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HETA 89-175-2045
MAY 1990
PLANNING RESEARCH CORPORATION
VIRGINIA BEACH, VIRGINIA

NIOSH INVESTIGATOR:
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I. SUMMARY

On March 21, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from employees of the Planning Research Corporation, Virginia Beach, Virginia. The requestors were concerned about the quality of the indoor environment and thought that it may be causing or contributing to ill-health symptoms among employees. The symptoms reported in the request included headache, nausea, and eye irritation. Complaints regarding smoking in the work environment and a lack of ventilation were also expressed.

Ten to 20% of the workers within the office complex reported burning of the eyes, sore throat, unusual fatigue or sleepiness, headache, or nasal discharge or sinus congestion while at work on the day of the survey.

Average environmental carbon dioxide (CO_2) concentrations ranged from a low in the morning (between 7:00 and 8:00 am) of 1625 parts per million (ppm) to a high of 2400 ppm in the afternoon (between 1:00 and 2:00 pm), with a gradual rise between these time periods. CO_2 concentrations greater than 1000 ppm are thought to be an indication that the building ventilation is inadequate. Temperature and relative humidity measurements, with few exceptions, were within comfort guidelines.

The smoking policy was in a transitional phase where smoking was permitted in private offices. A smoke-free work environment was to begin July 1, 1990.

A moderate percentage of the workers experienced symptoms suggestive of an indoor environment with poor air quality. A larger percentage of complaints suggested that there were problems with ventilation and air movement. Environmental measurements confirmed that ventilation was inadequate. The presence of these symptoms, the report by almost half of the workers that the environment has stuffy, and the desire expressed by half of the work force to change certain of the enviromental conditions within the office, all indicate that improvements to the ventilation system at this office facility would be beneficial. Recommendations include adding ventilation to the heating and air-conditioning system.

KEYWORDS: SIC 7371 (Computer programming services), indoor air quality, carbon dioxide, temperature, relative humidity, sick-building syndrome,

II. INTRODUCTION

On March 21, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation from employees of the Planning Research Corporation, Virginia Beach, Virginia. A variety of health complaints had caused concern among employees for the quality of the indoor air environment. Symptoms reported included headache, nausea, and eye irritation. Complaints regarding smoking in the work environment and a lack of ventilation were also expressed.

On August 16-17, 1989, an environmental investigator from NIOSH conducted a health hazard evaluation at the Planning Research Corporation (PRC) business offices in Virginia Beach. In September, 1989, environmental results were summarily reported to PRC and the requestors' representative. This final report will include the environmental data and results of a symptom questionnaire.

III. BACKGROUND

Planning Research Corporation in Virginia Beach, VA, is a developer of computer programs and software, primarily for the U.S. Navy. The staff of 64 full-time employees is comprised of two-thirds programmers and one-third technicians and engineers. PRC has been at this location for 12 years.

The building which houses the PRC operations was constructed as a warehouse (24,000 ft^2) in 1977. The exterior is brick, with windows evenly spaced around half of the building. The windows do not open. Currently, greater than three-quarters of the interior space is studded and walled into office area.

The office space is divided into six heating and cooling zones. Each zone is controlled by only one thermostat. Constant volume air handlers, one for each zone, are located between the false ceiling of the office space and the roof of the building. There are no mechanical means for providing outside air to the interior spaces. The systems use electrical power to heat and cool. Supply and return air systems are ducted. Each single-occupant office has at least one air supply duct. Larger offices, the conference room, and more spacious working areas have more supply air ducts, with some having three or four. Air is returned to the air handler via the return ductwork originating in hallway ceilings. There is a computer center which has its own system. The individual units were difficult to access for inspection, and there was no maintenance schedule where periodic inspection and cleaning were performed.

At the time of the NIOSH site investigation, smoking was allowed in private offices and in shared offices where all were smokers. In shared offices where there was a non-smoker, the wishes of the non-smoker prevailed. In the recent past, there was no smoking policy. A goal has been set for a smoke - free work environment by July 1, 1990.

IV. EVALUATION DESIGN AND METHODS

The purpose of the evaluation was to document the health status of the worker population at PRC, and to measure ventilation and comfort parameters. A brief health symptom and comfort questionnaire was distributed to all employees present on the evaluation day. All questionnaires (42) were returned without respondent's names but did have the room number where the employees' work station was located. Measurements of carbon dioxide and the temperature and relative humidity were made throughout the office areas. A representative sampling was made from each heating and cooling zone. Three serial measurements were made at each location, beginning in the morning and ending in mid-afternoon. This measurement strategy allowed trends in environmental parameters though the day to be observed.

Carbon Dioxide

Real-time carbon dioxide (CO_2) levels were determined using a Gastech Model RI-411A CO_2 indicator. This portable, battery operated instrument monitors CO_2 (range 0- 4975 ppm) via non-dispersive infrared absorption with a sensitivity of 25 ppm. Instrument zeroing and calibration was performed daily prior to use with zero air and CO_2 span gas of known concentration (800 ppm). Confirmations were conducted throughout the instrument use period.

Temperature and Relative Humidity

Real-time temperature and relative humidity measurements were conducted using a Vista Scientific, Model 784, battery-operated psychrometer. Dry and wet bulb temperature readings were monitored and the corresponding relative humidity determined via the manufacturer-supplied curve.

V. EVALUATION CRITERIA

NIOSH investigators have responded to approximately 700 complaints of indoor air quality problems in a wide variety of settings. The majority of these investigations have been conducted since 1979, paralleling the "energy efficiency" concerns of building operators and architects.

Commonly, the symptoms and health complaints reported by building occupants have been diverse and not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, varying degrees of itching or burning eyes, irritations of the skin, including rashes, sinus problems, dry and irritated throats and other respiratory irritations. The workplace environment has been typically implicated because workers' symptoms reportedly disappear when they are away from the office.

The causes of comfort and health problems related to indoor air quality are typically multifactorial, which makes determination difficult. The investigations NIOSH has conducted have been classified by primary type of problem found: inadequate ventilation; contamination from inside the building; contamination from outside the building;

microbiological contamination; contamination from the building materials; and "unknown".

The predominant problems identified in the NIOSH indoor air quality investigations can be placed into the following three general categories listed in order of decreasing frequency: inadequate ventilation, chemical contamination, and microbiological contamination. Inadequate ventilation, a category which includes shortages of outside air, poor distribution, and short-circuiting of supply air, is reported most commonly in the NIOSH building investigations (greater than 50% of the cases). These ventilation problems make it difficult to control heating and cooling, and allow the accumulation of contaminants in the occupied space. The resulting conditions may cause occupants become uncomfortable or experience adverse health effects.

Standards for indoor air quality in office buildings do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards and recommended limits for occupational exposures.[1-3] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria, and thermal comfort guidelines.[4,5] Scientists suspect that work related complaints may be attributable not to individual environmental species, but to the cumulative effect resulting from exposures to low concentrations of multiple pollutants, and work environments outside of comfort ranges.

The bases for monitoring carbon dioxide, and the temperature and relative humidity are presented below.

A. <u>Carbon Dioxide</u>

CO_2 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 an occupied space. The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality[4], recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 CFM/person for smoking lounges, and provides estimated maximum occupancy figures for each area.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased.

B. <u>Temperature and Relative Humidity</u>

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants will find the environment thermally comfortable.[5]

VI. RESULTS

A. Medical

Table 1 shows the number of respondents who reported their personal impressions regarding the comfort level of their work stations on the day of the industrial hygiene survey. The majority felt that there was insufficient air movement both in the morning and the afternoon. Only one employee felt that the air movement was excessive. The majority of employees felt that the temperature was acceptable. In the morning, 3 felt that it was too warm, while 5 felt it was too cold. In the afternoon, 9 felt it was too hot, and 3 felt it was too cold. Likewise, the majority felt that the humidity was in a comfortable range. Few felt noise levels were excessive in the office. However, the majority of workers felt that the air was excessively stuffy in the morning. In the afternoon, they were evenly divided with regard to the air being too stuffy within the work place. The vast majority felt that dust in the work place was not a problem at the time of the survey. Twenty of the 42 respondents were uncomfortable enough to desire an adjustment in one or more of the above environmental conditions. Major causes of discomfort mentioned by the respondents included stale air, cigarette smoke, and the need for circulation of fresh outside air within the offices.

Table 2 shows the number of workers who noted the presence of specific odors at their work station on the day of the survey. It also shows the workers overall assessment of the air quality within the building. Forty-two percent of the workers noted the presence of tobacco smoke at their work station during the day. Twenty-one percent noted the odors of cosmetics, 17% noted food smells, and 12% noted the presence of body odor. Four (10% of) respondents considered the air quality within their work space excellent, 16 (39%) termed it good, 12 (29%) rated their air quality fair, while 9 (21%) felt that their air quality was poor.

Table 3 shows the number of employees who experienced symptoms which began while at work during the day of survey. The most common complaints were dry, itchy, or teary eyes, and sore, strained eyes; about 20% of the workforce experienced these symptoms during the day. Also of note is that 17% of the workers reporting a headache which began during the work day, 19% experienced sleepiness or drowsiness, and 12% had unusual fatigue or tiredness. Twelve percent of the respondents reported nasal discharge which began during their work day, and 17% experienced sneezing which began during their workday. Lower back and shoulder/neck pain were reported by 17% and 12%, respectively.

B. Environmental

Results of the environmental evlauation are presented in Table 4, and summarized in Figures 1 and 2. All indoor CO_2 concentrations, except for those measured in the warehouse and warehouse office areas (sample location 15), were much greater than 1000 parts per million (ppm), the guideline suggested by ASHRAE, and ranged from 1500 to 2575 ppm (Table 4). The outdoor concentration remained at 350 ppm throughout the day. Early morning concentrations (7-8am) averaged 1625 ppm, late morning concentrations (10-11am) averaged 2150 ppm, and mid-afternoon concentrations (1-2pm) averaged 2400 ppm (Figure 2).

The indoor temperature ranged from 68 to 78°F across all areas measured throughout the day (Table 4).

The relative humidity ranged from 54 to 72%. The next highest RH below the maximum was 63%. All of the temperature and relative humidity pairings fall within the acceptable ranges of operative temperature and humidity shown in Figure 4, from ASHRAE, with the exception of the final relative humidity measurement made at the reception area for the building. The high afternoon measurement is attributable to employees and clients coming and going, allowing infiltration of humid outdoor air into this area. Some of the temperature and relative humidity pairs are in the range denoted "winter". However, results of a recent study by ASHRAE reported that some people find this "winter" range ideal year-round.[6] The average temperature in the building gradually rose throughout the day, while the relative humidity fell. Average temperatures and relative humidities were 71°F and 58%, 73°F and 58%, and 75°F and 56% respectively during the measurement periods (Figure 3).

Thermostat setpoints and temperature readings were recorded for the five zones during environmental measurement rounds. All but one temperature read within % 2 degrees of the setpoint. The thermostat in area 27 (Figure 1) read 4 to 7 degrees higher than it's setpoint each time. Calibration of this thermostat should be checked.

VII. DISCUSSION

Ten to 20% of the workers within the office complex reported experiencing symptoms of mucous membrane discomfort such as burning of the eyes of sore throat, complaints of unusual fatigue or sleepiness, headache, and nasal discharge or sinus congestion beginning at work on the day of the survey. While these symptoms are nonspecific and can be due to a variety of causes, their presence, the report by almost half of the workers that they considered the air as being "stuffy", and the desire expressed by half of the work force to change certain of the environmental conditions within the office, all indicate that the addition of a ventilation system at this office facility would be advisable.

Environmental measurements made in the office areas showed that there was inadequate ventilation. The consequence of this condition is that low level pollutants normally present, and those which may result from certain activities (smoking for example), will accumulate. The ensuing concentrations (except for tobacco smoke) may not be health threatening, but may be the cause of the symptoms being reported. It should be noted that the inability of the heating and air-conditioning system here to provide outside air for dilution was known at the outset of the evaluation. It was designed for total recirculation of the office air.

Air samples for certain potential indoor air pollutants, such as volatile compounds, particulate matter, and microorganisms, were not collected during this evaluation. While there is very seldom a case where a single factor or pollutant is contributing to poor indoor air quality, it was obvious in this instance a lack of ventilation had an overwhelming influence.

Placement of thermostats in the office did not allow for control of comfort at all locations. All thermostats were in the core areas of the building, while each system serviced both core and perimeter office space, which normally have different and varying load (heating and cooling) components. Optimally, the heating and cooling systems for the building should service core and perimeter areas separately.

VIII. RECOMMENDATIONS

Based upon the findings of this evaluation it seems clear that the addition of ventilation with outside air will improve the quality of the indoor environment.

Planning Research Corporation should install a ventilation system at their facility in Virginia Beach, Virginia. This system should provide fresh air to all office spaces at a rate of 20 cubic feet per minute per occupant, and comply with the other provisions of the AHRAE Standard 62-1989. A ventilation contractor with experience in designing ventilation systems for office buildings should be consulted.

IX. REFERENCES

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Planning Research Corporation
2. Confidential Requestor
3. NIOSH Atlanta Region
4. OSHA, Region 3

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 1
Number of Respondents Who Reported the Following Personal Impressions
Regarding Their Work Environment on Day of Industrial Hygiene Survey

	This MORNING	This AFTERNOON
1. Has the AIR MOVEMENT been:		
too much	1	1
too little	21	25
just right	18	15
2. Has the TEMPERATURE been:		
too hot	3	9
too cold	5	3
just right	32	29
3. Has the HUMIDITY been:		
too humid	5	6
too dry	2	3
just right	31	31
4. Has the NOISE LEVEL been:		
too loud	6	5
too quiet	0	0
just right	35	37
5. Has the air been TOO STUFFY?		
No	19	21
Yes	22	21
6. Has your work are been TOO DUSTY?		
No	37	38
Yes	4	4

7. Number who would like to adjust one or more of the above conditions:

No Adjustment	22
Yes, Adjust	20

NOTE: Total number of respondents equals 42, but not every worker answered all questions.

Table 2
Workers Who Noticed These Types of ODORS
at Their Workstation on Day of Survey

		Number	Percentage of Respondents
a.	Body odor	5	12
b.	Cosmetics, such as perfume or after-shave	9	21
c.	Tobacco smoke	18	42
d.	Fishy smells	1	2
e.	Other food smells	7	17
f.	Musty or damp basement smells	3	7
g.	Odors from new carpet	0	0
h.	Odors from new drapes or curtains	0	0
i.	Odors from diesel or other engine exhaust	1	2
j.	Odors from a photocopying machine	0	0
k.	Odors from printing processing (press, binding materials, etc.)	2	10
l.	Odors from other chemicals such as adhesives, glues, cleaners, white-out, rubber cement, pesticides, etc.	3	7
m.	Odors from pesticides	0	0
n.	Odors from cleansing of carpets, drapes, or other furnishings	1	2
o.	Odors from paints	0	0
p.	Other unpleasant odors	0	0

Table 3

Subjective Air Quality Rating
at Respondent's Workstations on Day of Survey

Air Quality	Number	Percentage of Respondents
Excellent	4	10%
Good	16	39%
Fair	12	29%
Poor	9	21%

Table 4

Number of Employees Who Began Experiencing Any Of The
Following Symptoms While AT Work On Day Of Survey

		THIS MORNING AT WORK	THIS AFTERNOON AT WORK	TOTAL NUMBER REPORTING SYMPTOMS BEGINNING AT WORK	PERCENTAGE OF 42 RESPONDENTS
a.	headache	2	5	7	17%
b.	nausea	3	0	2	7%
c.	runny nose	3	0	3	7%
d.	stuffy nose/sinus congestion	5	0	5	12%
e.	sneezing	6	1	7	17%
f.	cough	6	1	3	7%
g.	dry, itching, or tearing eyes	6	3	9	21%
h.	sore/strained eyes	5	3	8	19%
i.	blurry/double vision	1	1	1	2%
j.	burning eyes	4	2	6	14%
k.	unuaual fatigue or tiredness	2	3	5	12%
l.	sleepiness or drowsiness	4	4	8	19%
m.	chills		1	1	2 5%
n.	problems with contact lens	3	0	3	7%
o.	dizziness/lightheadedness	1	0	1	2%
p.	feeling depressed	1	0	1	2%
q.	tension or nervousness	3	1	4	10%
r.	difficulty concentrating	0	1	1	2%
s.	pain or stiffness in upper back	2	1	3	7%
t.	pain or stiffness in lower back	3	4	7	17%
u.	pain or stiffness in shoulder/neck	2	3	5	12%
v.	pain or stiffness in hands or wrist	1	1	2	5%

Table 5
Carbon Dioxide, Temperature, and Relative Humidity Measurements
Planning Research Corporation
Virginia Beach, Virginia
August 17, 1989
HETA 89-175

Location	CO_2, ppm			Temp., °F			RH, %		
	7a-8a	10a-11a	1p-2p	7a-8a	10a-11a	1p-2p	7a-8a	10a-11a	1p-2p
Outside	350	350	350	74	78	84	96	84	74
1	1500	2100	2200	68	73	71	64	54	72
2	1500	1975	2250	69	74	76	60	54	50
3	1575	2000	2300	69	73	75	60	58	52
4	1675	2100	2500	70	71	74	56	58	56
5	1575	2000	2300	70	70	72	56	60	58
6	1825	2200	2575	73	73	75	54	58	56
7	1600	2200	2525	71	73	74	58	58	56
8	1675	2100	2525	70	73	75	60	58	56
9	1675	2300	2400	73	76	76	58	56	52
10	1700	2200	2400	70	72	75	60	58	56
11	1625	2200	2400	72	74	75	58	55	56
12	1600	2200	2400	71	75	76	58	60	54
13	1625	2150	2350	75	74	78	56	54	50
14	1600	2150	2300	74	75	78	58	52	50
15	875	950	950	71	73	73	60	62	62
Warehouse	875	975	975	72	73	75	58	66	63

Figure 1

Average Carbon Dioxide Concentrations

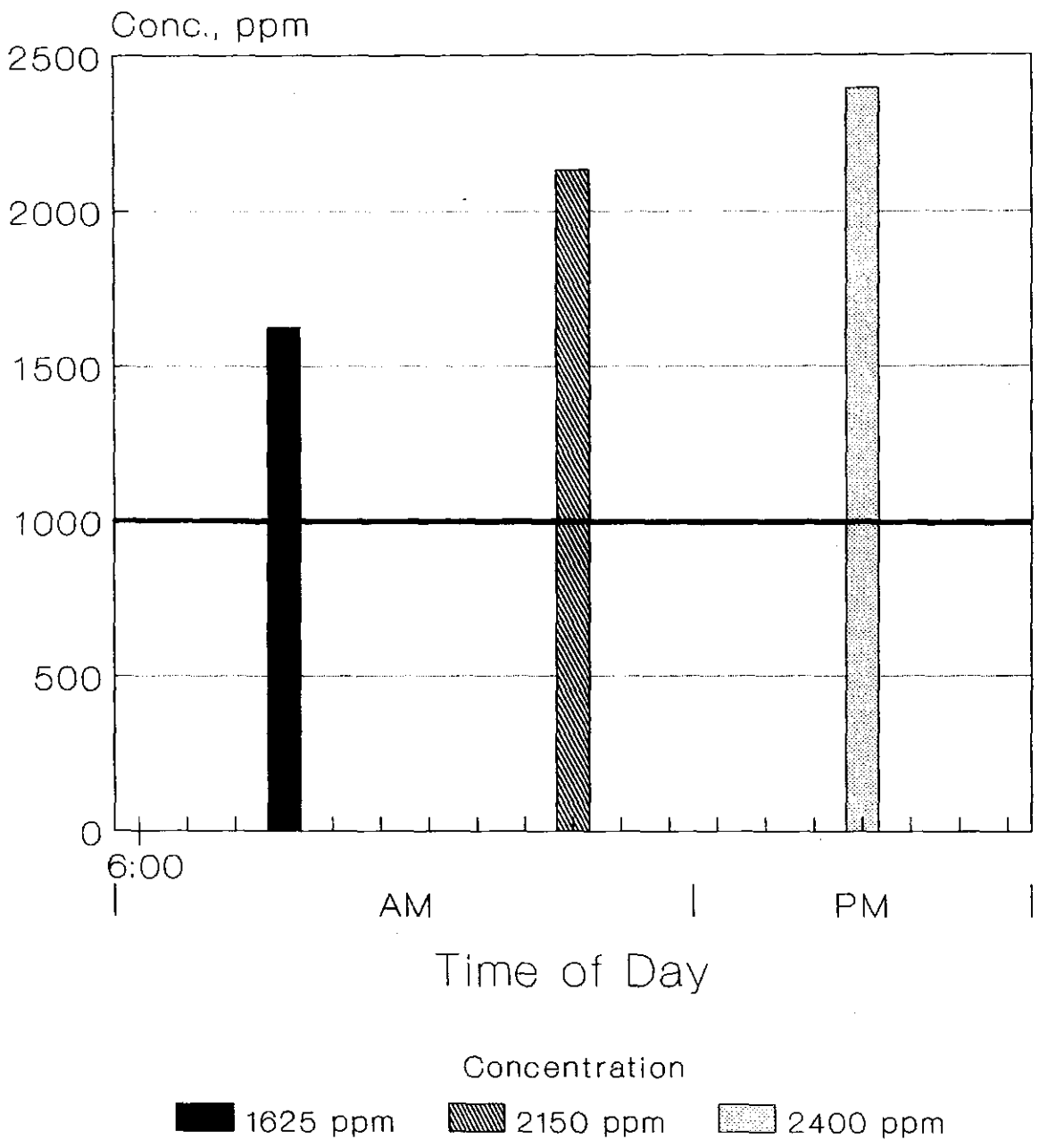
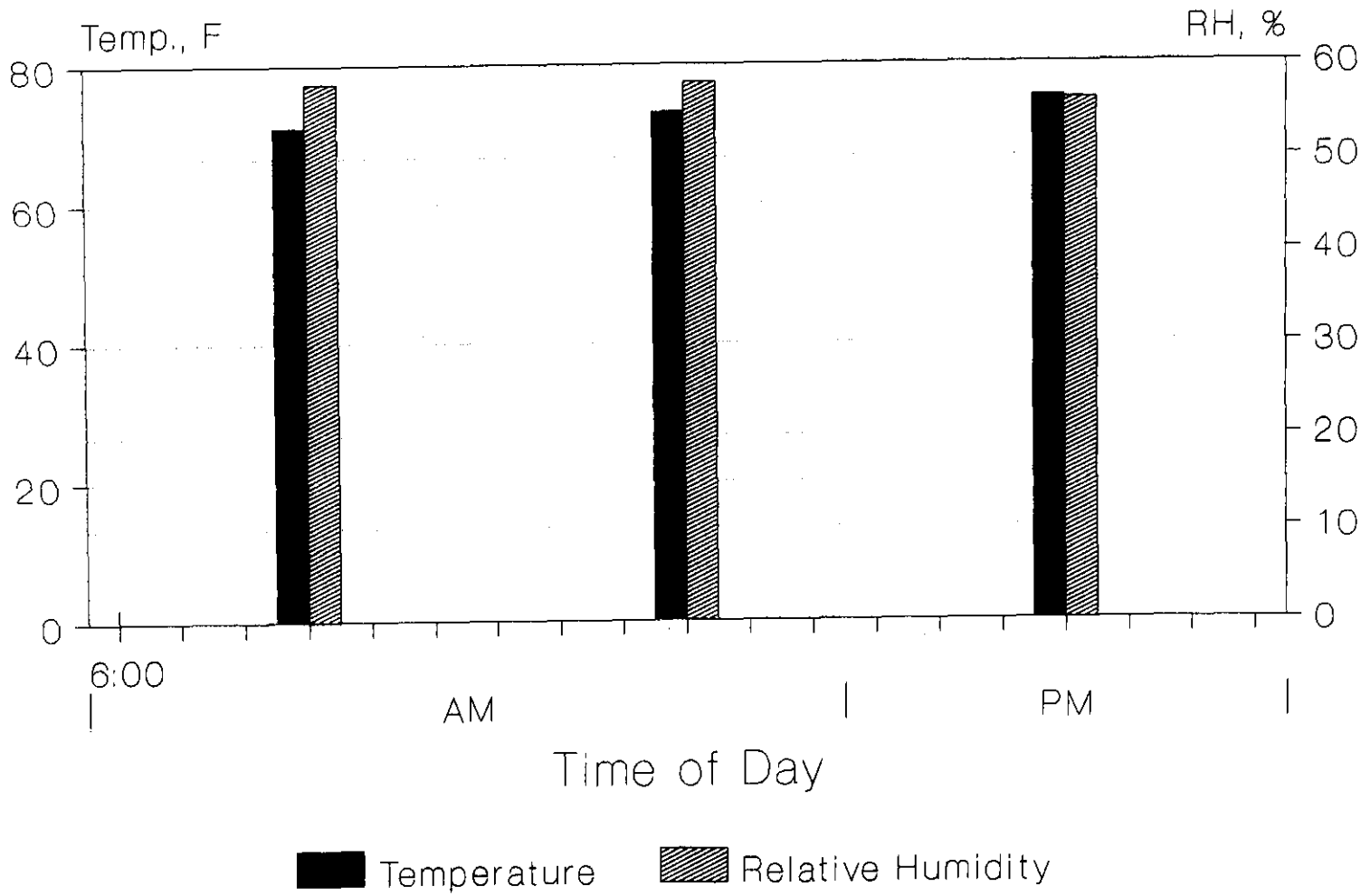


Figure 2 Average Temperatures and Relative Humidities



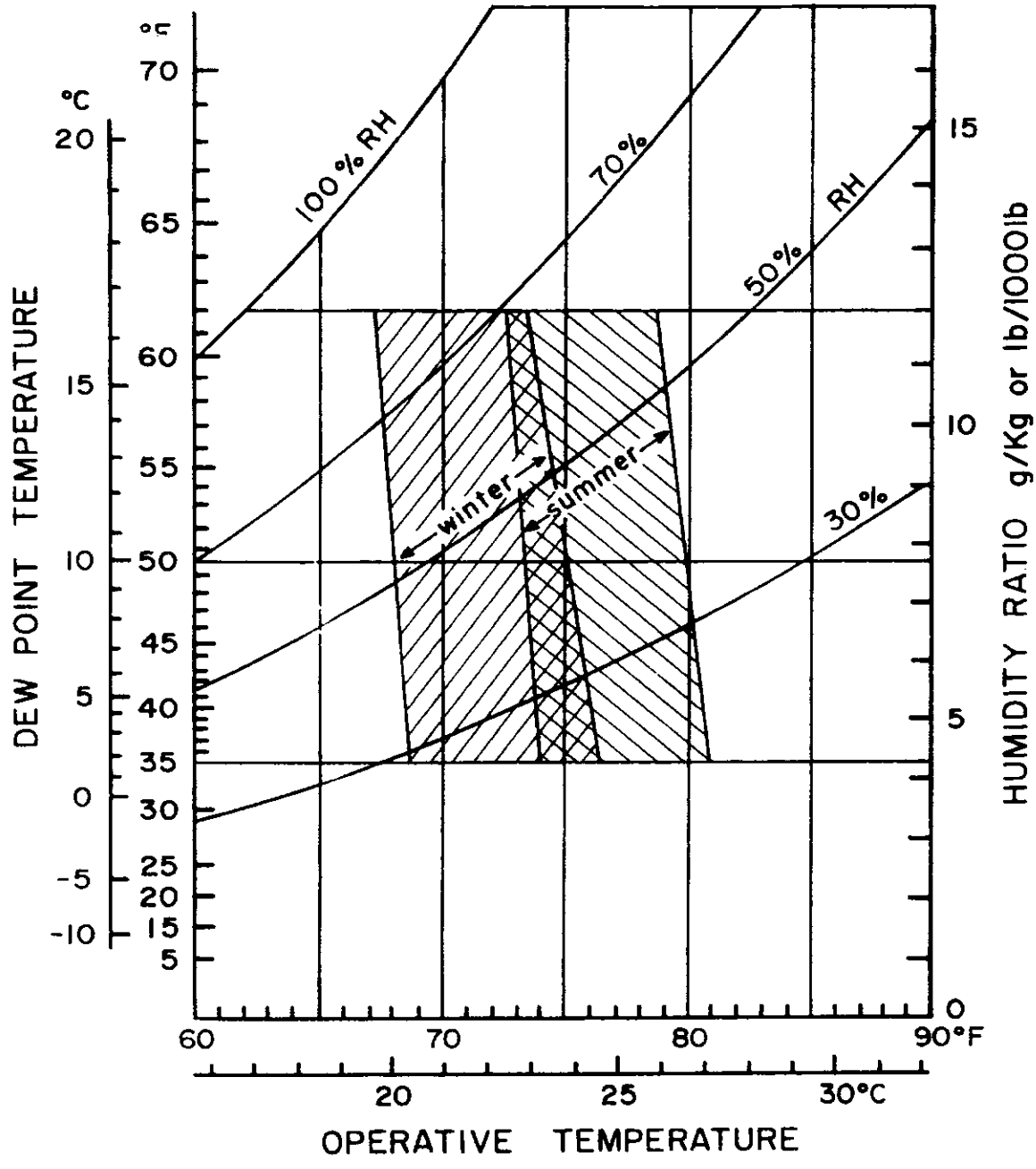


Figure 3 Acceptable ranges of operative temperature and humidity for persons clothed in typical summer and winter clothing, at light, mainly sedentary, activity (≅ 1.2 met).