

SAFEGUARD FOR FOREST FIRE-FIGHTERS IN CHINA

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ABSTRACT

This paper gives an account of the dangers and impairments in face of fire-fighters, which are caused by flame, high-temperature, harmful gases, dust, oxygen-deficiency, as well as the bad environment. It focus on the techniques of the protection equipments for forest fire-fighters, such as helmets, suits, gloves, boots, rescue wraps, tents and sleeping bags etc, which are used in our country nowadays. Finally, it puts forward ideas concerning the developing tendency of the protection equipment used in forest fire-fighting in China, that is, flame-retarding, multiple functions, seriation and standardization and the making up of the regulations and laws.

INTRODUCTION

Forest fire-fighting is an extremely hard and dangerous task. Nearly 1,000 people are burnt to death each year all over the world in forest fire-fighting. Since 1950s, over 100 people are burnt to death and several hundreds of people are injured in the forest fire-fighting in china. Therefore, the governments of our country have been paying great attention to the safeguard of the forest fire-fighters. Especially in the recent years, fund for research and development of protection equipments for forest fighters have been applied widely and obvious social benefits and economic benefits have been achieved. However, in view of the requirements for developing the forest fire-suppression service, more works must be done to improve the protection equipments both in variety and in quality.

THE DANGERS AND IMPAIRMENTS IN FACE OF THE FIRE-FIGHTERS

Forest fires are the intensive chemical reaction of inflammables and oxygen in forest under high temperature. In the course of inflaming, in addition to generating flame and high temperature, large amount of smoke will be released, which usually results in oxygen-deficiency in air.

1. Impairments Caused by Flame and High Temperature¹

The flame temperature of forest fire is usually in the range from 600°C to 900°C, it can injure not only the exposed parts of human body directly, but can also cause various kinds of impairments through burning the suits of fire-fighters, which can burn the skin and flesh, or even main persons for life; in serious cases, even the lives of fire-fighters can be endangered.

Under high temperature, heat, acted on the organism of human body, can not only burn the

skin and flesh, but also dilate the blood vessels under the skin, speed up the flow of blood and increase the heat given out from skin directly, so that the metabolic confusion of water salt in human body will take place, because of the large amount of sweat secreting. In serious cases, it will bring about collapse and make the fire-fighters feel weak all over the body. Working under high temperature environment for too long time can lead to high body temperature, because the heat within the human body can not be given off easily, when the body temperature rises to over 41°C, the function of temperature regulation of human body will be lost; once the temperature rises up to 43°C, the life of human being will be endangered.

Researches on five residence fires in the United States by Preao, show the effects of high temperature on human body as follows: at 126°C, it is difficult to breathe; at 140°C, the endurance time of people is five minutes; at 149°C, it is extremely difficult to breathe through mouth and it is the temperature limit for escaping; at 160°C, the skin will turn dry rapidly with unendurable pain; at 182°C, people will be injured irrecoverably within 30 seconds; at 204°C, skin will turn wet, the endurance time of respiratory system is less than four minutes.

In the practice of fire-fighting in forest, the distance between fire-fighters and fire is not far and the fire-fighters sometimes are surrounded with great fires. The temperature of the environment, where the fire-fighters are in, may be 250°C or higher. From this we can see that the impairments caused by high temperature on fire-fighters in forest fire-fighting are extremely serious.

2. The Impairments Caused by Smoke²

The smoke given off from forest fires is composed of carbon particles, liquid fog drops and various gases floating in air on the way of spreading.

The smoke can keep off the sunlight, so as to make the visibility of fire-fighters drop down drastically, to make fire-fighters nervous and cause disorders in physiology and difficulties in action. The strong stimulating effects of smoke on eyes and respiratory organs can result in symptoms, such as tearing, nose running, sneezing, coughing and even restraining from breath.

In addition to the harmful gasses of carbon monoxide and carbon dioxide generated from forest fires, there are also hydrocarbon (HC) and nitrogen oxide (NO) etc. Among these gases, the main lethal factor is carbon monoxide. The oxygen is transmitted into human body through the heme (H_b) in blood of lungs. Once the carbon monoxide is drawn into the lungs of human body, it will be combined with the heme in the blood and change into carbon monoxide heme (COH_b). As the affinity of heme to CO is much stronger than that of oxygen, the reaction speed is about 200times faster. Therefore when the carbon monoxide is drawn into the human body, the amount of heme, which serves as transmitter of oxygen, will decrease; while the normal supply of oxygen for human body decreases, oxygen deficiency in body will result in obstruction in the brain and nerve centre. When the concentration of carbon monoxide increases up to 0.15 percent, headache will occur in 15 minutes, paralysis will occur in 30 minutes and death will occur in an hour. When the concentration reaches 1.28 percent, effect will occur at once; people will lose consciousness after 2-3 breathes and will die within 1-3 minutes.

Forest fire can generate large amount of carbon dioxide, which is harmless when the concentration of it is low. However it will speed up and deepen breath, when the concentration of carbon dioxide is on the medium level, so as to enhance the respiratory capacity per minute. As a result the drawing-in rate of toxin and stimulus by fire-fighters will be quickened and, as a result, dangers will be increased. When the concentration reaches 10 percent, people will lose consciousness within 30 minutes; and when it reaches 20 percent, people will lose consciousness within 1 minute.

Nitrogen oxide (NO) and nitrogen dioxide (NO₂) are two main kinds of nitrogen oxide. Nitrogen oxide can generate heme which stimulates the central nerves. Under high temperature, it can also generate nitrogen dioxide through quick reactions with oxygen in air. When the concentration reaches 3ppm, spasm of bronchial tubes will occur within an hour; when it reaches 150 ppm death will occur soon.

The incomplete burning of forest can produce hydrocarbon, among which the alkene and arene can form harmful second pollutants in the course of reaction under the affect of light³.

Besides, forest fire consumes oxygen in air. When the content of oxygen in air drops from 21 percent to 17 percent, the regulation function of flesh nerves will be injured. When the oxygen drops to 14-10 percent, people will lose consciousness. If the person can not be recovered with oxygen or fresh air within a few minutes, death is inevitable.

3. Other Impairments

Some of the forests are located in areas where slopes are steep, and fire-fightings are usually carried out during night when flames are usually low. Therefore, injuries and death easily take place because of slip, rolling stones or fallen woods.

In addition, the conditions of field fire-fighting and lodging are extremely poor, with great mobility and long duration time. The fire fighters are usually confronted with coldness, damp and insects etc, which often result in various impairments and disease, so that the fighting capacity of the fire-fighters are often affected seriously.

PROTECTION MEASURES AND EQUIPMENTS⁴

Nowadays, the apparatus and tools used to extinguish forest fires in our country are mainly wind extinguishers, NO.2. apparatus and small portable drug sprayers, water sprayers etc, The distance between fire-fighters and flames is about 1-2m, and the fire-fighters have to endure a high temperature over 250°C. Therefore, they can be easily injured by flame, sparks and smoke. Sometimes, they may be enclosed by fire. Before 1985, the forest fire-fighters in our country didn't have any specially-made protection equipments, so effective protection was not available. Under such condition, the rate of fire suppression is low; while the rate of injuries and death of fire-fighters is high. In order to improve such backward situation, the scientific and technological personnel have developed successively many protection equipments and life-saving equipments which are fit for fire-fighters in china, in accordance with the characteristics and demands of forest fire suppression in China.

1. Fire-fighting Helmet

In order to protect the heads (including face and neck) of fire-fighters from injury effectively, the helmets are made up of three parts; the main body, the face mask (including smoke-proof glasses and smoke-proof mouth mask) and the cape. The contour and structure of the fire helmet are identical with the construction safety helmet. The helmet body is made of polycarbonate modified with glass fibre. The lining of the helmet is made of polyethylene and the oxygen index of helmet body is 31. It can resist radiation heat over 300°C. Burnt in fire of 800°C, it will be only carbonized and produce no flame. It is self-extinguishable when it is moved away from fire. It has good impact-absorption property. The face mask is made of steel paper plate with aluminium powder coating. The smoke-proof glasses is made of organic glass, rimmed with fire retardant foam plastic which can prevent smoke from choking the eyes. The smoke proof mouth mask is made of superfine polypropylene and active carbon felt with desirable smoke screening rate which reaches 94.3 percent. The cape is made of flame retardant cloth. The fire helmet has the features of fire resistance,

smoke-proof and impact resistance, and it is portable and comfortable.

2. Fire-fighting Suits

At present, the forest fire-fighting suits are divided into fire fighting suits and director's suits, which are made with face materials of flame-retardant pure cotton cloth, blend flame retardant textiles and flame retardant fibre fabrics. The cloth of pure cotton and flame retardant fabrics are thin canvas, gauze kahki and gabardine etc, finished with CP retardant materials or Propan (THPC) fire retardant materials. The blend fire retardant textiles is Conex and cotton-interwoven fabric finished with CP fire retardant materials. The flame retarded fibre fabric is blended with fire retardant viscose ray-on fibre and wool (in proportion of 50:50). All these face materials have excellent fire retardant property, with oxygen index over 31; charred length below 5 cm; and the function of self-extinguishing after the fire is removed. When the materials are moved away from the fire, there will be no afterglow and fire-spreading. In addition, the materials are soft, non-toxic, ventilating and washable for more than 50 soap washings. The strength of the materials are high. The fire fighting suits made of the fire retarded face materials are capable of alleviating fire progression and there is no flame when the suits are being burn in fire. They can be self-extinguished after the fire source is removed and the carbonized matter will form an insulation layer, which will play a role of protecting the fire fighters.

3. Fire-fighting gloves

To meet the demand of forest fire extinguishing, the design of the gloves should be a type of long sleeve and five fingers. The palm portion is made of fire retardant cattlehide leather and the sleeve is made of canvas. Two-layer materials are used for the hand back and sleeve, while leather strips are used to rim along the seams. The gloves have the features of fire resistance, heat isolation, flexibility and duration.

4. Fire-fighting Boots

The fire retarded boots are kinds of long tube-shaped shoes with metal zipper installed inside and borer tapes attached to the upper rim of the tube and around the foot ankle. Inside the sole, which is made of fire retardant rubber, there is a stick-proof layer. The design of the sole face is a kind of large-teethed and backward and forward jigsaw pattern, The vamp is made of water-proof leather and the tube is made of water-proof and flame retarded canvas of polyvinyl alcohol fibre. These boots have the features of fire resistance, water-proof stick-proof and slip prevention.

5. Fire Rescue Wrap

Fire rescue wrap is a kind of emergency rescue equipment used as a shelter to protect fire-fighters from direct injury caused by flame and radiative heat. It can also be used to prevent fire-fighters from suffocation caused by thick smoke when they are surrounded by fire and can not escape. It is a triangle and tent-shaped shelter with four cushion strips and press strips attached to the bottom edge. The face materials are composite cloth of glass fibre and aluminium. It has the properties of reflection of radiative heat, fire resistance and smoke prevention.

When flame is coming, fire-fighters must open the rescue wrap quickly and then cover their bodies with the wraps as a cloak. The fire-fighters must lay down on the ground on the stomachs with legs forked towards the direction of the fire and with arms bent beneath their faces. In this way, both the cushion strips and the edge strips will be pressed under his body with his two arms and two feet tightly. With faces close to the earth, fire-fighters can breathe easily with cooler and cleaner air, and then they can leave the rescue wrap when the fire is gone.

6. Fire-Resistant Tent

Fire resistant tent can be divided into four types: the single tent, the double tent and the triangle and

rectangle shaped tent. The face materials for top face and sides are made of flame retarded and water proof taffeta, while the bottom face is made of flame retarded and water proof polyvinyl alcohol fibre canvas. It has the features of fire resistance, water proof, damp proof and mosquito prevention.

7. Fire Resistant Sleeping Bag

The face materials of sleeping bags is flame retarded and water proof taffeta, and the inside materials is eider down, It has the features of fire resistance, cold prevention and damp proof. To meet the demand for fire extinguishing in field, multiple functions such as to be used as a quilt and an overcoat etc. are required.

SOME IDEAS AND SUGGESTIONS

1. The helmets, suits, gloves, tents and sleeping bags, commonly used by people, are usually made of materials such as common plastic, leather, rubber and cloth. All these materials are inflammable, except leather which has certain flame retarding property. People, wearing clothes without fire-retardant capacity, can be injured or burnt to death, because the clothes can be easily burnt and the inflaming of the clothes can not be distinguished easily when it is on fire. Equipped with flame retarding devices, the self flame resistance of the fire-fighters can be enhanced. As a result, not only body impairments and death can be decreased, but also the fire fighting capacity will be enhanced. For this reason, it is extremely necessary to equip the fire-fighters with flame retarding equipments.
2. The aviation and ground transportation in forest area in China have not been developed sufficiently. Transportation in forest for fire fighting depends on manpower to certain extent. To reduce the load of fire-fighters, it is necessary to produce portable equipments with multiple functions. For instance, the helmet can be fire resistant, impact resistant and smoke proof; while the sleeping bag can be used as a quilt and overcoat as well.
3. At present, complete sets of various protection equipments for forest fire-fighters in China are wanted. In order to improve the overall functions of fire-fighting in China, a number of new products (such as apparatus of toxic gas prevention and oxygen supply) must be developed and complete sets of equipments should be also developed so as to work out a series of protection equipments.
4. In order to form standardized and serial production of the protection equipments for the forest fire-fighters in China, so as to achieve excellent social benefits and economic benefits, it is urgently necessary to formulate all kinds of national standards and professional standards. At the same time, relevant regulations and laws must also be worked out for people to follow.

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