HYPERTHERMIA IN HYPERBARIC CHAMBERS

Two divers died in a decompression chamber following a 400 foot dive. The cause of their death was not immediately obvious. Some of the evidence suggests that the immediate cause of death may have been hyperthermia (heat stroke).

The deaths occurred in a chamber with a volume of approximately 400 cubic feet. The partial pressure of oxygen in the chamber is estimated to have been 0.4 to 0.5 atmospheres. The balance of the mix was helium save for 0.8 atmospheres of nitrogen. The temperature of the atmosphere at the time of transfer is estimated to have between 110°F and 120°F degrees.

Man’s tolerance to high temperature may be related to his temperature sense, his ability to lose heat by regulatory sweating, and his ability to move heat from his body core by blood flow to the skin surface, where cooling is most effective.

Cooling by evaporation of the sweat produced makes short exposures to extremely hot environments tolerable. However, when the ambient vapour pressure approaches 44 mm Hg (ie. A dew point of 36°C or 97°F) or that typically found on man’s skin while sweating in the heat, tolerance is drastically reduced. A temperature of 50°C (122°F) may well be intolerable if the dew point temperature is greater than 25°C (77°F, 24 mm Hg) and if both deep body temperature and heart rate rise rapidly within minutes.

The proteins in the delicate nervous tissues in the hypothalamus of the brain which function in the body’s temperature regulation may be damaged if core temperature goes too high, ie. above 41°C (106°F). Inappropriate vasoconstriction, cessation of sweating increased heat production by shivering, or some combination of these may result. Such heat stroke damage is frequently irreversible and carries a high risk of fatality.

A heat storage by the body of 80 Kcal (320 BTU) (or a rise in body temperature of 1.4°C or 2.5°F degree) for an average sized man represents an average voluntary limit. Collapse can occur at about 160 kcal (640 BTU) of storage (2.8°C or 5°F degree rise).

A final problem is the hyperventilation which occurs predominantly in hot/wet conditions and results in washing out more of the CO_2 in the blood than is desirable. This can lead to sensations of tingling and numbness of the skin and result in vasoconstriction in the brain with occasional loss of consciousness.

Total sweat rates in excess of 2 litres per hour can occur in short exposures, but about 1 litre per hour is an average maximum level sustainable for an accliminated man.

The partial pressure of water vapour at 120°F (49°C) degrees is 88 mm Hg and has a specific volume of 203 cubic feet per pound.

A400 cubic foot chamber will hold 0.9 litres of water in the atmosphere at a temperature of 120°F (49°C) degrees.

Humidity control in the complex was normally accomplished by allowing the atmosphere to circulate by convection between the main chamber and the transfer chamber, the moisture condensing on the transfer chamber walls. The dew point temperature would be perhaps 50°F degrees or higher. (Vapour pressure 9 mm Hg).

When the door to the transfer chamber was closed humidity control stopped. If the divers started to sweat at the high rate of 2 litres per hour due to the high heat it would take 5 minutes for the vapour pressure to reach 44 mm Hg at which point skin cooling due to sweat evaporation would be negligible. This does not count water carried in from wet diving gear or water generated by the sodalime canister.

From the above it can be assumed that no skin cooling occurred due to sweat evaporation after five minutes.

A man doing work equivalent to house cleaning will produce heat at the rate of 180-300 kcal/Hour (800-1400 BTU/Hour). If all this heat is retained by the body a heat storage of 160 kcal could be reached as soon as 32 minutes resulting in collapse. If heat is being added through the lungs and skin, collapse can occur even sooner.

A man is breathing Helium/Oxygen at 300 feet with a ventilation rate of 1 cubic foot per minute and a gas temperature of 114°F, 16°F above body temperature, will add heat at a rate of 0.5 kcal/minute. If the breathing rate increases due to an increase of core temperature the rate of heat addition will increase more.

Consider an extreme case with a breathing rate of 2 cubic feet per minute, and a gas temperature of 130°F degrees, collapse could occur as soon as 23 minutes after initial exposure.

One's body must always be able to give up heat. At no time should chamber temperature be allowed to increase above 35°C (95°F) degrees.

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Reference: ASHRAE 1972 Handbook of Fundamentals