HETA 97-0079-2658
Northwest Airlines
Memphis, Tennessee

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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Calvin K. Cook of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing was performed by Juanita Nelson.

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Health Hazard Evaluation Report 97-0079-2658
Northwest Airlines
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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Machinists and Aerospace Workers to evaluate baggage handlers' exposures to carbon monoxide (CO) in the bay area of the Baggage Handling facility of Northwest Airlines located in Memphis, Tennessee. The request stated that baggage handlers experienced symptoms of watery, itchy eyes and unspecified respiratory problems believed to be associated to exhaust emissions of vehicles used to transport passenger baggage.

On April 1-3, 1997, a NIOSH health hazard evaluation (HHE) was conducted that included 29 personal breathing-zone (PBZ) measurements using real-time and colorimetric dosimeters to assess CO exposures among baggage handlers. A real-time area measurement for CO was taken in the middle of the bay area for a 24-hour period to characterize general room concentrations. A copy of a confidential symptoms questionnaire was distributed to each baggage handler to gather background and baseline information about the prevalence of reported health effects. Material Safety Data Sheets (MSDSs), ventilation blueprints, and OSHA Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs) for the previous two years were requested and reviewed.

Time-weighted average (TWA) exposures to CO ranged from 1 to 14 parts per million (ppm), below the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit value (TLV®) of 25 ppm for an 8-hour TWA, which is the most stringent occupational exposure criteria for CO. Peak CO exposures, however, were as high as 393 ppm, which exceeded the NIOSH ceiling limit of 200 ppm. The 24-hour real-time area sample revealed a TWA concentration of 1 ppm and a peak concentration of 186 ppm, approaching the ceiling limit of 200 ppm. According to questionnaires completed and returned by 16 of 30 baggage handlers (response rate of 53%), the most common symptoms reported were headaches and eye, nose and throat irritation.

Full-shift TWA concentrations measured for CO were below the ACGIH TLV® of 25 ppm. However, real-time monitoring revealed PBZ instantaneous peak exposures that exceeded the NIOSH ceiling limit of 200 ppm. High exposure to peak CO concentrations are likely responsible for some reported health complaints (headache, nausea) that are consistent with CO exposures. Recommendations are offered in this report to reduce worker exposures to CO and tobacco smoke, properly connect the facility's CO monitoring system, and address the potential for heat stress.

Keywords: SIC 4581 (Airport Terminal Services) carbon monoxide, CO, baggage handlers, baggage facility, exhaust emissions, heat stress, airport.

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INTRODUCTION

In February 1997, NIOSH received a HHE request from the International Association of Machinists and Aerospace Workers to evaluate carbon monoxide (CO) exposures among Northwest Airline's baggage handlers who operated leaded gasoline-powered and propane-powered vehicles in the Baggage Handling facility at the Memphis International Airport. The request stated that workers experienced symptoms of watery, itching eyes and unspecified respiratory problems. On April 1-3, 1997, a NIOSH investigator conducted an industrial hygiene evaluation to assess baggage handlers' exposures to CO. At the close of the investigation, preliminary findings and recommendations were discussed during an informal meeting with management and a union representative. This report presents the final results and conclusions from this NIOSH HHE.

BACKGROUND

Northwest Airlines employed approximately 30 baggage handlers over three shifts. Their duties included handling and transporting passenger baggage to and from cargo compartments of airplanes, transport conveyors, and transport vehicles. Baggage handlers spend much of their workday performing duties inside the Baggage Handling facility (approximately 61,000 square feet) which is an open bay that allows transport vehicles to pass through. Two large open doorways (40 ft. by 12 ft.) were located on the east and west ends of the bay. A fleet of baggage handling vehicles (80 tugs and airline runners) make up the majority of traffic passing through the bay. Other traffic included escort vehicles, maintenance trucks, and propane-powered carts. Located at the east end of the bay was a real-time CO monitor connected to 16 sensors positioned uniformly throughout the bay area. The CO sensors operated by diffusion and had a monitoring range from 0 to 500 parts per million (ppm). The monitor had a *caution* alarm set to activate a visible light when peak CO concentrations reached 21 ppm, and a *primary* alarm that triggered an audible alarm (120 decibels) when concentrations reached 40 ppm. The monitor was reportedly inspected, maintained, and calibrated every 60 days by maintenance personnel. For hazard communication, signs were posted throughout the bay to inform vehicle operators not to idle engines when not in use.

Ventilation to the Baggage Handling facility was provided by 27 separate exhaust diffusers located on the south end of the bay. Each diffuser had an exhaust flowrate of 6,000 cubic feet per minute (CFM) and all operated continuously. Makeup air to the facility was not provided mechanically. Rather, due to pressure differences created by exhaust ventilation, outside air primarily entered the facility through the two large open doorways. Twenty-four ceiling fan units were located uniformly throughout the facility to provide air circulation.

EVALUATION METHODS

On April 1, 1997, NIOSH investigators conducted a walk-through inspection to obtain preliminary information about the facility's layout and processes. During the first shift (6:00 a.m. to 3:00 p.m.) on April 2-3, 1997, 29 personal breathing-zone (PBZ) measurements for CO were taken on baggage handlers to assess their exposures during the entire work-shift. Two types of CO dosimeters were used: (1) Toxilog® Atmospheric Monitors[1] and (2) Dräger® colorimetric detector tubes[2]. Dosimeters were generally placed on workers who were not tobacco smokers; those workers who were smokers were asked not to smoke while wearing a dosimeter. In some cases, workers wore both Toxilog® and Dräger® dosimeters. To characterize general room CO concentrations generated throughout the day, a

1 A real-time instrument equipped with an electrochemical sensor and data logging capabilities with a range of 0-4096 ppm.

2 Measurement accuracy of ± 50%.

Toxilog® dosimeter was placed in the middle of the bay for a 24-hour period.

Copies of a confidential symptoms questionnaire were made available to each baggage handler to determine baseline information and the prevalence of their health complaints. Requested and reviewed were Material safety data sheets (MSDSs), ventilation blueprints, and OSHA Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs) for the previous two years.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[2] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[3]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA-approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Carbon Monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless, tasteless gas which can be a product of the incomplete combustion of organic materials such as propane, gasoline, oil, natural gas, coal, or wood. In the body carbon monoxide combines with hemoglobin and interferes with the oxygen carrying capacity of blood. Symptoms may include headache, drowsiness, dizziness, nausea, vomiting, collapse, myocardial ischemia, and death.[(4)] The NIOSH REL for CO is 35 ppm TWA for up to 10 hours. The OSHA PEL for CO is 50 ppm as an 8-hour TWA, and the ACGIH TLV® is 25 ppm as an 8-hour TWA. NIOSH has also established a ceiling limit (not to be exceeded at any time during the workday) of 200 ppm.

RESULTS AND OBSERVATIONS

Air Sampling

Carbon monoxide measurement results are presented in Tables 1 and 2. Seven real-time PBZ measurements for CO ranged from 1 ppm to 14 ppm, below the ACGIH TLV® of 25 ppm as an 8-hour TWA concentration. Peak CO exposures, however, were as high as 393 ppm (exceeding the NIOSH ceiling limit of 200 ppm by nearly twofold).[3] The highest TWA concentrations were measured on vehicle operators who reportedly were non-smokers. The 24-hour real-time area sample revealed a TWA concentration of 1 ppm and a peak concentration of 186 ppm, approaching the NIOSH ceiling limit of 200 ppm.

Questionnaires

Questionnaires were completed and returned by 16 of 30 baggage workers present during the HHE; a response rate of 53%. The most common symptoms reported were headaches and eye, nose, and throat irritation. Of the 16 respondents, seven reported frequent headaches almost daily; four reported eye irritation; three reported sinus irritation; two reported throat irritation; and one reported episodes of nausea.

The final section of the questionnaire allowed employees to discuss other concerns about their health and work environment. The issues presented were the following: (1) not enforcing the *No Smoking* policy; (2) concerns for potential exposure to asbestos from material on roof-support beams; and (3) lack of air-conditioning in the bay area during summer months that prompted concerns for heat stress.

Other Observations

- The CO monitoring system had only eight of the 16 sensors connected to the system's control unit. Since initially installed, sensors located at the west end of the bay have not been in operation.
- Several exhaust diffusers were blocked by equipment and storage boxes.

[3] The exact source of peak exposures could not be verified. Potential sources of CO were either by baggage handling vehicles or tobacco smoke.

- In spite of warning signs that informed vehicle operators to turn off their engines when idle, the CO alarm was activated twice during the evaluation. On both occasions vehicle engines were allowed to run unattended for short periods.
- Some workers inquired about their potential exposure to asbestos from insulation material that covered the facility's roof-support beams. According to the pertinent MSDSs, the material is inorganic, non-combustible and asbestos-free.
- When CO alarms were activated during the evaluation, some workers were not aware of procedures that should be taken to avoid exposure.

CONCLUSIONS AND RECOMMENDATIONS

Full-shift TWA concentrations of CO were below the ACGIH TLV® of 25 ppm; however, real-time monitoring revealed PBZ instantaneous peak exposures that exceeded the NIOSH ceiling limits of 200 ppm by nearly twofold. Peak exposure to CO is likely responsible for some reported health complaints (headache, nausea) that are consistent with CO exposures. The following recommendations are offered to reduce worker exposures to CO and tobacco smoke, correct facility deficiencies, and address the potential for heat stress.

1. Exhaust ventilation serving the Baggage Handling facility is essential in reducing CO concentrations generated in the bay area. Therefore, equipment and storage boxes that block exhaust diffusers should be relocated to ensure proper ventilation.

2. In combination with good ventilation, the primary means to control CO exposure is to maintain transport vehicles by providing regularly scheduled tuneups and testing for excessive CO emissions. Overlooking simple maintenance items, such as improperly gapped sparkplugs, can cause CO emission problems. Regular service checks on transport vehicles (when applicable) should include the following:

- ensure sparkplugs are properly gapped and in good condition;
- perform a compression test to determine true engine condition;
- inspect the distributor for play, rotary cap for contaminants, and make sure the cap has no cracks;
- inspect air filters for smooth passage of air;
- inspect carburetor to ensure it operates properly; and
- adjust engine timing.

3. The remaining eight sensors to the CO monitoring system's control unit should be connected. With all sensors in operation the entire bay can be monitored for CO as designed.

4. The requirement that engines of transport vehicles inside the bay be shut off when not in use should be enforced. Also, establish written guidelines or standard operating procedures for actions to be taken by workers when the CO alarm has activated. Such written guidelines can be incorporated with the existing safety training program.

5. Additional PBZ real-time monitoring, and observation of work practices is suggested to help identify the specific source(s) for elevated peak exposures.

6. Because the bay area of the Baggage Handling facility is not cooled during summer months, and employees perform moderate to heavy work activities (often times in direct sunlight), heat-related illnesses (e.g., heat stroke, exhaustion, cramping) are possible. A proactive approach to avoid heat-related illnesses would include the following guidelines:

- evaluate the work environment for thermal comfort;
- acclimate workers to heat;
- provide plenty of drinking water and fluids; and
- implement employee training and education.

More comprehensive information to avoid heat-related illnesses is included in an Appendix.

7. NIOSH recognizes environmental tobacco smoke (ETS) as a substance that poses an increased risk of lung cancer and possibly heart disease to occupationally exposed workers. Workers who are non-smokers should not be involuntarily exposed to tobacco smoke. The existing *No Smoking* policy should be enforced that permits smoking only in the designated smoking area of the bay. A warning sign should also be posted to indicate the designated smoking area.

8. Also, since it was an issue of concern, workers should be informed about the non-asbestos material on roof-support beams. These issues can be presented during safety meetings and briefings involving employees.

REFERENCES

1. CDC [1988]. NIOSH recommendations for occupational safety and health standards. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. MMWR 37 (suppl S-7).

2. ACGIH [1996]. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Code of Federal Regulations [1993]. OSHA Table Z-1. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

4. Hathaway GJ, Proctor NH, Hughes JP, Fischman ML [1993]. Chemical hazards of the workplace, 3rd ed

Table 1
Personal Breathing-Zone Results for Carbon Monoxide
Northwest Airlines, Memphis, TN
(HETA 97-0079)
Sampling Date: April 1, 1997

Job Title	**Sampling Method**	**Sampling Time (min.)**	**Carbon Monoxide Concentration (ppm)**	
			8-Hr. TWA	**Peak**
Vehicle operator	Toxilog®	412	2 ppm	69
Vehicle operator	Dräger®	412	5 ppm	NM
Vehicle operator	Toxilog®	358	1	25
Vehicle operator	Dräger®	358	trace	NM
Vehicle operator	Toxilog®	412	2	58
Vehicle operator	Dräger®	412	trace	NM
Vehicle operator	Toxilog®	352	2	47
Bag room worker	Dräger®	352	trace	NM
Bag room worker	Dräger®	402	trace	NM
Vehicle operator	Dräger®	326	trace	NM
Bag room worker	Dräger®	392	trace	NM
Vehicle operator	Dräger®	65	trace	NM
Vehicle operator	Dräger®	391	trace	NM
Vehicle operator	Dräger®	320	trace	NM
Bag room worker	Dräger®	313	trace	NM
Exposure Criteria				
NIOSH Recommended Exposure Limit (REL)			35 ppm TWA	200 ppm (C)
OSHA Permissible Exposure Limit (PEL)			50 ppm TWA	NA
ACGIH Threshold Limit Value (TLV®)			25 ppm TWA	NA

Abbreviations:
NM = not measured
NA = not available
ppm = parts per million
TWA = time-weighted average
C = ceiling limit
Trace = less than 1 ppm

Table 2
Personal Breathing-Zone Results for Carbon Monoxide
Northwest Airlines, Memphis, TN
(HETA 97-0079)
Sampling Date: April 2, 1997

Job Title	**Sampling Method**	**Sampling Time (min.)**	**Carbon Monoxide Concentration (ppm)**	
			8-Hr. TWA	**Peak**
Vehicle operator	Toxilog®	430	14	393
Vehicle operator	Dräger®	430	6	NM
Vehicle operator	Toxilog®	434	6	69
Vehicle operator	Dräger®	434	4	NM
Vehicle operator	Toxilog®	353	3	18
Vehicle operator	Dräger®	353	4	NM
Bag room worker	Dräger®	363	2	NM
Vehicle operator	Dräger®	429	5	NM
Vehicle operator	Dräger®	353	trace	NM
Vehicle operator	Dräger®	347	trace	NM
Bag room worker	Dräger®	345	3	NM
Vehicle operator	Dräger®	347	4	NM
Bag room worker	Dräger®	410	6	NM
Vehicle operator	Dräger®	406	6	NM
Exposure Criteria				
NIOSH Recommended Exposure Limit (REL)			35 ppm TWA	200 ppm (C)
OSHA Permissible Exposure Limit (PEL)			50 ppm TWA	NA
ACGIH Threshold Limit Value (TLV®)			25 ppm TWA	N/A

Abbreviations:
NA = not available
NM = not measured
ppm = parts per million
TWA = time-weighted average
C = ceiling limit
Trace = less than 1 ppm

Appendix
Northwest Airlines, Memphis, Tennessee
HETA 97-0079

Heat Stress

Our bodies maintain a natural heat load resulting from metabolic processes, muscular activity, and various environmental sources such as the sun, heated surfaces, and the air. The body maintains a constant internal temperature through three adaptive mechanisms: blood flow, muscular activity, and sweating. Blood flow to the skin is increased when the body needs to lose heat to the environment, and decreased when the body needs to conserve heat. Sweating, however, is the major method for cooling the body via evaporation of sweat. When the body is regularly exposed to a hot environment, it acclimatizes, usually within a week, to better tolerate the heat stress.

When the body's natural regulatory mechanisms fail to cope with heat stress, a variety of conditions may develop. Heat stroke is the most serious of these conditions, since it can result in death. This condition occurs when the body's temperature regulatory systems fails, and sweating ceases to control body temperature. The skin is hot and dry, the worker is delirious or unconscious, and the body temperature may be above 105°F. When heat stroke occurs, the victim should be moved to a cool area, soaked with water, and vigorously fanned to accelerate cooling. Prompt medical attention is necessary to minimize any long term health effects from heat stroke.

Heat exhaustion is a condition which may resemble the early stages of heat stroke. It is caused by excessive loss of fluids and/or salt, and is characterized by weakness, fatigue, giddiness, nausea, headache, moist skin, and pale complexion. Victims of heat exhaustion recover quickly by resting in a cool area and drinking copious amounts of fluid. Every heat exhaustion case should be treated as a potential heat stroke case.

Heat cramps are spasms of the muscles caused by depleted salt (NaCl) levels. Tired, overworked muscles are most susceptible to cramps. Adequate hydration with isotonic fluids (*e.g.* Gatorade) may help prevent and/or treat heat cramps.

Heat syncope, or fainting, occurs when the unacclimatized worker stands erect and immobile in the heat. Blood and blood flow to the brain. Treatment is to have the person lie down, while prevention is to increase movement/activity.

Heat rash, i.e. prickly heat, occurs in hot, humid environments where sweat does not easily evaporate. The sweat ducts become clogged, producing a skin rash which is very uncomfortable. Workers with heat rash are more susceptible to other heat-related illnesses, since the clogged sweat glands reduce the body's capacity for cooling. The worker can prevent or alleviate this condition by taking regular breaks in a cool place, and by daily bathing and drying of skin.

There are a number of heat stress guidelines that are available to protect against heat-related illnesses such as heat stroke, heat exhaustion, heat syncope, and heat cramps. These include, but are not limited to, the wet bulb globe temperature (WBGT), Belding-Hatch heat stress index, and effective temperature.[1,2,3] The underlying objective of these guidelines is to prevent a worker's core body temperature from rising excessively. The World Health Organization has concluded that "it is inadvisable for deep body temperature to exceed 38°C (100.4°F) in prolonged daily exposure to heavy work."[4] Many of the available heat stress guidelines, including those proposed by NIOSH and the American Conference of Governmental Industrial Hygienists (ACGIH), also use a maximum core body temperature of 38°C as the basis for the environmental criterion.[5,6]

Both NIOSH and ACGIH recommend the use of the WBGT index to measure environmental factors because of its simplicity and suitability in regards to heat stress. The International Organization for Standardization, the

American Industrial Hygiene Association, and the U.S. Armed Services have published heat stress guidelines which also utilize the WBGT index.[7,8,9] Overall, there is general similarity of the various guidelines; hence, the WBGT index has become the standard technique for assessment of environmental conditions in regards to occupational heat stress.

The WBGT index takes into account environmental conditions such as air velocity, vapor pressure due to atmospheric water vapor (humidity), radiant heat, and air temperature, and is expressed in terms of degrees Fahrenheit (or degrees Celsius). Measurement of WBGT is accomplished using an ordinary dry bulb temperature (DB), a natural (unaspirated) wet bulb temperature (WB), and a black globe temperature (GT) as follows:

$$\mathbf{WBGT_{in} = 0.7\ (WB) + 0.3\ (GT)}$$ for inside or outside without solar load,

or

$$\mathbf{WBGT_{out} = 0.7\ (WB) + 0.2\ (GT) + 0.1\ (DB)}$$ for outside with solar load.

Originally, NIOSH defined excessively hot environmental conditions as any combination of air temperature, humidity, radiation, and air velocity that produced an average WBGT of 79ºF (26ºC) for unprotected workers.[10] However, in the revised criteria for occupational exposure to hot environments, NIOSH provides diagrams showing work-rest cycles and metabolic heat versus WBGT exposures which should not be exceeded.[5] NIOSH has developed two sets of recommended limits: one for acclimatized workers (recommended exposure limit [REL]), and one for unacclimatized workers (recommended alert limit [RAL]). Similarly, ACGIH recommends Threshold Limit Values (TLVs) for environmental heat exposure permissible for different work-rest regimens and work loads.[6] The NIOSH REL and ACGIH TLV criteria assume that the workers are heat acclimatized, are fully clothed in summer-weight clothing, are physically fit, have good nutrition, and have adequate salt and water intake.

Modifications of the NIOSH and ACGIH evaluation criteria should be made if the worker or conditions do not meet the previously defined assumptions. The following modifications have been suggested:[11]

1. Unacclimatized or physically unconditioned - subtract 4°F (2°C) from the permissible WBGT value for acclimatized workers.

2. Increased air velocity (above 1.5 meters per second or 300 feet per minute) - add 4°F (2°C). This adjustment can not be used for air temperatures in excess of 90-95°F (32-35°C). This correction does not apply if impervious clothing is worn.

3. Impervious clothing which interferes with evaporation:

   a. Body armor, impermeable jackets - subtract 4°F (2°C).
   b. Raincoats, turnout coats, full-length coats - subtract 7°F (4°C).
   c. Fully encapsulated suits - subtract 9°F (5°C).

4. Obese or elderly - subtract 2-4°F (1-2°C).

5. Female - subtract 1.8°F (1°C). This adjustment, which is based on a supposedly lower sweat rate for females, is questionable since the thermoregulatory differences between the sexes in groups that normally work in hot environments are complex.[12] Seasonal and work rate considerations enter into determining which sex is better adapted to work in hot environments.[13]

Selection of a protective NIOSH WBGT exposure limit is contingent upon identifying the appropriate work-rest schedule and the metabolic heat produced by the work. The work-rest schedule is characterized by estimating the amount of time the employees work to the nearest 25%. The most accurate assessment of metabolic heat production is to actually measure it via calorimetry. However, this is impractical in industrial work settings. An estimate of the metabolic heat load can be accomplished by dividing the work activity into component tasks and adding the time-weighted energy rates for each component.[5]

The ACGIH heat exposure TLVs are published for light, moderate and heavy work load categories. The work load categories are described by the following energy expenditure rates:[6]

1. Light work - up to 200 kcal/hr,

2. Moderate work - 200 to 350 kcal/hr,

3. Heavy work - 350 to 500 kcal/hr.

NIOSH's recommended standard for exposure to hot environments states specific actions that should be implemented when the time weighted average WBGT exceeds the REL/RAL for either men or women. Any one of the following practices shall be implemented to insure that the worker's core temperature does not exceed 38°C:

- Acclimatization.
- A work/rest regimen to reduce peak psychological strain and improve recovery.
- Even distribution of work load over the work-shift.
- Schedule hot jobs during coolest part of the day.
- Regular breaks in cool rooms and/or areas to replenish water. Drinking water should be cooled (50°F to 59°F), potable water with only individual drinking cups used. The use of salt tablets and salted drinking fluids is not recommended. Salt tablets can irritate the stomach, and the relatively high salt content in the average U.S. diet should provide workers with adequate amounts of salt.
- Appropriate protective clothing.
- Engineering controls to reduce the heat load. Some examples of these are air conditioning and fans to reduce heat through convection, and shielding to protect workers from radiant heat.

NIOSH recommends that employees be periodically trained in appropriate ways to handle heat stress, in recognition of excessive heat stress, and in first aid. It should be noted that persons with heart problems, with diabetes, with hypertension, who are on "low sodium" diets, and who use alcohol or drugs (including therapeutic medication), are at an increased risk of obtaining a heat-related illness and should consult a physician. Any female worker who is pregnant should inform their personal physician that they work in a hot environment.

REFERENCES FOR APPENDIX

1. Yaglou C, Minard D [1957]. Control of heat casualties at military training centers. *Arch Indust Health 16*:302-316.

2. Belding H, Hatch T [1955]. Index for evaluating heat stress in terms of resulting physiological strain. *Heat Pip Air Condit 27*:129.

3. Houghton F, Yaglou C [1923]. Determining lines of equal comfort. *J Am Soc Heat and Vent Engrs 29*:165-176.

4. WHO [1969]. Health factors involved in working under conditions of heat stress. Geneva, Switzerland: World Health Organization. Technical Report Series No. 412.

5. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 86-113.

6. ACGIH [1990]. Threshold limit values and physical agents and biological exposure indices for 1990-1991. Cincinnati, OH: American Conference of Governmental Industrial Hygienist.

7. ISO [1982]. Hot environments: estimation of heat stress on working man based on the WBGT index. Geneva, Switzerland: International Standards Organization. ISO No. 7243-1982.

8. AIHA [1975]. Heat exchange and human tolerance limits, heating and cooling for man in industry, 2nd ed. Akron, OH: American Industrial Hygiene Association, pp 5-28.

9. U.S. Department of Defense [1980]. Occupational and environmental health: prevention, treatment and control of heat injuries. Washington, DC: Headquarters, Departments of the Army, Navy, and Air Force, TB MED 507, NAVMED P-5052-5, AFP 160-1.

10. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, OH: U.S. Department of Health, Education and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 72-10269.

11. Ramsey JD [1978]. Abbreviated guidelines for heat stress exposure. *AIHAJ 39*:491-495.

12. Kenney WL [1985]. A review of comparative responses of men and women to heat stress. *Environ Res 37*:1-11.

13. NIOSH [1997]. Assessment of deep body temperatures of women in hot jobs. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-215.

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