



## Lessons Learned: *The Use of Personal Protective Equipment on Wildland Fire Entrapments in 1993*

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During 1993, two wildland fire entrapments were investigated on-scene by fire equipment specialists from the Missoula Technology and Development Center (MTDC). One, a wildfire in California, involved nine firefighters; the other, a prescribed burn in New Mexico, involved 16 firefighters. Both fires offer some excellent "Lessons Learned" on the performance and use of personal protective equipment (P.P.E.). While the size, locations, fuel types, and burning conditions vary on wildland fires across the United States, there are many similarities in the use of P.P.E. that allow all firefighters to benefit from a review of these incidents (Fig. 1).



Figure 1.—On-site inspection of entrapment scene offers information on the event.

### Fire Shelter

In the entrapments that will be discussed, the fire shelter was used to protect some firefighters from high levels of radiant heat. Some of the important lessons learned concerning fire shelter use in these entrapments include:

- Individuals are still trying to outrun flame fronts while carrying heavy packs; they are seldom successful. When entrapment is imminent, firefighters must get shelters out and get rid of packs, which slow up escape and deployment and often ignite on the firefighters.
- Two individuals successfully survived under one fire shelter (without injuries) when one person was unable to deploy his shelter in a timely manner.
- People are still failing to lie on the ground before the flame front catches them; the air within 18 inches of the ground is often sufficiently cool to protect the respiratory system even when no fire shelter is used.
- One person was wearing gloves that were too bulky to allow shelter removal from the carrying case without removing their gloves; others had oily gloves, which slipped on fire shelter case pull tabs.

- Several fire shelters showed some sign of wear inside the clear polyvinyl bags, but performed satisfactorily in use. These shelters were not properly inspected prior to use.

- Five individuals partially opened their fire shelters and used them as heat shields to walk along a narrow jeep trail above the fire. They did not fully deploy their shelters in the recommended manner and may have endangered themselves by being in a zone where super heated air and gases could have damaged their respiratory systems. Their fire shelters provided cleaner air and shielded them against some of the radiant heat.

- A jeep trail 8 feet wide and a forest road 16 feet wide both provided adequate areas to safely deploy fire shelters.

- A fire shelter with a 3-foot tear caused by a person trying to get under another person's shelter still provided adequate protection from the entrapped firefighters (Fig. 2).

- Many individuals traveled along roads to larger safety zones while inhaling harmful amounts of smoke and subjecting themselves to radiant heat without deploying their fire shelters as shields.

## Other Personal Protective Equipment

Other items of P.P.E. whose performance on these entrapments was worth noting include:

- Several individuals, attempting to outrun the fire on steep slopes, lost their hardhats because they were not using the chin straps. Hardhats can provide critical thermal protection for the head, reducing direct exposure to radiant heat or actual flame.

- Nomex shirts and overpants on several individuals were subjected to temperatures in excess of 600° F; they functioned as designed and provided thermal radiation protection to the individual involved.

- One individual, who did not deploy his fire shelter, had his face and neck shroud tucked inside his hardhat and failed to let it down when entrapped. He suffered minor burns to his ears when the fire burned by him.

- In all cases, leather lace-up boots provided good protection for entrapped firefighters and no injuries to the feet occurred. One person was wearing plastic boots, which are hazardous in a fire environment, do not meet minimum safety standards, and may contribute to foot injury.



Figure 2.—Even a damaged fire shelter provided protection for two entrapped firefighters.

- Close fitting face and neck shrouds restrict breathing and are uncomfortable when the wearer is running. The lack of an insulating air layer between the shroud and skin increases the heat load the wearer suffers. This can lead to burns from direct contact with the shroud or from radiant heat. At least one firefighter was so uncomfortable that he opened the shroud while running from the fire in order to breathe easier.

- Most line gear did not experience damage from the heat of the fire itself, but some damage and burning did occur when flammable items such as fusees or saw gas containers left in the firefighter's field pack caught fire (Fig. 3). Fusees will self-ignite when reaching 375° F. The igniter portion burns at 3,300° F and then the main portion of the fusees continues to burn at 1,600° F. These temperatures far exceed the design limitations of the P.P.E.

- All individuals entrapped were wearing cotton or cotton/polyester mix t-shirts. Both short-sleeved and long-sleeved versions were used. Although charring occurred, no ignition resulted on these items and the extra insulation between the Nomex outer shirt and the firefighter's skin reduced burn injury by about 15 percent.



Figure 3.—A line pack shows the effects of intense heat.

## Recommendations

While wildland firefighters never expect to be entrapped on fire assignments, the possibility always exists and actions to minimize injuries must be anticipated with reactions planned in advance of the actual event.

Actions that could be critical to your survival in the event of an entrapment include:

- Select escape routes and safety zones carefully and consider the potential rate of fire spread and fire intensity of the fuels in order to have sufficient time to escape.

- Always use all assigned P.P.E. in the method intended (i.e., sleeves down on shirts, gloves on, etc.) (Fig. 4).

- When entrapped with no escape route, the most important action to insure survival is to get face down on the ground where cooler air will help to protect your airway, even if you cannot get into your fire shelter before the high heat arrives.

- During an entrapment, always remove all flammable materials such as fusees, saw gas containers, and oil-soaked packs immediately, even if removal must be completed lying on the ground or in a shelter. Push pack well away from yourself and others.

- Never begin an operational period with clothing or P.P.E. that has gas, oil, or other flammable materials on them.

- Fire shelters should always be carried where they can be quickly reached, even on the run. Shelters should never be carried inside the firefighter's field pack.



Figure 4.—Forest worker gloves protected the hands of firefighters.

- Fire shelters should be inspected annually at the start of each fire season and re-inspected on a regular basis throughout the fire season (recommended re-inspections every 2 weeks). Specific information on inspecting fire shelters can be found in the publication “Inspecting Your Fire Shelter.”

- Practice deployments so that you can properly deploy and be within your shelter in under 25 seconds. Practice sites should include steep, uneven ground. Large fans should be used to simulate the high wind conditions that often occur on wildland fire entrapments.

- Refresh your fire shelter training every year and completely retrain every 3 years.

- Face and neck shrouds should not be worn on a regular basis since they cause heat stress and may tempt firefighters to take more chances. They should be worn when previously safe conditions worsen and escape or entrapment action becomes likely.

- Firefighters should deploy shelters and lie on the ground in extremely smoky conditions to minimize smoke inhalation, even when burn injury is unlikely. A shelter may prevent minor burns and smoke inhalation.

- Although fire shelters are designed for a single occupant, they may be used for two individuals if no other alternative exists.