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DEPARTMENT OF THE INTERIOR
AVIATION
ACCIDENT PREVENTION BULLETIN

Subject: Heat Related Mishaps

Area of Concern: Summer Operations

Distribution: All Aviation Users

Discussion: Summertime is coming and it's going to be …? Hotter than a pepper sprout? Hotter than blazes? Hotter than all get out? No matter how you say it, there's no denying that summer's on its way.

The human body is adapted to a relatively narrow temperature range. It can't function normally in hot and cold temperature extremes. Exposure to such extremes in the aviation environment impairs the efficiency of aircrews and adds to other stresses such as hypoxia and fatigue. Extreme climates can cause uncomfortable or unbearable cockpit conditions. Likewise, atmospheric temperature or altitude changes, aircraft interior ventilation and heating, and protective equipment can also create temperature extremes.

At times, aircrew members think that the temperature inside their aircraft resembles that of a flying oven. Summer time aviation operations for DOI usually takes place at relatively low above ground level (AGL) altitudes that are associated with high temperatures and humidity. The added heat associated with fire suppression missions can seriously limit a pilot's ability to accomplish complex tasks.

RADIANT HEATING

Solar radiant heat is the primary heat-stress problem in aircraft as the glass or Plexiglas™ produces a greenhouse effect. The temperatures in cockpits of aircraft parked on airfield ramps may be 50 to 60 degrees Fahrenheit higher than those in hangars because of the radiation of solar heating. This radiation, in turn, heats the interior cockpit and becomes a significant stress factor at altitudes below 10,000 feet**.** The body maintains its heat balance with several mechanisms. These are radiation, conduction, convection, and evaporation.

Radiation. Radiation involves the transfer of heat from an object of intense heat to an object of lower temperature through space by radiant energy. If the temperature of the body is higher than the temperature of the surrounding objects, a greater quantity of heat is radiated away from the body than is radiated to the body.

Conduction. Conduction is the transfer of heat between objects of different temperature that are in contact with each other. The proximity of these objects will determine the overall rate of conduction.

Convection. Convection is the transfer of heat from the body in liquids or gases in which molecules are free to move. During body-heat loss, the movement of air molecules is produced when the body heats the surrounding air. The heated air expands and rises because it is displaced by denser, cooler air. Respiration, which contributes to the regulation of body temperature, is a type of convection.

Evaporation. Evaporative heat loss involves the changing of a substance from its liquid state (sweat) to its gaseous state. Evaporation is the most common and usually the most easily explained form of heat loss.

Subject: Heat Related Injury

LIMITATIONS

Radiation, convection, and conduction all suffer one major disadvantage in cooling the body. They become less effective as temperature increases. When the temperature of the air and nearby objects exceeds skin temperature, the body actually gains heat. This gain may be dangerous to the aircrew.

When the temperature increases to about 82 to 84 degrees Fahrenheit, sweat production increases abruptly to offset the loss of body cooling through radiation, convection, and conduction. By the time the temperature reaches 95 degrees Fahrenheit, sweat evaporation accounts for nearly all heat loss.
Many factors affect the evaporation process. Some of these factors are:

- Protective clothing. NOMEX flight suits, for example, don't breathe.
- Availability of drinking water.
- Relative humidity above 50 percent.
- Environmental temperature above 82 degrees Fahrenheit.

Relative humidity is the factor that limits evaporation the most. At a relative humidity of 100 percent, no heat is lost through evaporation. Although the body continues to sweat, it loses only a tiny amount of heat. For example, a person can function all day at a temperature of 115 degrees Fahrenheit and a relative humidity of 10 percent if given enough water and salt. If the relative humidity rises to 80 percent at the same temperature, that same person may be incapacitated within 30 minutes.

Individuals vary in their response to heat stress. Some serious reactions are heat cramps, heat exhaustion, and heatstroke. Factors that influence the physiological responses to heat stress include the amount of work that individuals perform and their physical condition as well as their ability to adapt to the environment. Age, excessive alcohol use, lack of sleep, obesity, or previous heatstroke can also diminish tolerance to heat stress. If you've had heatstroke before, you are more likely to have it again.

PERFORMANCE IMPAIRMENT

Heat stress not only causes general physiological changes but also results in performance impairment. Even a slight increase in body temperature impairs an aircrew's ability to perform complex tasks. A body temperature of 101 degrees Fahrenheit roughly doubles an aviator's error rate. Generally, increases in body temperature have the following effects on an aviator:

- Error rates increase.
- Short-term memory becomes less reliable.
- Perceptual and motor skills slow, and the capacity to perform aviation tasks decreases.

PREVENTIVE MEASURES

By taking certain preventive measures, personnel can avoid heat stress. Preventive measures include: reducing workload, replacing lost water and salt, adapting to the environment, wearing protective clothing, and increasing ventilation.

Replace water and salt loss. The human body cannot adjust to a decreased intake of water. People must replace water that is lost through sweating to avoid heat injury. The body normally absorbs water at the rate of 1.2 to 1.5 quarts per hour. A reasonable limit for the total consumption for a 12-hour workday is from 12 to 15 quarts. Therefore, additional water intake is required. Individuals should drink one quart per hour for severe heat-stress conditions or one pint per hour for moderate stress conditions. Crew members should be encouraged to drink fluids as conditions permit, especially if physical activity is anticipated.

Salt loss affects those personnel who either have not adapted to the environment or have adapted but are subjected to strenuous activity under heat stress. Replenishing salt is important. Normally, adding a little more salt to food during preparation is enough to replenish the salt level.

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Adapt to the environment. Adaptation is essential to prevent heat injury. An individual who has not adapted to the environment is more susceptible to heat injury and disability. While basic acclimation to heat can be attained in 4 to 5 days, full heat acclimation takes from 7 to 14 days, with two to three hours per day of carefully supervised exercise in the heat.

Wear protective clothing. In direct sunlight, an individual should wear loose clothing for adequate ventilation and evaporative cooling. In a hot environment, clothing protects an individual from solar radiation but reduces the loss of body heat from convection and conduction. Dark-colored clothing absorbs more radiant heat while light-colored clothing reflects it. To help reduce the heat load to the head, individuals should wear headgear to shade their head.

Increase ventilation. The pilot, more than any other crew member, must guard against heat stress. The pilot should direct the cool air entering the aircraft to his head and neck area to reduce heat build-up.

As a reminder, heat and other environmental factors should be part of the daily operational risk assessment.

References: http://www.pilotfriend.com/aeromed/medical/environmental_effects.htm
http://www.nielsenhayden.com/makinglight/archives/007766.html
http://www.sefsc.noaa.gov/HTMLdocs/heatstress.htm

When the heat gets “UNBEARABLE” this summer – cool off !

/s/ Robert Galloway
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