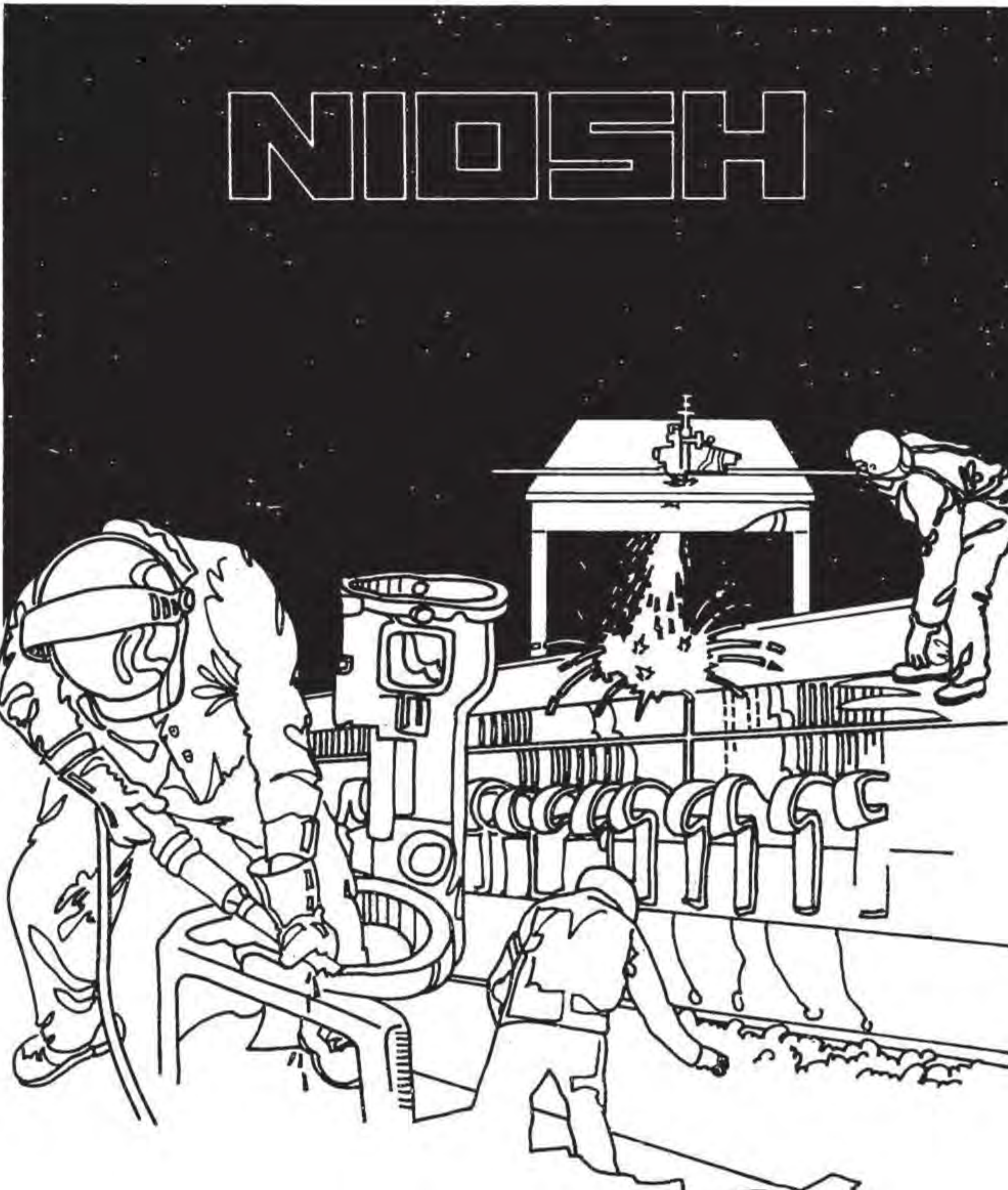
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 82-262-1262
IDEAL CEMENT
LAPORTE, COLORADO

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 or 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, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

HETA 82-262-1262
FEBRUARY 1983
IDEAL CEMENT
LAPORTE, COLORADO

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I. SUMMARY

In May 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate whether or not occupational exposures had caused medical complaints to workers at the Ideal Cement Plant, LaPorte, Colorado.

On June 1-2 and July 29, 1982, NIOSH investigators performed environmental and medical investigations. The environmental evaluation consisted of heat stress measurements and air sampling for measurement of exposure to respirable particulate, sulfur dioxide (SO_2), sulfate (SO_4), and cyclohexane solubles.

Excessive heat exposures were found in areas where workers were repairing a plugged cyclone. Wet Bulb Globe Temperatures (WBGT) ranged from 84°F to 97°F. The criterion for WBGT is 79°F. One of three samples for respirable particulate exceeded the evaluation criterion of 5 mg/M^3, and one of four samples for sulfur dioxide exceeded the evaluation criterion of 5 mg/M^3. The cyclohexane soluble samples were below laboratory detection limits.

Six workers (two per shift) in the preheat building were interviewed privately. The workers on the evening (second) and night (third) shifts had pre- and post-shift weight, pulse, and oral temperature measured. The workers on the evening shift also had their pulse monitored during the time they were clearing out a blockage in the cyclone.

Pre- and post-shift weights, temperatures, and pulses showed no significant changes. This indicated that the workers were well acclimatized and replaced body fluids lost by excessive sweating. Workers do get dizzy when exposed to excessive heat when cleaning the clogged cyclones. This is due to working too long under extreme heat and not having an adequate cooling station when resting. Workers also experienced eye, nose, and throat irritation, and occasionally experienced nosebleeds.

On the basis of the environmental and medical data collected, NIOSH determined that there is a heat stress problem when cleaning the cyclones and there is a hazard from overexposures to respirable particulates and sulfur dioxide. Recommendations that can help eliminate these health hazards are included in this report.

KEYWORDS: SIC 3273 (Ready-Mixed Concrete), cement, sulfur dioxide, heat stress

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request in May 1982 from Ideal Basic Industries, Denver, Colorado, to evaluate unknown occupational exposures causing a variety of medical complaints at the Ideal Cement Plant in LaPorte, Colorado. Environmental/medical evaluations were conducted on June 1-2 and July 29, 1982. The results of the survey were discussed with management during the survey and after laboratory results were received.

III. BACKGROUND

This cement plant has a new kiln and preheat building designed to use limestone containing a small percentage of Karogen, an organic substance from which shale oil can be extracted. In cement making the Karogen serves as part of the fuel when temperatures are maintained above a minimal level. It also serves as a source of sulfur oxides in the exhaust. The management requested the evaluation because the workers were concerned about fumes given off by the Karogen and several workers have passed out or become seriously disoriented while on the job. In the area where the evaluation occurred there are only four to five workers per shift.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Heat stress measurements were taken using a standardized WIBGET® heat stress monitor that takes direct readings for Wet Bulb Globe Temperatures (WBGT), Globe (G), Wet Bulb, and Dry Bulb.

Three general area air samples for cyclohexane solubles were collected on silver membrane filters using vacuum pumps operated at 1.5 liters per minute and analyzed according to NIOSH P&CAM Method No. 217. These samples were run because oil shale present in the limestone may contain carcinogens. If large quantities of cyclohexane solubles had been found, additional chemical analysis would have been performed.

Four sulfur dioxide and sulfate general area air samples were collected on treated AA filters using vacuum pumps operated at 1.5 liters per minute and analyzed according to NIOSH P&CAM Method No. 268.

Three respirable particulate breathing zone air samples were collected on preweighed M5 filters using cyclones and vacuum pumps operated at 1.7 liters per minute and analyzed gravimetrically.

B. Medical

The six workers (two per shift) in the preheat building were interviewed privately. The workers on the evening (second) and night (third) shifts had pre- and post-shift weights, pulse, and oral temperature measured. The workers on the evening shift also had their pulse monitored during the time they were clearing out a blockage in the cyclone. The worker's weight was measured on a bathroom spring scale and temperature was measured using an oral thermometer.

These two shifts were evaluated since workers on these particular shifts were having the highest incidence of medical problems. These two shifts also do cleanouts and maintenance in extremely hot areas. The first shift is involved mainly in cement production.

V. EVALUATION CRITERIA AND TOXICOLOGY

A. Environmental

The three sources of criteria used to assess the workplace concentrations of air contaminants were (1) the Occupational Safety and Health Administration (OSHA) standards (29 CFR 1910.1000); (2) the NIOSH criteria for a recommended standard; and (3) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for Chemical Substances in the Workroom Environment (TLV).

	Environmental Exposure Limits 8-hour Time-Weighted Exposure Basis
Cyclohexane solubles................	*
Sulfate............................	1 mg/M^3 (ACGIH**/OSHA)
Sulfur Dioxide.....................	1.5 mg/M^3 (NIOSH) 5.0 mg/M^3 (ACGIH) 13.0 mg/M^3 (OSHA)
Respirable Particulate.............	5 mg/M^3 (ACGIH/OSHA)

mg/M^3 = milligrams of substance per cubic meter of air
* = no standard or criteria has been established
** = TLV for H^2SO_4 which is what SO_4 would hydrolize in the presence of moisture.

Both NIOSH[1] and ACGIH[2] recommend the use of the Wet Bulb Globe Temperature (WBGT) in assessing hot environments. Three different temperature measurements are required: (1) Natural Wet Bulb (WB) temperature where the thermometer bulb is kept wet allowing cooling by evaporation. The dryer the air and the greater the breeze, the lower the temperature reading relative to the dry bulb temperature. (2) Dry Bulb (DB) temperature which is simply a temperature reading. This is primarily air temperature, but is slightly affected by radiant heat (sun or surroundings). (3) Globe Temperature (GT) in which the thermometer bulb is inside a hollow black globe. Radiant heat absorbed by the black globe heats the air inside giving a higher reading than the dry bulb temperature.

WBGT is calculated using one of two formulas:

1. Outdoor with solar load

   WBGT = 0.7 WB + 0.2 GT + 0.1 DB

2. Indoors or Outdoors with no solar load

   WBGT = 0.7 WB + 0.3 GT

Recommended ACGIH Threshold Limit Values (TLVs)[2] assume the worker has had time to acclimate (about one week). Permissible WBGT levels vary with how strenuous the work is and on how much of an hour is spent working and how much is spent resting. As dislodging buildup would be heavy work, the TLV for 25% work, 75% rest each hour would be 30°C (86°F) WBGT. These levels assume the worker has an adequate fluid and salt intake and is wearing normal clothing. It also assumes the rest area is at approximately the same WBGT as the work area. For 50% work/50% rest, the WBGT should only be 27.9°C (82.2°F). The TLVs are considered safe for most workers without surveillance. Higher heat exposures are permitted with adequate medical surveillance. Also rest periods can be shortened if the rest area is cooler than the work area.

B. Toxicological

1. Sulfur Dioxide and Sulfate

Exposures to SO_2 in excess of 5 mg/M^3 will cause irritation of the eyes, nose, and throat. Respiratory distress may also occur. Repeated exposures may cause dermatitis. The tolerable limit of SO_2 is about 30 mg/M^3 and the least detectable odor is about 5 mg/M^3.

2. Respirable Particulate

Exposures to respirable particulate may cause unpleasant deposits in the eyes and nasal passages. Some respirable problems due to deposition in the lungs may also occur.

3. Heat

The body's heat load derives from basic metabolic processes, muscular activity, and environmental sources, such as the sun, hot surfaces through contact or by radiation, and the air (if it is above body temperature). The body maintains a fairly uniform internal temperature through a number of adaptive mechanisms either to produce more heat or to get rid of excess heat as the situation demands. The three most important methods involve blood flow to the skin, muscular activity, and sweating. Blood flow to the skin is increased when the body needs to lose heat to the environment and decreased when it needs to conserve heat. Muscular activity is increased when more heat is needed (shivering for example) and decreased (if possible) when less heat is desired. Sweating is the major method of losing heat in a hot environment and depends on the evaporation of the sweat to produce the cooling. When regularly exposed to hot environments the body acclimates over about a week so the individual can better handle the stress caused by the heat.

Increases in blood flow in general are most easily monitored by measuring the heart rate (pulse). This does not distinguish between added blood flow to muscles because of activity and increased flow to the skin because of the need to get rid of excess body heat, but does give a fair measure of the overall strain on the heart. Pulse rates in excess of 110 beats per minute at the start of a rest period are considered excessive.[3]

Although core body temperature is most likely reliably measured by rectum, oral temperatures are considerably easier to measure and run about one degree lower than rectal temperatures. Their disadvantages are that they take longer (if a glass clinical thermometer is used) and that they are influenced by cold or hot drinks, smoking, etc. Oral temperatures at the beginning of a rest period should not exceed 37.6°C (99.6°F).[3]

Short term swings in body weight are due to gain or loss of water. Thus a loss of body weight over shift can be used to assess how much water has been lost through sweating and not been replaced. A loss of greater than 1.5% of total body weight is excessive and requires greater attention to fluid replacement.[3] The body loses salt along with the water which must also be replaced, preferably in food, although beverages with 0.1% salt can also be used. (One level tablespoon of salt in 15 quarts of water or one level teaspoon of salt in one gallon of water represents 0.1% salt.)

C. Heat Stress[1]

Figure I diagrams various reactions to heat stress. The problems caused by a failure to fully cope with the stress are to the right of the figure.

1. Heat syncope (fainting) and heat edema occur in unacclimated workers standing erect and immobile in the heat. Blood and body fluid tend to accumulate in the feet and legs, reducing the blood returning to the heart and consequently reducing blood flow to the brain. Treatment is to have the person lie down. Prevention is to move around.

2. Heat cramps and water intoxication can occur when the salt lost in sweating is not adequately replaced but the water is. The muscle cramps are most likely to occur in the most used muscles and can occur either during work or after work. Although more likely in unacclimated workers, it can occur in anyone who sweats a lot, drinks lots of salt-free fluids, and fails to increase salt consumption. Persons on diuretics, which interfere with the body's salt regulating mechanisms, should consult with their doctors on how to handle both the medical problem for which they are on the medication and the body's need for extra salt for the sweat. Under more severe conditions the problem can progress to salt depletion heat exhaustion.

3. Heat exhaustion, either due to salt depletion or water depletion, leads to weakness, extreme fatigue, giddiness, nausea, and headache. The skin is clammy and moist indicating that sweating is still active. Complexion may be pale, ruddy, or flushed. Oral temperature may be normal or low, but the rectal temperature is usually elevated (37.5°

to 38.3°C, 99.5° to 101°F). The worker may faint on trying to stand, and is shocky (weak, thready pulse, and low blood pressure). The major problem is a loss of circulating body fluid (dehydration). Correction is to replace the fluid with a balance of water and salt. Milder cases can probably be handled with rest and fluids (such as the 0.1% salt solution). More serious cases should receive prompt medical attention. (DO NOT TRY TO FORCE LIQUIDS INTO AN UNCONSCIOUS PERSON.)

4. Heat stroke represents a complete breakdown of the body's heat regulating mechanism. It is a medical emergency which is usually fatal if not treated promptly. Of prime importance in emergency first aid is RAPIDLY COOLING the person by immersion in cold water, wrapping the naked person in wet towels, and fanning to allow evaporative cooling or some similar method of cooling. The three cardinal signs of heat stroke are:[1] (1) hot, dry skin: red, mottled, or cyanotic; (2) an elevated body temperature usually 41°C (106°F) or higher, and rising; (3) brain disorders: mental confusion, delirium, loss of consciousness, convulsions, and coma.

5. Skin problems associated with heat exposure include heat rash (prickly heat) in which sweat ducts get clogged with a resulting inflammation of the sweat glands. It is characterized by discomfort and tiny red vesicles in the affected area. It is caused by the skin remaining constantly wet with unevaporated sweat and can be prevented by allowing the skin to dry between heat exposures. In the dry Southwest this is only likely to be a problem in skin folds, or on prolonged and repeated use of an impervious suit.

   Anhidrotic heat exhaustion is somewhat similar to heat rash and may follow an extensive heat rash. It shows up as a non-sweating area of skin with "gooseflesh" like eruption caused by deep blocking of the sweat ducts. It is unlikely in temperate climates where the hot season is of only limited duration.

VI. RESULTS AND DISCUSSION

A. Environmental

On June 1-2 and July 29, 1982, NIOSH performed environmental and medical investigations. The environmental investigation consisted of time-weighted average (TWA) measurements of respirable particulate, sulfur dioxide, sulfate, and cyclohexane solubles and heat stress measurements. Overexposures were found in 25% of the SO_2 and SO_4 samples and in 33% of the particulate samples. Refer to Tables 1 and 2. Cyclohexane solubles including analysis for fluroanthene pyrene, B(a)A, chrysene, and B(a)P were below laboratory detection limits. The reason for running cyclohexane solubles was due to the small fraction of oil shale present in the lime used to make the cement and possible polynuclear aromatic content. WBGT values ranged from 82° to 97°F.

B. Medical

Pre- and post-shift weights, temperatures, and pulses showed no appreciable changes. These findings indicate that the four workers tested were adequately replacing fluids lost to sweat during the shift. They all indicated they drink about one gallon of water or tea during the shift. One of the day workers, who has had some medical problems not necessarily related to the heat, indicated he only drank slightly over a quart of fluid, mostly coffee. This is probably not an adequate fluid intake.

Monitoring of the evening workers during hot cyclone cleanout at level 8-1/2 showed the pulse as soon as they took a break routinely exceeded 110 beats per minute after working 17 minutes. After resting for four minutes in a slightly cooler area one worker's pulse was down to 93 beats per minute but was back to 112 beats per minute after another seven minutes of work. After this the worker was relieved by his partner who raised his pulse from 76 to 140 beats per minute in 18 minutes of work. As both these workers were acclimated, in good health, and maintained an adequate fluid intake, they were probably not seriously jeopardizing their health, but they were working close to their heat stress limits.

On questioning, all the workers either reported dizziness, light-headedness, or weakness on occasions after working in the heat. Two episodes were mentioned where workers became disoriented and had stopped sweating. One was cooled with damp towels, the other apparently was not, but was sent home after resting in a cooler area. One worker mentioned that he would work until his arms stopped sweating (20-30 minutes) before resting. The general impression received was that the work force is not well informed on the dangers of heat stress and the appropriate first aid measures.

Besides the heat, the workers mentioned eye irritation and difficulty breathing when the dust was heavy or when the system became positive and fumes from the kiln entered the general building air. They also identified leaks in the top of the bag house as allowing corrosive, irritating fumes to be present which were likely to cause headaches. Besides the problem with heat and eye irritation, two workers mentioned nosebleeds--one severe. One worker passed out while doing a not-hot job involving much dust and smell. The doctor serving this company said he had only seen one person who appeared to be hyperventilating (overbreathing) but otherwise normal.

VII. CONCLUSIONS

A potential health hazard existed from excessive exposures to sulfur dioxide and sulfate and respirable particulate.

A heat stress problem was also documented when cleaning out the cyclones as shown by measurement, worker monitoring, and history. Further, the workers are not adequately informed on how to cope with excessively hot work and what first aid they should be ready to give in case their partner is overcome by heat.

VIII. RECOMMENDATIONS

1. Periodic measurements of sulfur dioxide and respirable particulate should be performed. Eliminating SO_2 and particulate exposures does not seem feasible under the present mode of operation.

2. Housekeeping should be improved and spills cleaned up using a vacuum system.

3. Workers should be provided an area to cool off every twenty minutes when working in the excessive heat areas such as unplugging cyclones.

4. Workers should be trained in appropriate ways to handle heat stress:

   a. Length of time in the stressful situation.

   b. Signs and symptoms of excessive heat stress.

   c. First aid for heat illness, particularly heat stroke.

   d. Preventive measures with emphasis on adequate fluid and dietary salt intake.

5. A scale should be provided so workers can weigh themselves pre-shift and post-shift to monitor adequacy of fluid intake.

6. Work practices for hot cleanouts should be established. This should include maximum times between rests and a cooler area for rest. This would probably best be accomplished by bringing in cooler air at the rest area. Some tempering will probably be needed in winter. Workers should continue to rest and cool off at more frequent intervals if they begin feeling ill effects from the heat. The practice of one worker relieving the other is good. Where there are only a few places requiring prolonged work in hot areas, besides the cool down ventilation, timers could be installed to remind the worker when a break is necessary.

IX. REFERENCES

1. Criteria for a Recommended Standard...Occupational Exposure to Hot Environments. DHEW (NIOSH) Publication No. 72-10269.

2. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981. ACGIH, Cincinnati, Ohio, 1981.

3. Procedures for Heat Stress Surveillance. Dukes-Dobos and Jannerfeldt. Personal communication April 27, 1981.

X. AUTHORSHIP AND ACKNOWLEDGMENTS

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XI. DISTRIBUTION AND AVAILABILITY

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Copies of this report have been sent to:

1. Ideal Basic Industries.
2. Ideal Cement Plant.
3. U.S. Department of Labor/OSHA - Region VIII.
4. NIOSH - Region VIII.
5. Colorado Department of Health.
6. State Designated Agency.

For the purpose of informing affected employees, a copy of this report shall be posted in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

General Area Air Concentrations of Sulfate (SO_4) and Sulfur Dioxide (SO_2)
in the Preheater and Bag House Areas

Ideal Cement Plant
LaPorte, Colorado

July 29, 1982

Sample Number	Location	Sampling Time	mg/M^3 SO_4	mg/M^3 SO_2
AA1	Preheater	3:07 PM - 5:00 PM	0.10	0.07
AA2	Above SO_2 Tower	3:05 PM - 8:25 PM	0.13	0.04
AA3	Bag House (top side)	2:59 PM - 8:30 PM	1.3	11.0
AA4	Preheater	3:03 PM - 8:25 PM	8.9	1.5
EVALUATION CRITERIA			1.0 *	5.0
LABORATORY LIMIT OF DETECTION mg/tube			0.004	0.004

mg/m^3 = milligrams of substance per cubic meter of air
* = TLV for H_2SO_4--which is what SO_4 would hydrolyze in the presence of moisture

TABLE 2

Breathing Zone and General Area Air Concentrations of Respirable Particulate

Ideal Cement Plant
LaPorte, Colorado

July 29, 1982

Sample Number	Location	Sampling Time	mg/M^3 Respirable Particulate
M5-7718	Plant Utility	2:45 PM - 8:32 PM	32.0
M5-7723	Plant Utility	2:55 PM - 5:00 PM	1.0
M5-7711	Pelletizer	3:10 PM - 8:21 PM	10.0
EVALUATION CRITERIA			5.0

mg/m^3 = milligrams of substance per cubic meter of air

TABLE 3

Wet Bulb Globe Temperatures (WBGT), Globe (G), Wet Bulb (WB), and Dry Bulb (DB) Temperatures (in Degrees Fahrenheit)

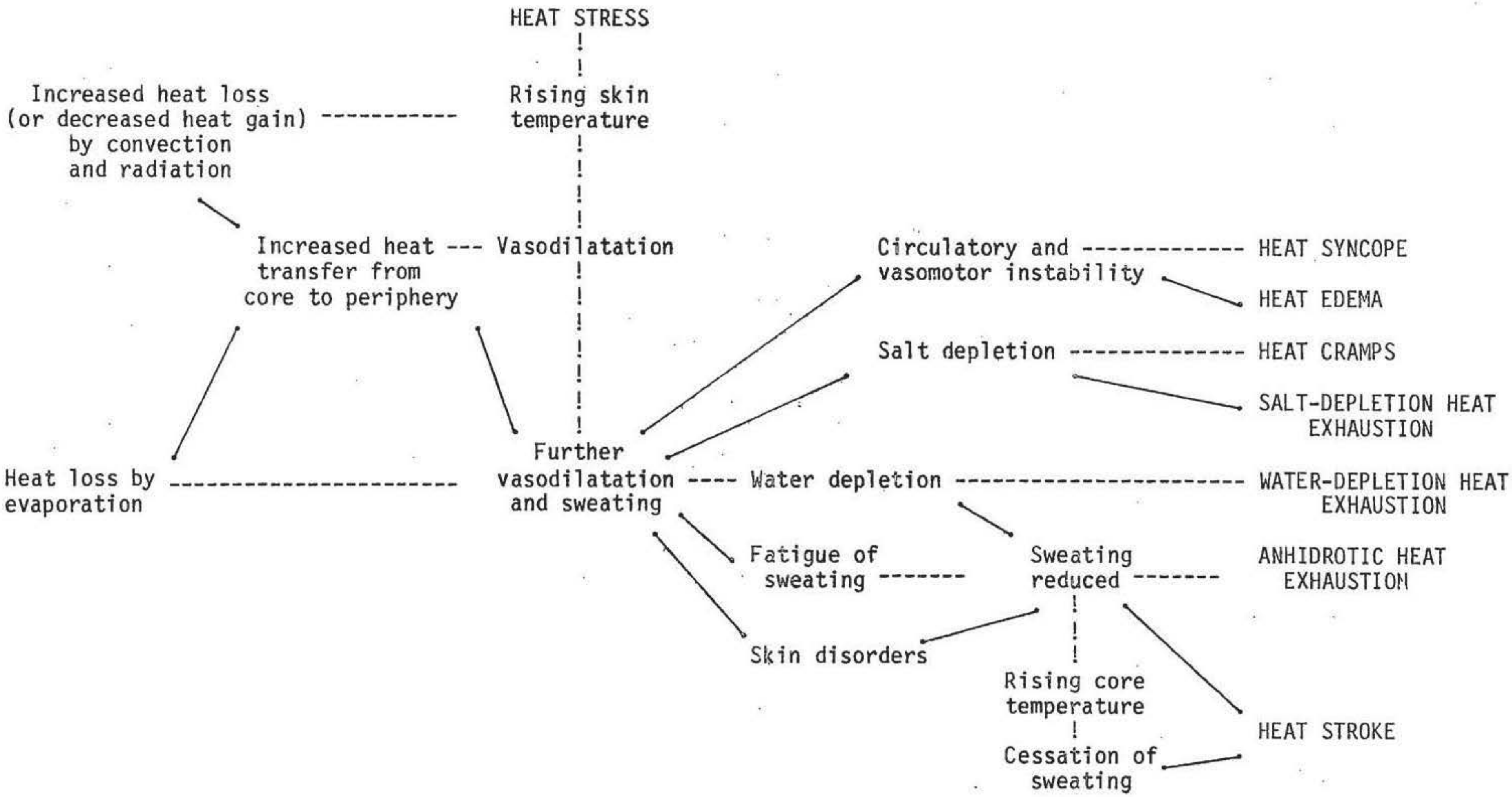
Ideal Cement Plant
Denver, Colorado

June 1, 1982

Time	Location	Temperature	
4:25 PM	Cyclone	WBGT	84
		G	109
		WB	74
		DB	105
4:35 PM	Cyclone	WBGT	95
		G	114
		WB	73
		DB	109
4:45 PM	Inlet to Cyclone	WBGT	95
		G	135
		WB	78
		DB	117
5:00 PM	Top of Cyclone	WBGT	97
		G	139
		WB	80
		DB	120
6:00 PM	Shelf Next to Top of Cyclone	WBGT	89
		G	122
		WB	76
		DB	121
6:30 PM	Bottom Level of Cyclone	WBGT	89
		G	122
		WB	76
		DB	121
9:00 PM	Inlet to Cyclone	WBGT	88
		G	125
		WB	74
		DB	105
9:10 PM	Top of Cyclone	WBGT	82
		G	107
		WB	71
		DB	102
10:00 PM	Cool Off Area	WBGT	82
		G	107
		WB	71
		DB	102

EVALUATION CRITERIA:	25% work/75% rest	WBGT	86
	50% work/50% rest	WBGT	82.2

FIGURE I
Heat Stress and Heat Disorders



Reference: Figure 3. Heat Stress and Heat Disorders, <u>Criteria for a Recommended Standard . . . . Occupational Exposure to Hot Environments</u>. NIOSH, HEW Publication No. HSM 72-10269, 1972.

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