## INTRODUCTION

It is extremely important for firefighters to understand the physiological effects of heat and how it affects their ability to perform work. The protected body can tolerate extremes in temperatures ranging from 50 to 100 degrees Centigrade. However, the body cannot tolerate a change in its own internal or core temperature of 4 degrees Centigrade without suffering some type of damage. This explains, in part, why ill effects are experienced with only a slight temperature above the normal of 98.6 degrees Farenheight.

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## HEAT GENERATION

The normal internal temperature of the body is created by the poor efficiency the body has for converting energy into actual physical work. It is estimated that only 25% of the body's energy stores actually produce work, while the other 75% of the energy is converted to heat in the process. When a physical activity is performed the metabolic energy need increases, resulting in a higher metabolic rate thereby raising the internal or core temperature.

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## HEAT TRANSFER

Heat energy always transfers from a warmer mass to a colder mass, so when walking outside on a cold night, the body radiates heat away and we feel colder. The temperature difference between the body and its surroundings is the driving force of heat transfer.

### Radiation

On a hot summer day, the direct rays of the sun warm the body by radiation, sometimes to the point of burning. Tanning and burning are caused by infrared and ultraviolet radiation from the sun acting on the skin. In Arizona the sun's rays are particularly strong and the body is absorbing heat whenever it is in the direct sunlight.

### Conduction

A very similar process to radiation occurs with conduction. In this case the transfer of heat is from a hot mass to a cold mass through direct contact. Conduction will be a factor any time that two masses at different temperatures are in direct contact with each other. This can take place between a body and clothing, water, furniture or even another body.

### Convection

Convection is the process of heat transfer that is created by the flow of air currents at different temperatures. The most common example of this is the wind chill factor.

## HEAT DISORDERS

The recognition of the early signs and symptoms of heat disorders allows for early intervention, avoiding the progression of events leading up to heat stroke.

Early warning signs of impending heat disorders include:

- A chilled feeling.
- Goosebumps on chest and upper arms.
- Throbbing pressure in the head.
- Unsteadiness.
- Nausea and fatigue.

If these early signs and symptoms are not recognized and immediate measures taken, it then becomes only a matter of time before signs and symptoms of heat cramps or heat exhaustion appear.

### Heat Cramps

Heat cramps are characterized by severe cramping of the skeletal muscles, primarily those muscles being used in the activity being pursued. Heat cramps are the result of the depletion of body water and minerals that accompany the sweating process. Heat cramps are the least serious of the heat disorders, but extremely painful.

### Heat Exhaustion

Heat exhaustion, which is characterized by extreme tiredness, breathlessness, dizziness, tachycardia, and a body temperature of 101'F - 104'F, may or may not be preceded by heat cramps and sweating may or may not occur. The individual may also suffer a varying level of consciousness. The reason for the potentially wide variety of signs and symptoms seen in exhaustion is because the body's ability to dissipate heat is now at its maximum limit and beginning to falter and the body temperature is rising. The extent to which an individual suffers or exhibits these signs and symptoms tends to be specific to the individual.

### Heat Stroke

Heat stroke is characterized by a body temperature of 105'F - 106'F, total confusion or unconsciousness, cessation of sweating, increased heart rate, low blood pressure, and ultimately death. In heat stroke, the body's temperature regulating systems have been completely overwhelmed and have ceased to function, resulting in a dramatic increase in internal body-core temperature. Unless active cooling methods are pursued immediately, severe injury or death will occur quickly.

## BODY HEAT DISSIPATION

Blood Flow Shifts

The center for temperature is located in the Hypothalamus region of the brain. When the Hypothalamus notices the rise in body temperature, its first thought is to return body temperature to resting or normal levels. It accomplishes this initially by shifts in blood flow; the blood picks up metabolic heat from deep in the core of the body and transports it to the blood vessels that lie close to the surface of the skin. These blood vessels are dilated to allow for more body heat to be brought to the surface by the blood and the dilation of the blood vessels also effectively slows down the speed of the blood as it flows through these vessels, allowing for longer exposure and more time to dissipate the heat. Assuming, the external environment is cooler the body heat is transferred or dissipated into the surrounding air.

Sweating

When blood flow shifts alone will not maintain body temperature the Hypothalamus will then invoke the sweating mechanism for relief. This cooling mechanism involves stimulation of sweat glands in the skin to produce perspiration. Perspiration or sweat is primarily composed of water and minerals, principally sodium and calcium. The production of sweat in itself does not cool the body, but the evaporation of the sweat involves a tremendous amount of heat loss.

PREVENTIVE MEASURES

Fitness

Higher levels of fitness will insure that the body is working at peak efficiency, which means it will require less effort to perform the same work. This will produce less body heat and better dissipation of heat that is produced.

Acclimatization

This technique allows the body to become accustomed to the heat by exposing it to heat in a controlled setting over a period of time. The body has the opportunity to make those adjustments necessary to better compensate for the build up of heat. To become better acclimatized to heat, the wearing of turnout gear each shift and performing some light exercises for a period of 10-15 minutes would suffice. The improvement in heat tolerance is associated with increased sweat production, lowered skin and body temperature, and a reduced heart rate.

Fluids

The amount of water lost during firefighting is estimated to be approximately one to two liters per hour or 10% of total plasma volume. It is essential to maintain adequate amounts of water and sodium chloride in the body. The best approach is to make a conscious effort to drink water at periodic intervals, regardless of thirst.

Clothing

Depending on the type of clothing worn heat transfer can be either enhanced or inhibited. Cottons and other natural fabrics tend to whisk the water away from the skin and push it to the outside where it can evaporate. Most synthetics restrict the passage of the water, which makes them feel hotter.

Protective clothing provides protection from the heat of the fire and the S.C.B.A. provides fresh air – both are essential pieces of equipment for safety. However, this same protective equipment effectively blocks all of the body's capability to dissipate the rising body heat. The newest designs of protective clothing are designed to maximize heat transfer, particularly with GoreTex vapor barriers that allow the internal pressure to squeeze the sweat to the outside of the coat, but there is no way to make this 100% effective as of this writing.