

MEDIA FOR

Fire Engineering

Print this article

Close

Doffing Superheated Turnout Gear

by Patrick L. Brown

From the 2008 personal protective equipment e-Newsletter, sponsored by



A recent survey by *Fire Engineering* revealed that a vast majority of firefighters have received little if any training regarding the doffing of superheated turnout gear. This finding is very troublesome, because improper doffing of this turnout gear can cause significant injuries to the firefighter wearing the gear. How do you handle a firefighter encapsulated within superheated turnout gear? Before I answer this question, let me explain how turnout gear works.

How the Gear Works

Turnout gear is comprised of three separate components: the outer shell, the moisture barrier, and the thermal liner.

Outer shell. This provides resistance to flame and heat plus protects the remainder of the gear from rips, tears, and abrasions.

Moisture barrier. This provides some thermal protection because it does have some insulating value, but its most important tasks are preventing fluids from entering the gear while still allowing perspiration out. These tasks are vital to the performance of the gear and to the safety of the firefighter. Water must be kept out to prevent the saturation of the thermal layer. The moisture barrier must also allow body heat and perspiration to escape to reduce the firefighter's rate of metabolic heat buildup. Excessive heat buildup can lead to stress-related injuries for firefighters.

Thermal layer. This blocks the transfer of heat from the fire to the firefighter, accomplished through air pockets within the thermal layer. These pockets of air are poor conductors of heat. It is important to note that the insulating

factors of air can be disrupted by moisture and compression. Moisture displaces the air in the air pockets and is a very good conductor of heat. Compression forces out the air in the air pockets, which allows the unimpeded conduction of heat.

As you can see, each component is vital to the performance of the turnout gear; one component is no more important than the next. The components work together and frequently provide more protection as a single unit than the sum of the three parts added together.

How We Know Gear Will Perform Correctly

Now that we understand how turnout gear works, how do we know it is going to perform correctly? Each turnout gear design is independently tested to see if it meets the minimum standards of NFPA 1971, *Standard on Protection Ensemble for Structural Fire Fighting and Proximity Fire Fighting*. Many values are tested but the ones we will focus on are Flame and Heat Resistance, Thermal Protective Performance (TPP), Total Heat Loss (THL), and Conductive and Compressive Heat Resistance (CCHR).

Flame Resistance is tested by suspending materials that make up the gear in a Bunsen burner flame for 12 seconds. The material is then removed and the time the gear continues to burn is noted. This time represents the "After Flame Time." NFPA 1971 states that materials that make up our gear cannot have an "After Flame Time" of more than two seconds. The materials are also examined for the distance the item is damaged by the fire. This is noted as the "Char Length." The maximum "Char Length" per the 1971 standard is four inches.

Heat Resistance is evaluated by placing the materials that make up the gear in a special 500°F oven for five minutes. The materials that make up the gear are then examined for any signs of ignition, melting, dripping, or separation. None of these conditions is acceptable according to the standard, plus the materials cannot exhibit shrinkage of greater than 10 percent.

Thermal Protective Performance (TPP) represents how well the gear protects the skin from a second-degree burn in flashover situations. This test is performed by placing the three composite layers of the gear in a simulator. Below the layers are a radiant heat source and a convective flame; above the layers is a sensor. Heat transfer and time are noted and compared with a graph showing the blister point of skin. The rating is then derived from this information. The minimum TPP rating according to the NFPA standard is 35. Dividing the TPP rating in half provides roughly the number of seconds until a second-degree burn is sustained. Thus, a TPP rating of 35 provides about 17.5 seconds in a flashover situation before the firefighter receives a second-degree burn. It is important to note that moisture may significantly reduce this number, plus this rating does not take into account any heat retained in the gear prior to the flashover scenario. There is presently no optimized lab test method available for evaluating TPP in prolonged exposure to lower-level radiant heat or for assessing the effects of moisture on the TPP rating of our gear.

Total Heat Loss (THL) assesses the breathability of turnout gear. This is a very important value because the buildup of body heat under turnout gear is very damaging to the body, especially the cardiovascular system. A large number of firefighter fatalities each year are the result of stress-related injuries, namely strokes and heart attacks. Our turnout gear needs to breathe to allow this buildup of heat out. Breathability is so important that the recent revision of NFPA 1971 increased the THL requirement by 50 percent. THL is determined using a "sweating hot plate test." The three layers that make up your turnout gear are placed on a hot plate and a "dry thermal resistance measurement" is taken. Water is then added and an "apparent evaporative thermal resistance measurement" is taken. The measurements are put into an equation and the result is the THL value. The minimum THL rating per NFPA is 205 w/sq. meter. A higher THL represents better breathability. It is important to note that TPP and THL have an inverse relationship. If you increase the TPP rating, you will decrease the THL, and vice versa.

Conductive and Compressive Heat Resistance (CCHR). This standard requires that areas of compression (shoulders and knees) provide the same level of protection as the rest of the turnout gear. This standard is tested with the gear dry and wet on a plate heated to 500°F. The shoulder portion of the gear is placed on the plate under two psi of pressure (representing the shoulder straps of an SCBA) for 25 seconds. The same is done for the knees but with eight psi of pressure (representing the force a 180-pound firefighter would exert on the knee while kneeling). The shoulders and knees must maintain the same rating as the rest of the gear.

The importance of properly performing turnout gear cannot be overstated.

Why the Environment Is Hotter

Firefighters today face challenges that our forefathers rarely, if ever, encountered. Furniture of the past was stuffed with cotton and horse hair, which had a low heat release rate compared with today's furniture, which is stuffed with synthetic foam. The chairs of the past had a peak heat release rate of about 225 kW. Today's chairs have a peak heat release rate of more than 2,100 kW. The average size family room requires about 1,000 kW before flashover occurs. That being said, the heat release from a modern chair stuffed with synthetic foam will quickly lead to flashover, while the chair from the past stuffed with cotton or horse hair will not produce the same result.

Home fires today are much hotter than fires of the past because homes are filled with items made of similar synthetic materials. Fires today are also hotter because homes are bottled up and better insulated than homes of the past. Today's hotter fires burn while the toxic and highly volatile products of combustion build. There is no place for the heat to go, so the room temperature rises.

We also get to fires much earlier today. In the past, the fire department often wasn't called until the fire was well developed. Today, because of smoke detectors and 911 services, we often get to the fire scene as the fire flashes over.

As firefighters, what do we do if we go into a fire just as the room flashes over? Deputy Chief (Ret.) Vincent Dunn of the Fire Department of New York states the only way for a firefighter to survive a flashover is to get out of the room. He states the point of no return is five feet inside the room. Five feet provides you with a few seconds to get out of the superheated environment. But surviving the flashover doesn't mean everything is now okay. The cool air you are accustomed to breathing from your SCBA has now been heated and is now warm. Every movement is accompanied by burning pain because your turnout gear has been pushed to its limits. It has absorbed all the heat it can and is now off-gassing. You need to get out of the building.

The actions of your fellow firefighters as you exit the building will determine the extent of your injuries. If your fellow firefighters see your turnout gear smoking as you exit the building and turn a hoseline on you to help "cool you down," it is very likely that you will sustain some burns. The water being applied to the superheated turnout gear will likely steam and cause steam burns. In addition, the water is going to disrupt the off-gassing process. This will cause the heat, which was once being off-gassed, to be driven back into the turnout gear, where it will likely steam any moisture in our thermal layer or further heat up the thermal layer. The end result would be the firefighter suffering burns.

I recently heard of a case in which a firefighter came out of a structure after an encounter with a superheated environment. The firefighter was calling out for help because he felt he was burning up. Fellow firefighters came to his aid and started to pat him down while he was in his gear. These firefighters, unknowingly through their actions, pushed the superheated air out of the air pockets of the thermal layer and onto the skin of the distressed firefighter, causing significant burns.

How to Remove Superheated Gear

What is the proper way to assist a firefighter encapsulated in superheated turnout gear? My discussions with turnout gear representatives have led me to this conclusion: Don't hose down the firefighter! Don't pat him down and don't roll him on the ground! The most important thing to do is to get the superheated turnout gear off of the firefighter.

If you are the firefighter trapped within this superheated gear and there is no assistance available, you must economize your movements while trying to prevent compression of your turnout gear as you doff your gear. With gloved hands, loosen the shoulder straps of your SCBA (photos 1).



(1) Photos by author. [Click to enlarge](#)

Next start to open the storm flap from the top down while unzipping or unclasping the turnout coat (photos 2, 3).



(2) [Click to enlarge](#)



(3) [Click to enlarge](#)

On the way down, unbuckle the SCBA waist belt (photo 4), then unclasp and open your turnout pants (photo 5).



(4) [Click to enlarge](#)



(5) [Click to enlarge](#)

Open the coat wide (photo 6) and roll it and the SCBA off of your shoulders and down your arms (photo 7).



(6) [Click to enlarge](#)



(7) [Click to enlarge](#)

When the coat is down to the wrist area, you can then bend over to step on and remove the gloves, then step on the coat and remove it the rest of the way (photos 8, 9).



(8) [Click to enlarge](#)



(9) [Click to enlarge](#)

The coat should be inside out at this point. You can now remove the suspenders from your shoulders (photo 10) and let the pants fall as far as they can (photo 11).



(10) [Click to enlarge](#)



(11) [Click to enlarge](#)

Pull one foot out of your boot, then completely out of that pant leg (photo 12).



(12) [Click to enlarge](#)

Repeat the procedure on the other boot and pant leg (photo 13).



(13) [Click to enlarge](#)

Though not optimum, the described method will allow you to remove your gear, with limited injury.

If you are a firefighter who sees another firefighter encapsulated within superheated gear, you must quickly assist him with turnout gear removal. Instruct the encapsulated firefighter to try and stand still to prevent injury. With gloved hands, loosen the SCBA shoulder straps, open the storm flap, and unzip or unclasp the coat. Open the coat wide and roll it and the SCBA over the shoulders and down the arms. Remove the gloves and complete the removal of the coat. Now unclasp and open the pants, remove the suspenders from the shoulders, and let the pants fall. Roll the pants over the boots, and assist with boot removal like standard doffing procedures.

Though unlikely, if the zipper or clasps on the coat have melted or are inoperable, you will need to cut the turnout coat off of the firefighter. With a pair of trauma shears, cut the fabric tape to either side of the zipper. If the coat is equipped with clasps, you are going to have to cut through the coat. Yes, this will destroy the coat, but if it has sustained enough heat damage to melt the zipper or clasps, the coat is not likely to be serviceable any longer. Remember, the best thing to do for a firefighter encapsulated within superheated turnout gear is to properly doff the gear.

The increased use of synthetic materials means fires will continue to burn hotter and, because of the ever-increasing cost of energy, buildings will be built tighter and tighter. It seems very apparent that firefighters are going to encounter more flashovers and more superheated environments. We owe it to each other to know how to properly doff a firefighter encapsulated in superheated turnout gear.

References

Dunn, Vincent. *Safety and Survival on the Fireground* (Fire Engineering, 1992).

Kutlu, Bengi and Aysun Cireli. "Thermal Analysis and Performance Properties of Thermal Protective Clothing," *Fibers and Textiles*, July/Sept. 2005.

Lawson, J. Randall. "Firefighter Protective Clothing and Thermal Environments of Structural Firefighting," National Institute of Standards and Technology, August 1996.

Lawson, J. Randall et al. "Estimates of Thermal Properties of Firefighter Protective Clothing Material," National Institute of Standards and Technology, June 2005.

National Fire Protection Association (NFPA) 1971-2007, *Standard on Protection Ensemble for Structural Fire Fighting and Proximity Fire Fighting*.

Stull, Jeffrey O. "Understanding Key Turnout Gear Tests," FireRescue1.com, 2007.

Patrick L. Brown is a firefighter and paramedic with the Chicago (IL) Fire Department. He is a state-certified firefighter III, fire officer I, and instructor II as well as a licensed registered nurse specializing in emergency medicine and trauma.

To access this article, go to:

http://www.fireengineering.com /display_article/331858/25/none/none/BRNIS/Doffing-Superheated-Turnout-Gear