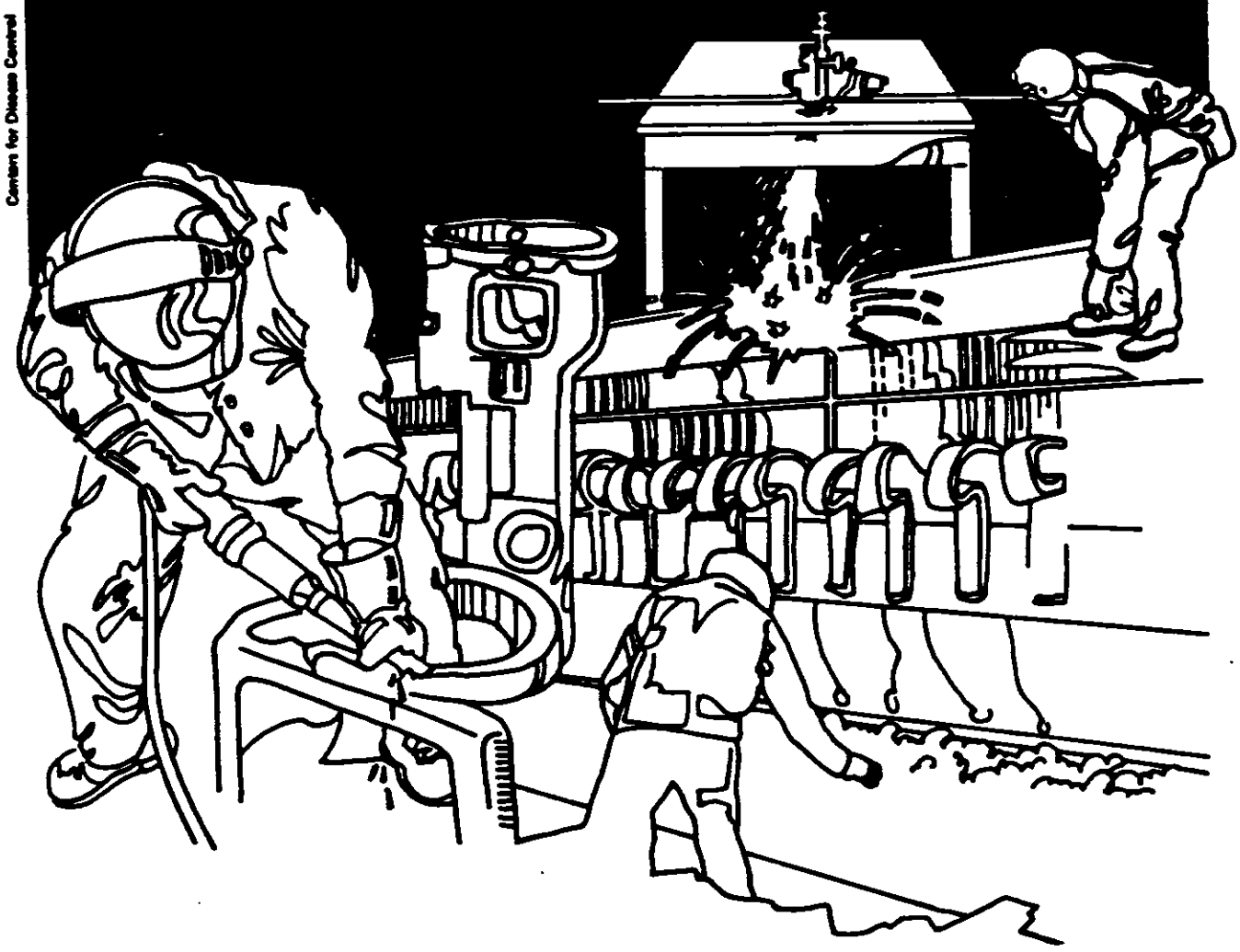
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 89-155-1979
ARCADE PARKING GARAGE
PROVIDENCE, RHODE ISLAND

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 89-155-1979
AUGUST 1989
ARCADE PARKING GARAGE
PROVIDENCE, RHODE ISLAND

NIOSH INVESTIGATOR
Edward A. Kaiser, Ph.D.

I. SUMMARY

On February 17, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management of the Arcade Parking Garage, Providence, Rhode Island, to provide technical assistance by determining carbon monoxide exposure levels to garage employees. The request was precipitated by several informal employee complaints to management expressing their concerns regarding adverse health effects they were experiencing which included tiredness, fatigue, dizziness and headache. Employees felt these symptoms were the result of exposure to carbon monoxide from motor vehicle exhaust emissions.

An initial site visit was conducted on March 9, 1989. Environmental monitoring consisted of carbon monoxide and carbon dioxide air sampling in a collection booth and in the office.

The results of the NIOSH short and long-term air sampling indicated exposure to carbon monoxide ranging from 17 to 103 PPM, (NIOSH 8-hour TWA Criteria - 35 PPM). Carbon dioxide (CO_2) levels were measured at greater than 1000 PPM in the office area, indicating inadequate ventilation. The CO_2 concentrations were all well below the industrial standard (5,000 PPM) but were above the 1000 PPM indoor air quality guideline. Measurements for thermal comfort were taken. Temperatures were between 62 and 65 degrees F., with relative humidities ranging from 28.3 to 43.7%. These thermal comfort values are within the ANSI/ASHRAE, 55-1981, Standard's guidelines for human occupancy.

All reported employee symptoms were consistent with the effects expected from carbon monoxide exposure.

Based on the results of this survey, it has been determined that a potential health hazard existed due to a build-up of carbon monoxide in excess of NIOSH and OSHA criteria in the office area. Levels of carbon dioxide above 1000 PPM were found in the cashier's office, further substantiating the need for improvements in the ventilation of this area. Recommendations are found in the body of this report to minimize employee exposures to carbon monoxide, and to establish good work practices.

KEYWORDS: SIC 7525 (Parking Structures), carbon-monoxide, vehicle-exhaust-emissions, combustion by-products, parking garage.

II. INTRODUCTION

On February 17, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management of the Arcade Parking Garage, Providence, Rhode Island, to provide technical assistance by determining carbon monoxide exposure levels to garage employees. These employees work in the cashier areas of the parking garage facility. In response to this request, a Regional Industrial Hygienist visited the Arcade Parking Garage facility on March 9, 1989 to characterize carbon monoxide exposures to these employees.

On March 9, 1989 an opening conference was conducted with Maintenance and Engineering personnel. During the opening conference, NIOSH objectives and procedures were discussed and pertinent employee work schedule information was collected. In addition, management provided a brief history of employee complaints relative to vehicle exhaust exposures.

III. BACKGROUND

The Arcade Parking Garage has 9 parking levels (8 above ground, one level below ground), which accommodates approximately 900 cars. The building is constructed of reinforced poured concrete and the above ground parking spaces are open to the outside, allowing the free circulation of outside air. The facility was built in 1984, the same year it opened for business. There are a total of 6 employees who work as maintenance staff and cashiers. The cashiers (2-4 employees) work in either a booth (dimensions: four feet by five feet with a seven foot ceiling), which is located between two exiting lines of traffic; or in a central office, (dimensions eleven feet by twenty-one feet, with a seven foot ceiling) which is located adjacent to one of the exiting lines of traffic.

There is no mechanical supply or exhaust ventilation provided to either the booth or the office area. A Chromalox, ceiling mounted, re-circulation heater provides heated air (27,300 BTU/hour) to the office. A portable, Westinghouse electric space heater provides heated air to the booth. The office has a Westinghouse air-conditioner for summer cooling. The booth has no air-conditioning unit.

IV. EVALUATION DESIGN AND METHODS

CO exposure was monitored at the cashiers' stations for both the booth and office area. Additional CO measurements were made inside the office (at the desk and back bench) to determine if accumulation of CO occurs throughout the day.

Since the office area was not mechanically ventilated, and employees gather in this area during non-peak periods, natural ventilation was assessed using carbon dioxide levels as an indoor air quality indicator.

(A) Carbon Dioxide

Carbon dioxide concentrations were measured in both the general office work areas and also the collection booth, using a Draeger pump and colorimetric detector tubes. The measurement range for the detector tubes was 0.01-0.3% (100-3000 ppm).

(B) Temperature and Relative Humidity

Temperature and relative humidity levels were obtained in both the general office work areas and also the collection booth, using a Cole-Palmer LCD Digital Hygrometer, Model 3309-50.

(C) Carbon Monoxide

CO concentrations were obtained using three different direct reading measurement tools. Long-term colorimetric detector tubes were used in conjunction with SKC, Model 222-3, low-flow piston pumps, to assess CO exposures for extended periods of time. An Energetics Science, Inc., Model 1735, Series 2000, CO Ecoloyzer was used to assess CO levels throughout the work shift, especially during the heaviest traffic exiting periods (3:30 to 6:30 PM), and, at intermittent times during the survey period colorimetric CO detector tubes were used in conjunction with a Draeger bellows sampler to further assess short-term CO levels.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental criteria for 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 if their exposures are maintained below these levels. A small percentage of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition and/or by a specific substrate hypersensitivity (allergy). Also, 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 adverse health effects even if the occupational exposures are controlled at the level established by the evaluation criteria. 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 this factor potentially increases overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria considered for this study were: (1) NIOSH criteria documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's), and (3) the U.S. Department of Labor, Occupational Safety and Health Administration's (OSHA) federal occupational health standards, permissible exposure limits (PEL).[3,5,6] Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.[6] A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-10 hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

(A) Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless gas, slightly lighter than air. It is produced in the presence of incomplete combustion of carbon-containing compounds. The major sources of human exposure to CO are engine exhausts, tobacco smoke, and inadequately-ventilated combustion products from appliances and heaters that use natural gas, propane, kerosene or similar fuels. The combination of incomplete combustion and inadequate ventilation can result in overexposure to this gas.

The danger from over exposure to this gas arises from its affinity for the hemoglobin (Hb) molecule in red blood cells. Hemoglobin is the oxygen carrier in the blood. On inhalation, CO acts as a metabolic asphyxiant, causing a decrease in the amount of oxygen delivered to the body tissues. CO, upon entering the lungs and diffusing across lung tissue membranes and into the capillary blood network, combines with Hb to form carboxyhemoglobin, which inturn decreases the amount of free Hb still available for oxygen transfer (or oxygen-carrying capacity) to body tissues. Hb affinity for carbon monoxide molecule is 300 times its affinity for oxygen.[1]

Intermittent exposures to CO are not cumulative in effect, and, in general, symptoms occur more acutely only with high exposure concentrations to CO. The hazard of exposure to CO is compounded however, by the insidiousness with which high concentrations of CO-Hb can be attained without marked physiological symptoms. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness and nausea. These initial symptoms may advance to vomiting, loss of consciousness and collapse if prolonged or high exposures are encountered. Coma and death may follow if high exposures continue without intervention.[2]

Long-term, low-level exposures to CO can increase the risk of heart attack in some people. The myocardium is more sensitive than any other muscle tissue to the decreased amount of available oxygen in blood, as can be caused by exposure to CO. Not surprisingly, therefore, there is substantial evidence of an association between exposure to CO and disturbances of the cardiovascular system, including some limited evidence of an increased risk of myocardial infarction among persons living in environments with high CO levels.[4]

The criteria used to evaluate occupational exposure to CO are:

OSHA -	Permissible exposure limit (PEL)	- 50 PPM - TWA
NIOSH -	Recommended exposure limits (REL)	- 35 PPM - TWA
		- 200 PPM - Ceiling
ACGIH -	Threshold limit values (TLV)	- 50 PPM - TWA
		- 400 PPM - STEL

TWA = 8-hour time-weighted average
Ceiling = level not to be exceeded at any time
STEL = short-term exposure limit, a 15-minute time-weighted average which should not be exceeded at any time during a work day

The OSHA standard, as well as the ACGIH TLV, for CO is 50 PPM, averaged over an 8-hour workshift. NIOSH recommends an 8-hour-TWA exposure limit of 35 PPM, with a ceiling level of 200 PPM.

(B) Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into a building. The outdoor, ambient concentration of carbon dioxide is usually 150-300 PPM. It is important to realize that the carbon dioxide concentrations are normally higher indoors than outdoors, even in buildings with few reported complaints.

However, if the indoor carbon dioxide concentration is more than 1000 PPM, or 3 to 4 times the outdoor concentration with no source other than exhaled breath, inadequate ventilation would be suspected, and complaints such as headache, fatigue, and eye and throat irritation are frequently found to be prevalent. The carbon dioxide concentration itself is not responsible for the complaints, but the elevated concentration of carbon dioxide indicates that concentrations of other contaminants in the building may also be increased and contribute to occupant complaints. When carbon dioxide concentrations are above 1000 PPM, occupant complaints may occur; many health agencies recommend that 1000 PPM be used as an upper limit guideline.

This does not mean that if this level is exceeded the building is hazardous or should be evacuated, but rather this level should be used as a guideline that helps maximize comfort for all occupants.

(C) Provisions for Adequate Amounts of Outside Air

Currently, neither NIOSH nor OSHA have developed ventilation evaluation criteria for general office work areas. Criteria used by design engineers are the guidelines published by ASHRAE, "Ventilation for Acceptable Indoor Air Quality ASHRAE 62-1981". The previous recommendation for general office space was 5 cubic feet per minute (CFM) of outside air per person in non-smoking areas, and 20 CFM of outside air per person in areas where smoking is allowed. A new ASHRAE standard, (62-1989), which was ratified in June, 1989, specifies that for general office work areas, outside air should be delivered at a rate of 20 CFM/person. The basis for this rate is to achieve an acceptable level of indoor air quality by reasonably controlling carbon dioxide (1000 PPM), particulates, odors, and other contaminants common to those spaces. The requirement for smoking areas is 60 CFM per person.

ANSI/ASHRAE Standard 55-1981, "Thermal Environmental Conditions for Human Occupancy," published in 1981, specifies conditions in which 80% or more of the occupants will find the environment thermally comfortable. Figure 1, which was taken from this document, presents the acceptable ranges of temperature and relative humidity according to ASHRAE. It should be noted that as many as 20% of the occupants, because of individual preferences, may not feel thermally comfortable even if general room temperatures and humidities are within the ASHRAE comfort range.

VI. RESULTS

Tables I, II and III list the environmental results obtained for carbon dioxide, temperature, relative humidity and short-term and long-term carbon monoxide exposure levels.

Air quality and thermal comfort measurements collected during the NIOSH evaluation are presented in Table I. Carbon dioxide concentrations ranged from 800 to 1100 PPM during the work day of March 9, 1989. The outside air carbon dioxide concentration was 200 PPM.

Temperatures measured were between 62 and 65 degrees F. The relative humidity ranged from 28.3% to 43.7%. Outside relative humidity was 43.7% and outside temperature was 42 degrees F.

CO concentrations using Ecolyzer-recorded values ranged from a low of 5-7 PPM, in the morning hours, to a high of 82 PPM in the late afternoon, just after the crest of exiting traffic from this facility. Draeger bellows sampler with short-term colorimetric detector tube measurements agreed with Ecoloyzer data (see Table II.). Long-term colorimetric detector tubes indicated that the average employee exposure to carbon monoxide, while collecting parking fees at the office cashier's station was 17 PPM. Exposure at the booth was higher (58.6 PPM) but exposure duration is considerably shorter (64 minutes), as the booth is only open during peak traffic exiting periods. An interesting observation was the fact that CO levels within the general office area were higher than at the cashier's station: 72.9 PPM at the table and 103.5 PPM near the back cabinet. These results indicate that CO becomes entrapped and accumulates in the office area, causing unnecessary exposure to CO during slow periods. If employees were to work in the office all day, their personal exposures to CO would exceed both the NIOSH recommended exposure level (REL) of 35 PPM and the OSHA standard of 50 PPM.

VII. CONCLUSIONS

Based on the results of this survey, it has been determined that a potential health hazard existed due to a build-up of carbon monoxide in excess of NIOSH and OSHA criteria in the office area. The environmental data indicate that thermal conditions are within the recommended thermal comfort range established by ASHRAE. Levels of carbon dioxide above 1000 PPM were found in the cashier's office, further substantiating the need to improve ventilation to this area. The health complaints and symptoms reported by cashiers and maintenance personnel (malaise, eye irritation, headaches, tiredness, etc.) are consistent with the environmental assessment.

VIII. RECOMMENDATIONS

This evaluation demonstrates the need for both mechanical supply and exhaust ventilation in the office area. Therefore, the following recommendations are made to reduce employee exposures to carbon monoxide.

Install mechanical ventilation that will provide a continual source of fresh air to the office. The system should be designed to keep the office under positive pressure, relative to the exiting traffic areas. Similarly, the booth should also be provided with mechanical ventilation.

Outside air louvers should not be located in an area where exhaust emissions can be taken up by air currents and then returned to the employee work areas. Furthermore, openings to inlet louvers and the inlets to the air handler should be equipped with appropriately efficient air filters to prevent particulate contamination of the supply, fresh outside air.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Gilbane Properties, Fleet Center
2. OSHA, Region I

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

TABLE I

INDOOR AIR QUALITY DATA
ARCADE PARKING GARAGE
PROVIDENCE, RHODE ISLAND
HETA 89-155
MARCH 9, 1989

Area	Carbon Dioxide (PPM)	Relative Humidity (%)	Tempera-ture degree F	Time
Office	900	28.3	62	10:40AM
Booth	800	29.1	65	10:45AM
Office	1100	43.7	64	4:45PM
Booth	800	31.3	64	5:35PM
Outside	200	-	42	4:10PM
Air	.-.	43.7	-	4:45PM

TABLE II

SHORT-TERM CARBON MONOXIDE CONCENTRATIONS
ARCADE PARKING GARAGE
PROVIDENCE, RHODE ISLAND
HETA 89-155
MARCH 9, 1989

Area	Time	Ecoloyzer Data (PPM)	Draeger Tube Values (PPM)
Office	10:40 AM	5-7	5
(various locations)	2:00 PM	18	
	2:50 PM	18	
	3:15 PM	25	
	3:30 PM	27	
	4:15 PM	-	40
	5:02 PM	29	
	5:08 PM	24	
	5:15 PM	31	
	5:25 PM	45	
	5:30 PM	-	50-60
	5:40 PM	61	
	5:55 PM	80	
	6:15 PM	75	
	6:35 PM	82	
Booth	10:45 AM	3-5	
	3:15 PM	15	
	4:31 PM	30	
	5:20 PM	35	
	5:30 PM	55	
	5:35 PM	60	
	5:40 PM	70	
	6:05 PM	74	

TABLE III

LONG-TERM CARBON MONOXIDE CONCENTRATIONS
ARCADE PARKING GARAGE
PROVIDENCE, RHODE ISLAND
HETA 89-155
MARCH 9, 1989

Location	Total Time Evaluated (MIN.)	Employee Exposure Level for Time Evaluated (PPM)
Office (at cashier's stand)	342	17.3
Table Area	82	72.9
Back Cabinet Area	61	103.5
Booth	64	58.6

FIGURE 1

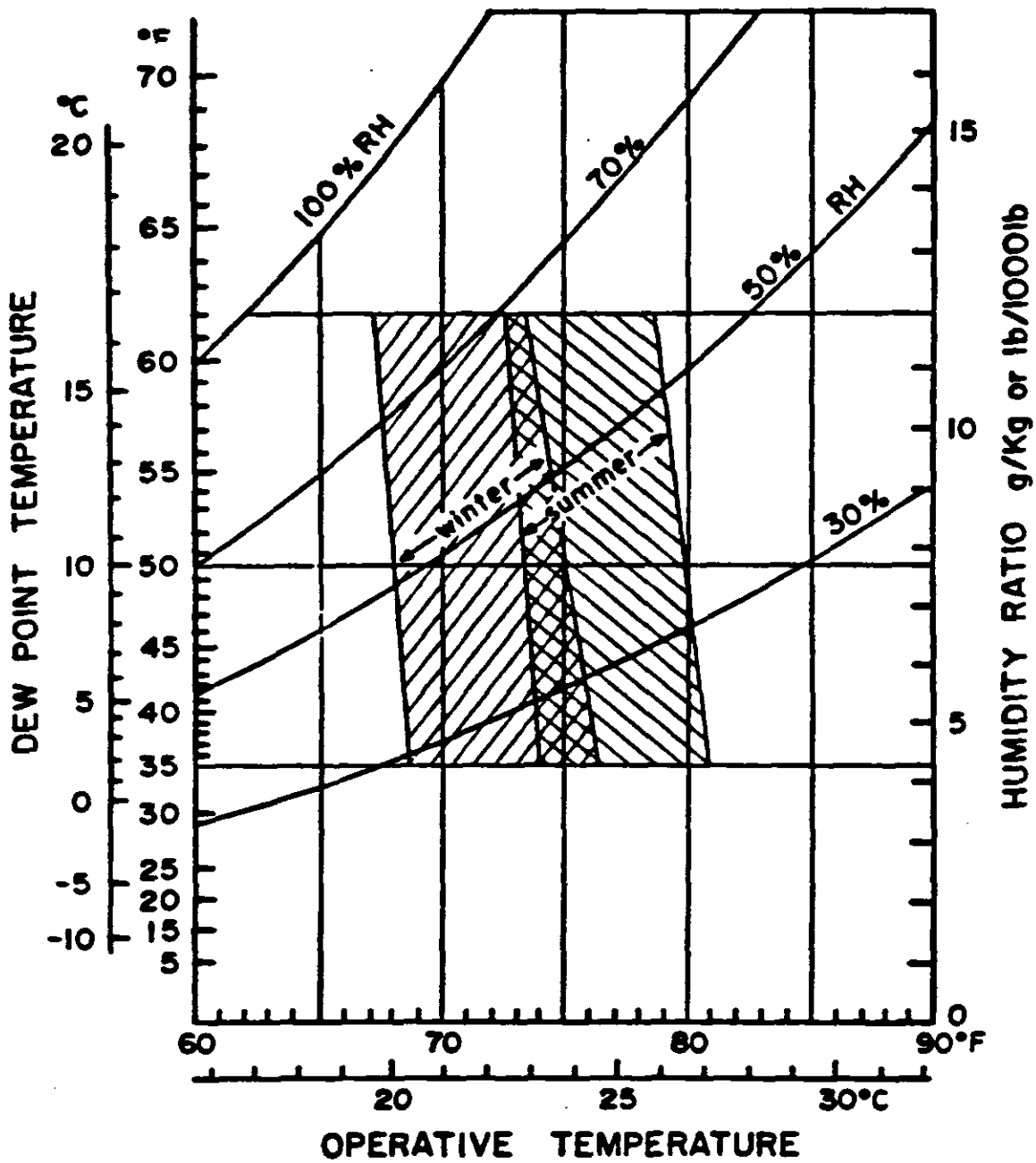

Figure 2 Acceptable ranges of operative temperature and humidity for persons clothed in typical summer and winter clothing, at light, mainly sedentary, activity (≈ 1.2 met).