.15 Guidelines for Heat Stress Control

Heat stress is a complex interaction among environmental factors, clothing requirements, and work demands. The most obvious manifestation of physiological strain is sweating, which is accompanied by increases in heart rate and body temperature. As exposures to heat stress become more significant and physiological strain increases, the ability to perform physical and mental work diminishes.

Environmental sources of heat stress include convection, which is heat energy transferred between objects by a moving fluid; radiant heat, which depends on the temperatures of surrounding walls, equipment, and other surfaces; conductive heat, which is the transfer of heat energy by bodies which are in direct contact; and air humidity, which affects the body's ability to cool by sweat evaporation.

Air temperature is not very good for predicting heat stress. An empirical index of environmental heat that was developed to account for these environmental factors is the wet bulb globe temperature (WBGT). WBGT is based on dry and wet bulb temperatures and radiant heat load as measured by a thermometer enclosed in a globe with a nonreflective black surface. Instruments are available which take the necessary measurement and compute the WBGT, which is then displayed on a meter. If prior measurement of the WBGT can cause problems due to radiation dose, job delay or even unavailability of those instruments, a method may be established for estimating the WBGT based on remote dry bulb (DB) temperature measurement and estimates of the relative humidity in the work areas (see table below).

Table 15.1 Estimating wet bulb globe temperature (WBGT)[a]

Relative Humidity	Estimated WBGT
100%	DB + 4°F
90%	DB + 2°F
80%	DB
70%	DB - 3°F
60%	DB - 5°F
50%	DB - 7°F
NOTE: 1. This method may underestimate the actual WBGT for work performed directly adjacent to hot steam pipes or other radiant heat sources.	
2. When the relative humidity is not known use 100% value for estimation.	

[a]Source: Carolina Power & Light (CP&L) Heat Stress Control Program for Nuclear Power Projects, P.O. Box 165, New Hill, NC 27562.

Work demands are estimated from tables of typical activities in terms of energy expenditure (metabolic heat). A work demand classification, based on the level of effort required, is shown below.

- Light work, such as supervisor tasks or light hand work, e.g., inspections, calibrations, operating equipment, supervising, etc.
- Moderate work, such as heavy arm work or arm and leg work, e.g., painting, cleaning, welding, surveying, most maintenance tasks, etc.

- Heavy work, such as heavy arm and leg work, e.g., continuous shoveling, mopping, installing shielding, cable pulling, manual decontamination, etc.

Clothing requirements mostly affect the body's ability to cool by sweat evaporation. Multiple layers of clothing or vapor barrier clothing significantly reduce the ability to evaporate sweat and therefore cause greater physiological strain. Clothing requirements are based primarily on the levels of radioactive contamination in the area and would normally consist of street clothing, single coveralls, double coveralls, or single coveralls with an impervious plastic or Tyvek outer suit.

Then, WBGT, work demands, and clothing requirements should be used to determine the amount of time any worker should be allowed to spend in the work area without personal cooling and/or other controls. As an example, Table 19.2 shows the stay times without cooling or other controls, described in the CP&L heat stress control program for nuclear power projects.

In conjunction with stay limitations, heat stress countermeasures should be taken to control heat stress. The countermeasures are selected only after an evaluation of the specific circumstances of job conditions and organizational constrains.

- Engineering controls, any mechanical assistance that can reduce work demands will cause a significant reduction in the level of heat stress. For instance, the use of pneumatic drivers or any power tools reduce metabolic heat (and therefore work demand). Increased ventilation and/or chiller systems, and the shielding of radiant heat sources should all be considered.

- Administrative controls can be used to reduce the risk of an overexposure to heat stress. The primary means is through the control of work methods which include minimizing time in the area, rotating workers, using work-rest cycles, encouraging the replacement of fluids, scheduling work for times when heat stress is reduced, changing clothing requirements, or letting the workers decide whether they can continue to work under the prevailing conditions, etc.

- Personal protection, in the form of personal cooling and reflective clothing, such as ice vests, vortex tubes, or bubble hood supplied respirators, etc.

The risks of heat stress can also be reduced by training the worker to recognize the symptoms of heat-related illnesses and by training him/her in the use of protective equipment and preventive measures, such as fluid replacement, balanced diet, lifestyle, health status, and acclimatization.

Controlling heat stress can have positive and negative impacts on external radiation exposure and external contamination. By minimizing time in the work area, external radiation dose will be reduced. Rotating workers and the use of work-rest cycles can lead to increased dose due to increased transition time when workers are entering or leaving the area. The use of engineering controls can result in decreased dose by improving worker efficiency and increased dose due to the time spent installing and removing them. Cooling devices can also increase worker efficiency but may hamper worker mobility. This is especially true of the vortex cooler and bubble hood which requires air lines.[1,2]

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[1]T.E. Bernard, Heat Stress Management Program for Power Plants, EPRI NP-4453-L, August 1991, EPRI Distribution Center, 207 Coggins Drive, P.O. Box 23205, Pleasant Hill, CA 94523.

[2]B.W. Morgan, "Guidelines for the Optimization of Radiation Worker Protection, 1992 Radiation Exposure Management Seminar", Pittsburgh, PA, October 4-7, 1992, Westinghouse Electric Corporation, Pittsburgh, PA.