vast array of possible burning materials firefighters may be called to extinguish and the fact that the studying of overhaul is relatively new, it may be assumed that additional unknown chemical hazards are present.

BURGESS STUDY

Toxicologist Jeffery Burgess, et al, in the study "Adverse Respiratory Effects Following Overhaul in Firefighters," used a different methodology than Dawn Bolstad-Johnson, et al.

Instead of monitoring the air during overhaul, researchers took spirometric measurements and measured serum pneumoproteins in the blood of firefighters after performing overhaul. Two groups of firefighters were used: Tucson firefighters, who used no respiratory protection, and the Phoenix firefighters, who used cartridge respirators. These measurements indicated that the cartridges did not prevent increased lung permeability in the firefighters. The serum pneumoproteins indicated that firefighters were exposed to carboxyhemoglobin, acetaldehyde, formaldehyde, sulfur dioxide, respirable dust, and sulfuric acid. (1, 471)

The study notes that "these findings provide strong evidence that the current practice of removing SCBA prior to overhaul may result in exposure to respiratory toxicants and subsequent adverse health effects." (1, 471) Note that although the Burgess study involved fewer fires than Bolstad-Johnson's, both are cutting-edge studies of the environmental health hazards of overhaul.

Burgess, et al. studied cartridge respirators' effectiveness to determine whether they provided a suitable alternative to the heavy SCBA. The study determined that cartridge respirators should not be worn as respiratory protection against

overhaul hazards. These studies prove that overhaul presents a serious health risk to firefighters who choose not to wear SCBA and that the occupational hazard of overhaul requires further study. So why, then, do firefighters not wear their SCBA during overhaul?

PPE USE SURVEY

To evaluate firefighters' SCBA use during overhaul, researchers created an online questionnaire and e-mailed it to 60 firefighters. Participants were requested to visit www.freewebs.com/jherbert and fill out an anonymous questionnaire regarding their use of PPE during overhaul. Forty-four of the persons solicited responded.

Fire department members above the rank of firefighter were not surveyed; the study focused on members most likely to physically perform overhaul. Analysis focused on the worker, not the supervising company or command officers. Additionally, engineers' responses may have caused deviations in the data since they are often operating at the pump panel during overhaul. Firefighters were solicited from A, B, and C shifts, from probationary firefighters to 20-year veterans.

SCBA Use

The responses illustrate a trend of a minimal emphasis on the invisible hazards of overhaul. Gender did not seem to affect SCBA use. Out of all responses, 13.6 percent of firefighters answered that they always wear their SCBA during overhaul, 6.8 percent stated that they never wear their SCBA during overhaul, and 79.5 percent responded that they sometimes wear their SCBA during overhaul.

A possible reason for the overwhelming majority response that they sometimes use their SCBA during overhaul is that overhaul occurs during several unofficial levels of severity. During short-duration structure fires, (e.g., a contents fire), the interior crew may begin overhaul immediately without exiting the structure for rest or more air. Firefighters assigned to begin overhaul immediately after the fire is declared under control would be more likely to wear their SCBA than if assigned to overhaul later on in the process when less smoke is visible (i.e., when respiratory hazard is less perceivable). Also, if firefighters did not report to rehab or take a break in between firefighting and overhaul, they would be less likely to remove their bottle than if they had already removed their PPE and SCBA.

The survey also showed that most of the respondents wear their SCBA more than half of the time for protection against respiratory hazards and, second, for personal safety. A small percentage said they never wear SCBA. Further data indicate that the vast majority of firefighters are aware that overhaul presents hazards that often require an SCBA but peer pressure or the cumbersome properties of wearing the SCBA may prevent them from wearing the SCBA about half of the time. Compared to an N-95 mask, the SCBA bottle is heavy; the shoulder straps restrict movement; and the face mask can get covered with debris, reducing visibility.

N-95 Filter Use

In addition to SCBA use, 71.4 percent of survey respondents said they sometimes wear an N-95 mask, 19 percent said they never wear one, and 9.5 percent said they always wear one. Fifty percent believe that the N-95 offers protection against respiratory hazards, a common misconception that needs to be changed through education.

Turnouts and Gloves

Regarding wearing full turnouts with gloves and hood during overhaul, 70.5 percent responded that they sometimes wear them during overhaul, 18.2 percent always, and 11.4 percent never. This is in contrast to the use of turnouts during firefighting: 98 percent that they always wear SCBA and full turnouts during residential and commercial structure fires, 86 percent always for car fires, and 52 percent always for trash fires.

Although no studies have been conducted specifically on toxic skin absorption during overhaul, many of the substances known to exist in the overhaul environment can be absorbed through the skin. Turnouts may not even protect against the gases, but limiting toxic substances such as asbestos from collecting on your skin may help keep them out of your airway. Although firefighters consider having a set of dirty turnouts as a badge of honor, frequent washing, which is actually decontamination, helps to reduce contact with hazards.

Concerning turnout maintenance, National Fire Protection Association (NFPA) 1851, *Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural and Proximity Fire Fighting* (2001 ed.), section 5.2.1, states: "After each use any elements that are soiled shall receive routine cleaning."

Section 5.3.1 says that an advanced cleaning of turnouts should be completed at a minimum of every six months. The Phoenix Fire Department has a turnout maintenance program in which members can have their turnouts professionally cleaned at anytime.

The 1997 Phoenix Fire Department SCBA Management Procedure (MP) 202.05B states that the use of SCBA is clearly indicated for "all personnel operating … where invisible contaminants are suspected to be present (i.e., carbon monoxide during overhaul)."[9]

The MP for overhaul, dating from 1995, however, does not discuss whether PPE should be worn during this phase of the operation. When the overhaul MP is revised, it should emphasize the use of turnouts and SCBA as well as offer a brief discussion of the respiratory hazards present.[10]

(5) Your SCBA is your best protection during overhaul. (Photo by author.)

The Occupational Safety and Health Administration (OSHA) *Respiratory Protection Standard 29 CFR 1910.134* requires a respiratory protection plan and annual refresher training for all employees required to wear respirators on the job. This includes annual fit testing and medical evaluations. The Phoenix Fire Department follows this regulation. During the annual refresher training, we present a video that stresses the importance of not relying on an N-95 mask:

"It will not shield your lungs from poisonous air during overhaul. Deadly carcinogens are present even when there's no smoke. They are invisible, tasteless, and odorless; that's why it's so easy to justify removing your respiratory protection. Don't do it! You could pay for this years down the line with a serious respiratory illness."[11]

In the fire service, each call is different from the last, conditions are always changing, and it is often impossible to provide blanket solutions to existing issues.

When it comes to overhaul, the level of PPE worn is usually a personal choice. In practice, it is similar to wearing a seat belt in the fire apparatus. Although everyone knows that it is the rule and the right thing to do, when a firefighter is turning out for an incident, he may remove his seat belt so he can get dressed as fast as possible. As with overhaul, the risk taken is rationalized as acceptable because the potential negative consequences seem remote.

This attitude toward overhaul needs to change. There is no rush, the incident is controlled, and a firefighter should be in shape to wear his bottle throughout the process. So it seems obvious that enforcing existing regulations would solve this health hazard, but the fire service generally shuns micromanagement, and in this area of moderately perceived risk, company and command officers rarely enforce the PPE regulations to the letter of the law.

RECOMMENDATIONS

Perhaps a few solutions could be introduced to mitigate this issue without great organizational change. Often, the utility truck responsible for refilling SCBA bottles leaves the incident before overhaul is completed, because most firefighters believe that they will not need to use their SCBA during the rest of the incident. If Command ordered the utility truck to remain on-scene until the last company was finished and reminded crews that it would be available to refill those bottles once overhaul is completed, maybe more firefighters would heed this advice while still feeling that they are making their own decisions.

Frequent crew rotation would eliminate using fatigue as an excuse for removing PPE during overhaul.

More overhaul hazards training is needed. In the survey, 29.5 percent of firefighters stated that they had never had any training on the hazards of overhaul. Although all Phoenix firefighters have received this training, it seems that it did not make a substantial impact on a large group within the department. This area could be highlighted more during annual fit testing.

Changing the fire service culture's views on overhaul may happen more quickly among the junior members. SCBA use during overhaul must be enforced in training academies nationwide.

Company officers need to be proactive in supporting SCBA use among their firefighters, and command officers need to be proactive in changing the culture's attitudes on overhaul hazards. A national review of volunteer and paid fire department members' attitudes toward wearing PPE during overhaul would reveal national trends in this area. Such a review could consider why supervisors allow firefighters to continue to disregard SCBA use for overhaul.

In a firefighter fatality investigation into a collapse that killed two firefighters during overhaul, NIOSH recommended that "fire departments should ensure that firefighters wear a full array of turnout clothing and personal protective equipment (i.e., SCBA and PASS devices) appropriate for the assigned task while participating in fire suppression and overhaul activities."[12] Although this incident involved a collapse, the NIOSH report stressed that toxic gases such as hydrogen cyanide and formaldehyde are dangerous to firefighters during overhaul. NIOSH has assembled a team of doctors as part of a task force to further investigate the prevalence of cyanide poisoning. NIOSH clearly states, "Exposures to these types of respiratory hazards can be reduced by the mandatory use of SCBA during both fire suppression and overhaul activities." (12)

Another possibility is to train certain members in using air monitors that can detect the gases present during overhaul. This is an expensive proposition compared with enforcing the use of SCBA, but it may add weight to the immediacy of the dangers to which firefighters are exposed and the validity of such enforcement.

Air-monitoring studies have shown that hazardous gases that are undetectable to our senses exist during overhaul, but more research needs to be conducted in this area to further evaluate what firefighters are exposed to and how those exposures may affect firefighter health. As an example, no study yet conducted has evaluated the effect of toxic compounds absorbed through the skin during fire suppression or overhaul. Even if the current practice of removing SCBA during overhaul is slow to change, an increased body of research proving that certain chemicals may impair firefighter health will aid the fire service as a whole when facing medical claim issues in the future.

Endnotes

1. Burgess, Jeffery L., et al, "Adverse Respiratory Effects Following Overhaul in

Firefighters." *Journal of Occupational and Environmental Medicine* 2001; 43(5), 467-473.
2. Bolstad-Johnson, Dawn, et al, "Characterization of Firefighter Exposure During Overhaul." *American Industrial Hygiene Association Journal,* September/October 2000, 636-641.
3. "Disposable Respirators (including N95)," Minnesota Department of Health Web site, http://www.health.state.mn.us/divs/idepc/dtopics/infectioncontrol/ppe/comp/n95.html. Retrieved October 23, 2006.
4. "Common Particles and Their Sizes in Microns" (graph), Lakeair Purification Systems Web site, http://www.lakeair.com/particles.html. Retrieved October 23, 2006.
5. "Acrolein," U.S. Environmental Protection Agency Technology Transfer Network Air Toxics Web site, http://www.epa.gov/ttn/atw/hlthef/acrolein.html. Retrieved January 30, 2008.
6. "Carbon Monoxide Poisoning," eMedicineHealth Web site, http://www.emedicinehealth.com/carbon_monoxide_poisoning/article_em.htm. Retrieved January 30, 2008.
7. "Formaldehyde and Cancer: Questions and Answers," National Cancer Institute Web site, http://www.cancer.gov/cancertopics/factsheet/Risk/formaldehyde. Retrieved January 30, 2008.
8. "Glutaraldehyde," California Department of Health Services Web site, http://www.dhs.ca.gov/ohb/hesis/glutaral.htm. Retrieved January 30, 2008.
9. "Self-Contained Breathing Apparatus," Phoenix Fire Department Management Procedure 202.05B, (June 1997). Phoenix Fire Department Web site, http://phoenix.gov/FIRE/20205b.html. Retrieved October 20, 2006.
10. "Overhaul," Phoenix Fire Department Management Procedure 202.12B (May 1995). Phoenix Fire Department Web site, http://phoenix.gov/FIRE/20212b.html. Retrieved October 20, 2006.
11. "Respiratory Protection Standards," Phoenix Fire Department training CD, 2006.
12. "Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul—Alabama." National Institute for Occupational Safety and Health, Fire Fighter Fatality Investigation and Prevention Program, Report F2006-07, October 27, 2006, www.cdc.gov/niosh/fire/reports/face200607.html. Retrieved February 26, 2007.

JEFFREY L. HERBERT is an engineer/paramedic with the Phoenix (AZ) Fire Department. Previously, he worked for the U.S. Forest Service as a Pleasant Valley Hotshot and as an engine boss with the Mesa (AZ) Ranger District. He is enrolled in the emergency management graduate program at Arizona State University.

Originally published March 1, 2008

FREE!

Gear Tracker

NFPA 1851 GEAR MANAGEMENT SYSTEM

IT'S TIME TO START TRACKING!

DO YOU KNOW...

WHEN YOUR GEAR NEEDS INSPECTED?
WHAT GEAR IS AT EACH STATION?
WHEN YOUR GEAR EXPIRES?

GEARTRACKER.FIREDEX.COM

FIRE-DEX COMMITMENT

WWW.FIREDEX.COM

Is There Any Benefit to the Traditional Timed Donning Drill?

By **ERIC SCHMIDT**

WE HAVE ALL experienced the training session of timed donning: the evaluation of a trainee's speed and proficiency to go from normal street clothes to a fully encapsulated thermally and respiratory protected firefighter ready to battle heat, smoke, and toxic gases. Completion time with no deficiencies is usually expected to be under two minutes. I ask you, When has anyone ever seen or done this on a fireground?

(1) Stage 1 in progress. ***(Photos by author.)*** *(2) Stage 1 boarding apparatus.*

When the bell sounds in the station, do personnel fully don personal protective clothing (PPC) and self-contained breathing apparatus (SCBA) to go on air prior to departing? Arriving in a personal vehicle at the scene, do personnel hop out of the car and breathe air from an SCBA two minutes later? Both of these scenarios seem nonsensical, yet that is the way we are trained. Another imperfection of the two-minute donning drill is that the

sequence sometimes is allowed to have no particular structure as long as there is a transformation from civilian to a firefighter on air in the allotted time. I have seen it perfectly acceptable to don a face mask as the very first piece of PPE in a donning drill or to be on air while adjusting helmet straps or putting on gloves.

To more closely resemble the actual change into a fully functional firefighter entering a hazardous atmosphere, I suggest the following four stages:

Stage 1: PPC only or exterior firefighter–turnout gear.

Stage 2: Interior assigned–SCBA put on back, no mask.

Stage 3: At entry point to immediately dangerous to life or health atmosphere (IDLH)–masking up, ready to go except for regulator.

Stage 4: Entry–clicking in as a team.

(3) Stage 2 exiting apparatus. (4) Stage 2 activities.

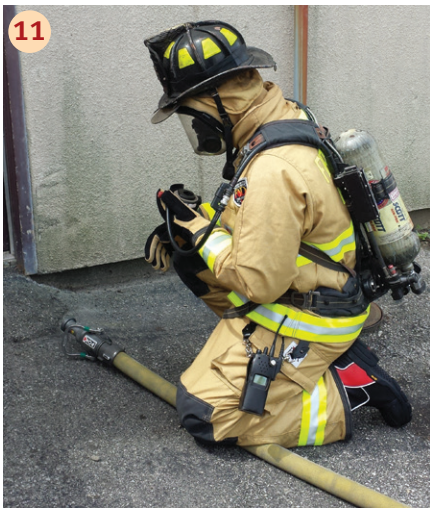
Each of these stages would be done as individual steps with individual time constraints. I have found that time allotments of 60 seconds for Stage 1, 15 to 30 seconds for Stage 2, 45 to 60 seconds for Stage 3, and no more than five seconds for Stage 4 work adequately.

Let's take a look at a more realistic scenario where donning PPE occurs in stages. Whether in the firehouse or just pulling up to a scene in your car, the first stage of donning includes PPC only. These two situations differ somewhat in sequence yet should both yield a Stage 2 interior assigned firefighter.

The bell rings in the station. A firefighter puts his hood on, steps into boots, pulls up pants, straps up suspenders, throws on a coat, and climbs onto the apparatus. With

(5) Stage 1 in progress. (6) Stage 1 complete. (7) Stage 1 activities. (8) Stage 2 beginning. (9-10) Stage 2 point of entry.

SCBAs in the seats, the firefighter should be able to exit the rig on arrival at the scene in a Stage 2 or interior assigned condition, tools in hand or hoseline assigned, ready to go to a point of entry (photos 1-4).



Another firefighter in a personal vehicle would arrive on location, don his turnout gear at his car, and report to command for an assignment. In Stage 1 PPE or as an exterior firefighter, he can hit a hydrant or set up a ladder, and so on. Since most of us don't carry a personal SCBA in our vehicle, he needs to obtain SCBA from the apparatus on scene along with tools or a hoseline for going interior (photos 5-8). Once SCBAs are secured on their backs, each firefighter proceeds to a point of entry.

(11-12) Stage 3 complete.

Since we don't wander around outside or throughout a massive commercial building on air until reaching an IDLH, they do not yet don their masks. This allows for visibility, communication, and conservation of limited air supply. At the point that a firefighter anticipates heat, smoke, and toxic gases, he will take a knee and mask up. It is preferable to do this with gloves on, but if he does remove any equipment—i.e., helmet or gloves—he needs to secure it under a knee or an armpit so it does not to get knocked aside by an exiting firefighter, an exiting civilian, or a moving hoseline (photos 9 and 10).

During training evolutions, for students who have practiced only a two-minute donning drill, this Stage 3 point of entry masking up often takes the most time. Their entire practiced donning routine is muddled and out of sequence. This is a most critical time period. We are in the immediate vicinity of danger, and speed and efficiency are paramount to our safety and getting inside to do the job. By training in stages of donning, the student will already have developed good habits at this point. Once each member of a team is ready to enter, and hoselines are bled of air and so on, with a simple click-in of the regulator, they enter as a unit. No one is wasting valuable air waiting for a member to complete his mask up (photos 11 and 12).

The Stages of Timed Donning (photo 13)

Stage 1, "Exterior Firefighter," 60 seconds: boots, pants, hood in place under coat (coat

(13) Donning Drill. (14-15) The firefighter on the left dons his issued radio under his coat. The firefighter on the right dons his personal handlight that will be under his SCBA. (16-17) The Interior Assigned position involves obtaining equipment (SCBA, radio, handlight) from a simulated apparatus. The firefighter on the left uses the coat method and then dons his handlight. The firefighter on the right uses the over-the-head method and places his radio in his radio pocket.

does not need to be fully closed at neck at this time), helmet with chin strap, and gloves (photos 14 and 15).

Stage 2, "Interior Assigned," 30 seconds: cylinder pressure read aloud, cylinder turned on, NO loss of air, SCBA placed on back with straps adjusted properly, buckle in center, weight on waist straps (photos 16 and 17).

(*Note*: Depending on department equipment and an individual's personal equipment, a radio turned on to the proper channel and operating, a working handlight, and accessible door chocks must be included at some stage of the donning sequence and checked prior to Stage 3.

(18-20) The firefighter on the left keeps his gloves on while donning his mask, The firefighter on the right removes his gloves and secures them. Both firefighters secure their helmets. In photo 20, both firefighters are ready to enter an IDLH. (21) Donning Stage 4.

DISCLAIMER: This article does not discuss the merits of SCBA donning methods or radio, handlight, and equipment placement—merely that such equipment needs to be incorporated into the donning sequence as the individual would do for an actual incident.)

Stage 3, "At Point of Entry," 60 seconds: kneeling, mask on, seal checked, hood over mask (gloves and helmet secured if removed while performing this step), coat fully closed up to neck and storm flap secured, gloves and helmet, no skin showing (photos 18-20).

Stage 4, "Entering IDLH," five seconds: regulator attached and breathing air (photo 21).

By creating good habits at the proper times at an incident, basic skill sets such as donning PPE will become second nature, like reaching for the light switch when entering a room even though the light is already on. This allows the body to perform on auto pilot while you initiate other processes. During Stage 1 or 2, you can size up a building, note activities currently in progress, and so on. During Stage 3, you can give last-minute team instructions, initiate right hand search, remind of egress point, turn on handlights, and so on.

The more we can incorporate realistic situations into our training procedures based on how we actually operate vs. an arbitrary two-minute timed drill that will never happen on a fire scene, the more prepared and proficient our firefighters will be, ultimately leading to improved levels of safety and situational awareness.

ERIC SCHMIDT is a member of the City of Beacon (NY) Fire Department. He was a volunteer for five years and has been a career firefighter for 19 years, a municipal fire instructor for six years, and a state fire instructor for 11 years.

Originally published August 1, 2015

Company Description:

Fire-Dex, LLC
780 S. Progress Dr.
Medina, Ohio 44256
Phone: 330-723-0000
Fax: 202-887-5291
URL: www.firedex.com
Info email: info@firedex.com

Fire-Dex® LLC started in 1983 and our impeccable customer care and quality products have been the core ingredients to us becoming the premier protective gear company.

Fire-Dex®, headquartered in Medina, OH (just outside of Cleveland), was the first manufacturer in the industry to be awarded the ISO 9001 -2000 edition and our robust quality system is currently certified to the ISO 9001-2008 edition. Our innovative manufacturing processes allow us to be nimble and flexible while providing the highest standards of quality. In addition, we can accommodate the needs of the largest departments. In fact, Fire-Dex® was the supplier of choice to deliver a 19,000-piece jacket order, the world's single largest order.

Whether your needs are for a simple hood or a large custom-configured order, Fire-Dex® is thrilled to give you our best and support your efforts in protecting our first responders.

LINKS:

- Fire-Dex Products
- Fire-Dex's NFPA 1851 Inspection, Cleaning, and Repair Trainings
- Gear Tracker; The NFPA 1851 Gear Tracking Solution
- FireWriter2 Custom Gear Configurator
- DuPont Nomex® and Kevlar® Firefighter Apparel