Regardless of the degree of protection afforded by any piece of clothing or equipment, much of the effectiveness will be lost if firefighters are not fully trained in its use and maintenance. The correct usage and maintenance of all items of protective equipment are heavily dependent on the individual firefighter's attitude, training and maintenance knowledge. All types of equipment are vulnerable to various forms of deterioration and failure of this piece of equipment would be extremely hazardous. Firefighters should receive instruction on inspecting equipment for deterioration or malfunction and trained, where applicable, in correcting defects.

For every protection added to the firefighter's equipment, there must be some compromise of the following:

- Dexterity of hand movements
- Agility of body movements
- Ability to sense the warning of fire by feeling and hearing
- Weight of equipment creating additional firefighter fatigue

Protective clothing for structural fire fighting normally consists of turnout coats, boots, helmets, gloves and pants. Proximity, entry and approach suits are available for other types of fire fighting. Special impervious suits must be considered for handling various chemical emergencies. The firefighter must understand the design and purpose of the various types of protective clothing and be especially aware of each garment's inherent limitations.

HEAD PROTECTION

Traditionally, the function of the helmet was to shed water with little other concern for protection from heat or cold or impact with the environment. The wide brim, particularly where it extends over the back of the neck, was an effort to prevent hot water and embers from reaching the ears and neck. As the use of backpack type air masks increased, this large rear overhanging brim has become a problem.

The web-type suspension network, located inside the shell, acts to support the helmet on the firefighter's head and to prevent the shell from striking the head when subjected to an impact force. The design concept is to prevent direct transmission of blows to the skull by distributing the force over the head as evenly as possible.

Energy Absorption Design

The energy-absorbing liner concept is a result of helmet designs from the fields of transportation and sports equipment. The helmet design is based on the assumption that where the time duration of impact is short, higher pressure can be absorbed without concussive effect. The impact energy is absorbed and dissipated over the entire surface of the liner. Two criteria are important here. One, the shell must be quite hard so as not to deform and, two, the liner must be fairly well fitted to the skull and be capable of absorbing the energies transmitted to it.

Requirement of Helmets

ANSI Z89 The requirements for a helmet specifically intended for fire fighting service include:

- The shell must be capable of withstanding a 2200 volt test, without current leakage exceeding 3 milliamperes. The shell must also provide protection from voltage up to 600 volts.
- The helmet must not transmit a force greater than 850 pounds from the impact of an 8 pound steel ball dropped on the center of the crown from a height of 5 feet.
- The helmet must also resist a penetration greater than 3/8-inch when a one pound pointed plumb bob is dropped on the center of the crown from a height of 10 feet.
- The helmet should be of heavy construction and should be wide-brimmed.

Care of Helmets

Helmets should be properly cleaned and maintained to insure their durability and maximum life expectancy. The following are guides for the proper care and maintenance of fire helmets:

- Dirt and all other foreign material should be removed from the shell.
- Remove chemicals, oils and petroleum products from the shell as soon as possible since these agents soften the shell material and reduce its impact and electric protection. See manufacturer's instructions on what materials to use to remove these products.
- Helmets which do not fit properly should be repaired or replaced since a poorly fitting helmet will reduce the helmet's ability to resist the transmission of force.

- Helmets which are damaged should be repaired or replaced
- To assure an adequate separation between the skull and an object that may penetrate the shell, the suspension network must leave 1-1/4-inch between the top of the firefighter's head and the crown of the shell.

TURNOUT COATS

Turnout coats are those coats used for protection in structural fire fighting. Turnout coats, like all other protective equipment, are only designed for a certain range of exposure. It is vital that firefighters thoroughly understand the limits of protection offered and not exceed those limits.

Layers

Research has indicated that multiple layers of lightweight material with several air sandwiches provide as near optimum protection as currently practical. Multiple layers conduct less heat to the firefighter's skin. The layer concept is a tradeoff approach in some respects. Every layer of added material will escalate cost and limit physical movement to some extent. The extra layers will also become uncomfortable after a certain period of time unless some method is devised to remove body heat buildup.

Outer Shell

The outer shell must necessarily be flame resistant and as lightweight as possible to lessen firefighter fatigue. Color, restriction of motion, cleaning effectiveness and permeability of the material are other factors to take into account. A permeable coat, even though treated to repel water, will still absorb some water which will evaporate when exposed to heat and thus cool the wearer. An impermeable coat repels water so it has no such cooling effect; however, in freezing weather the coat will dry faster and reduce the formation of ice. Materials receiving much use in the outer shell composition today include canvas, duck, rayon, nomex, kynol and some aluminized fabrics.

Vapor Barrier

The vapor barrier of the turnout coat is that material used to prevent or inhibit the transfer of water, corrosive liquids, steam or hot vapors from the outside of the coat to the firefighter's body. This barrier may be a back coating of flame resistant material given to the inner lining, or a separate liner. The separate liner will allow air flow for thermal insulation and will not be as stiff as a single heavy layer. The vapor barrier material is usually neoprene or other rubberized or vinyl moisture barrier. The material should be light, flame resistant and should not stiffen when subject to freezing conditions.

Inner or Insulating Liners

The inner lining is the material or material assemblage which is either sewn or snapped into the outer shell. The lining is for thermal protection and padding. Lightweight flannel, wool, cotton, and nylon quilt are all commonly used materials for the lining. To insure full protection, liners should come to within three inches of the shell's bottom.

When firefighters encounter high summer temperatures, there may be a tendency to remove the inner liners from turnout coats. This practice should not be allowed since removing the liner decreases the effectiveness of the concept of layers and air sandwiches. The reduced weight may lessen fatigue and perhaps give some brief relief from body heat, but the loss in protection is serious. It is important, however, that the vapor barrier and at least one additional layer be in place at all times.

Collar

The collar on turnout coats should protect the neck and throat when in the raised position. The water penetration protection of the collar should be at least equal to the vapor barrier. Most collars are water repellent cotton corduroy.

Closure

A storm-fly closure must be provided on the front of the coat for protection against steam and water.

Pockets

All pockets should have two holes at the bottom to allow for drainage of water.

Color and Visibility

Turnout coats are available in a variety of colors such as yellow, black, white, red, olive drab, orange, khaki, silver or brown. It has been found that a black coat exposed to the radiant energy of the sun will absorb more heat than lighter colors and therefore will increase temperature and discomfort to the wearer. However, when a black coat and other coats of lighter colors of the same material are exposed to the radiant energy given off by intense combustion of ordinary fires, there will be little measurable difference over an extended period of exposure. Black is an undesirable color for visibility under both day and night conditions. Lighter colors are more visible with white and yellow being the best choices. A complaint in using lighter colors for turnout coats is that they are more difficult to keep clean than the darker colors. Although they will appear dirtier, the greater safety factor in visibility outweighs this argument.

Wristlet

The turnout coat should have a suitable wristlet that meets the flammability tests recommended for the outer shell. The inner cuff material should be elastic with a small leather strip to anchor the wristlet to the cuff. The wristlet material should fit snugly but not impede donning of the turnout coat.

Length

The choosing of a coat length must be related to several factors including protection and physical agility. Coat length should not unnecessarily interfere with knee movements, particularly when climbing and crawling.

HAND PROTECTION

Protecting the firefighter's hands presents some unique problems. Although the need for hand protection is evident, it is often difficult to obtain while still maintaining manual dexterity. No single type of protection will be suitable for all types of exposures.

Leather Gloves

For routine fire fighting and most work activities involving exposure to cuts, bruises and puncture wounds, the traditional leather-palmed glove is the best selection currently available. These leather gloves may have a canvas back and can be fairly well fitted to a large percentage of firefighters. These gloves are usually sized in small, medium, large and extra large, and the fitting to the fingers will determine hand dexterity. As additional layers of protection are added, dexterity will rapidly diminish. Although leather gloves offer protection from the above hazards, they do present several problems that will need to be considered.

- Leather gloves absorb water and grow stiff with age.
- Leather gloves can be cut and punctured by the combination of sharp objects and pressure.
- Leather gloves offer limited protection from extremes of hot and cold.
- Leather gloves that come into contact with chemicals will absorb the material causing deterioration and increased exposure to the hands.

Plastic-Coated Gloves

There are many types of plastic-coated gloves available that keep the hands fairly dry. These gloves are preferred by some firefighters during cold weather. Varying degrees of insulation are also available in this style glove, although some loss of dexterity is to be expected. The main concern over the use of plastic-coated gloves is their reaction when exposed to radiant heat. There will frequently be some softening of exposed surfaces and once the heat migrates through to the skin, the gloves become very uncomfortable. If the heat is sufficient, perspiration from the hand can turn to steam and cause burns. As heat conducts slowly through a material in one direction, it also moves slowly in the opposite direction. Firefighters have found themselves having to remove plastic gloves because they have become unbearably hot.

FOOT PROTECTION

Hazards to the feet are numerous on the fire scene and the need for proper foot protection is obvious. When selecting the type of protection, consider the hazards that will be encountered. Injuries caused from heat, puncture and impact will all need to be guarded against.

Turnout Boots

Puncture resistance is important and is available in turnout boots through a midsole stainless steel plate approximately 0.018-inch thick. Some fire departments require insulation to be laminated into the rubber. The only disadvantage of this is that the added weight will tend to increase firefighter fatigue. There are also commercially available turnout boots with shin pads to reduce the strain encountered with leg-locks and crawling on floors. Pull-loops for the boots should be provided and be well secured. Select a boot lining that will not break up and cause blisters and discomfort. Turnout boots of 3/4 length should have good reinforcement patches at the knee fold since this is generally the source of early breakdown.

Even though there are not half sizes available in turnout boots, each firefighter should be fitted as closely as possible. If necessary, adequate socks should be added to provide a snug fit. Firefighters must not be allowed to share turnout boots since this practice is unsanitary. When boots are reissued, they should be sanitized by procedures recommended by an industrial hygienist.

Care and Maintenance

If the boot is to provide maximum protection, it must be properly maintained. The following guidelines are suggested for proper care and maintenance.

- Worn heels should be replaced by vulcanizing the new heel to the boot. This process restores the original protective quality to the boot.
- Oil, grease and debris should be washed from the boot since all have a deteriorating effect on rubber.
- Rubber deteriorates faster at points of strain so boots should not be kept in the down position longer than a tour of duty.
- Boots lose their protective quality through the deteriorating action of ozone on rubber. To minimize this problem, store boots in a dark, cool area.
- Worn, cut or punctured boots that cannot be effectively repaired should be replaced.

EYE PROTECTION

Perhaps one of the most common injuries on the fireground is to the eyes. Although statistics might indicate other injuries, it should be remembered that in many cases the individual will simply place his head under some available source of running water until the debris is flushed out and neither seek or receive any further treatment. Protection of the eyes should definitely receive attention.

Basic Requirements

Comfort to the intended user and adequate vision are paramount to a successful eye protection program. The field of vision for any type eye protection should be an effective angle of at least 105 degrees in order for the firefighter to be able to see the multitude of hazards with which he must deal. Since fire fighting is inherently associated with heat, providing eye protection on the fireground requires special consideration. Ventilation is often a problem not only in terms of eye comfort but also in terms of fogging which decreases visibility. This problem is more acute where full face coverage masks are used in conjunction with breathing protection, since the likelihood of a considerable amount of high humidity only complicates the problem. Numerous commercial preparations are available to cleanse and coat eye protection and facemask lens pieces.

Durability of any eye protection must be considered. Resistance to impact requires selecting materials which will absorb the impact and not shatter. Perhaps some of the best available materials for eye protection are those made from polycarbonates. In utilizing plastics, however, good vision will often be difficult to maintain since most plastics normally will become scratched after a relatively short period of usage.

Faceshields

Many fire departments have been placing dependence for both face and eye protection on faceshields which attach to the helmet. Most of the flip up out of the field of vision fairly easily and are generally acceptable to firefighters. Most of the current faceshields are made of polycarbonate plastics and can be positioned fully down for maximum protection or flipped up completely out of the peripheral vision. Most assemblies do not interfere with protective breathing equipment. However, temperatures upwards of 300oF may cause some polycarbonates and thermoplastics to lose their configuration. When selecting such devices, particular attention should be paid to the vertical height of the shield and to what degree side protection is provided.

Many of the plastics have upper temperatures from around 250oF to 300oF for structural stability. Some firefighters have complained that the shields soften and distort thus impairing vision. When the shield begins to distort, this is an excellent indication that the firefighter is in a dangerous environment and should not be there since the human skin blisters at around 130oF. for an exposure of only 20 seconds. At 160oF. second degree burns can occur in only one second of exposure. Faceshields are now available, however, that have a vented area around the top of the shield to allow the smoke and steam to escape.

Eyeglasses

Firefighters who wear prescription eyeglasses should select frames and lenses which meet ANSI Standard Z87.1 for severe exposure to impact and heat. Although it will increase cost of operation, those firefighters who wear eyeglasses should be provided with individual facemasks that have special lens holders mounted inside. In this manner, the firefighter has all of his sensory system working at its maximum. Regular eyeglasses cannot be worn with facemasks since the side temple pieces of the glasses create too much leakage.

Although contact lenses would solve the facemask problem, they should be avoided for several reasons. Primarily, they can compound injury where corrosive bases dissolve into the eye fluids and become entrapped behind the contact lenses. Due to the vigorous nature of fire fighting, a contact lens could also drop out at a very critical moment.

GENERAL CONCEPTS

There are essentially three basic ways to safeguard against hazards. The first, and most desirable, method is to eliminate all hazards at their source which would include preventing all types of hazardous situations. This solution, however effective, will not be possible in all circumstances even though this would be the utopian situation. When the potential hazard cannot be eliminated, the second recourse of safeguarding is to devise systems to intercept the threat on its path from is source to the individual. This can be accomplished by erecting fences, establishing guards or constructing fire walls. The interception concept is utilized by some types of protective clothing such as aluminized garments designed to reflect a large quantity of heat energy. The third method of safeguarding against hazards is to combat the attack by some form of defensive wall. The defensive wall concept as applied to fire fighting means the utilization of protective clothing and equipment.

When utilizing the defensive wall concept of protective clothing and equipment, it is paramount that the shortcomings and limitations of this protection be recognized by all firefighters. The firefighters must first understand that no one specific item in any category (helmets, boots, turnout coats) can defend against all attacks to the body. This implies that a range of protection or performance must be established and understood. The range of exposure is oftentimes greater than the range of performance of a particular item. Employing an item of protection to cover a degree of exposure that is beyond its design and capability is a common occurrence and one that is difficult to correct. Firefighters must be fully cognizant of the degree of protection afforded by all protective equipment and its inherent limitations.

Overconfidence in the degree of protection afforded by a piece of equipment may cause the firefighter to take unnecessary risks which could result in injuries. Overconfidence is the result of a series of successful operations with given items. The natural tendency will be to gradually forget the inherent limitations of any physical object. To amend this complacency, short classes covering protective equipment and clothing might be held intermittently. During the refresher class the limitations of the items can again be stressed.

Today's technological working environment may be beyond some firefighter's comprehension because of limited experience and/or education. These limitations may cause firefighters to underestimate the degree of risk in a fire situation. The result is that some emergencies may be attacked which are beyond the capability of men, equipment, and known techniques.