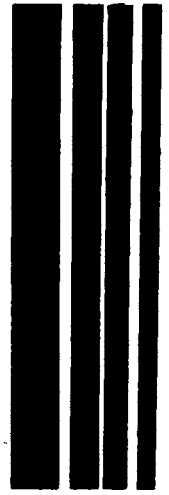


RECOGNITION OF OCCUPATIONAL HEALTH HAZARDS



510

COURSE MANUAL VOLUME II

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

DISCLAIMER

The opinions, findings, and conclusions expressed herein are not necessarily those of the National Institute for Occupational Safety and Health, nor does mention of company names or products constitute endorsement by the National Institute for Occupational Safety and Health.

FOREWORD

This document is part of a training package for the course entitled "Recognition of Occupational Health Hazards." The package was developed by the Human Resources Research Organization (HumRRO) in fulfillment of Contract CDC-99-74-32 with the U.S. National Institute for Occupational Safety and Health.

The training course is a five-day, 40-hour program for newcomers to the field of industrial hygiene. The package of course materials consists of the following pieces:

Course Manual, Volumes I and II

Appendices F-L

Course Director Guideline

Bi-Lingual Glossary (English/Spanish, Spanish/English)

Visual Aids

Parameters for the design of the training package were established with NIOSH representatives. The Project Officer was Dr. Thomas C. Purcell, Acting Deputy Director of the Division of Training in Cincinnati, Ohio.

The work was performed at the HumRRO Eastern Division in Alexandria, Virginia, under Dr. J. Daniel Lyons, Division Director. Mr. Robert C. Trexler was the Project Director. Ms. Lala J. Curry coordinated the design, development, and production of the training materials. She was assisted by Ms. Phyllis A. Price. Ms. Iris D. Perez assisted with copy preparation for the Bi-Lingual Glossary.

Technical content was prepared or supervised by Mr. Henry N. Doyle, Consultant in Industrial Hygiene. His associate was Mr. Ronald E. Bales, also an Industrial Hygienist.

The new course was based on the following NIOSH courses, originally intended for college and junior college audiences:

Evaluation of Occupational Hazards, Instructor's Manual and Student's Manual. Alexandria, Virginia: Human Resources Research Organization, August 31, 1972.

Industrial Hygiene Surveying Techniques, Instructor's Manual, Student's Manual, and Slide Set. Rockville, Maryland: U.S. Department of Health, Education & Welfare, Public Health Service, Health Services and Mental Health Administration, undated.

Mr. Doyle also served as technical consultant for the course in Evaluation of Occupational Hazards.

The Human Resources Research Organization is a non-profit corporation established in 1969 to conduct research in the fields of training, motivation, and leadership. It was part of the George Washington University from 1951 to 1969. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation.

December 31, 1974

ACKNOWLEDGMENTS

The new course entitled "Recognition of Occupational Health Hazards" is based largely on two other NIOSH courses.

Modules 2-4, 6, 9, 10, 13, 17, 29, and 33 were adapted from the following course materials:

Evaluation of Occupational Hazards, Instructor's Manual and Student's Manual. Alexandria, Virginia: Human Resources Research Organization, August 31, 1972.

Modules 7, 8, 14-16, 22-24, 30-32, 34, 35, and 38 were adapted from the following course materials:

Industrial Hygiene Surveying Techniques, Instructor's Manual, Student's Manual, and Slide Set. Rockville, Maryland: U.S. Department of Health, Education & Welfare, Public Health Service, Health Services and Mental Health Administration, undated.

The Pretest in Module 1 and the Examination in Module 39 were adapted from parts of both courses.

The original slide numbers from the Surveying course have been retained. The other text and visual material has been reorganized and renumbered.

Source material from both previous courses has been reprinted with credit lines. Renewal of permissions has been requested, where appropriate.

New copyrighted material appears in Module 18 (reprint) and Module 28 (Visual 28-1). Reprint permission has been requested.

Additional visual material has been drawn heavily from and credited to the following NIOSH publication:

The Industrial Environment--Its Evaluation and Control.
Washington, D.C.: U.S. Government Printing Office, 1973.

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INTRODUCTION

This Supplementary Course Program is intended as an extension of the Instructor and Student Manuals for the course entitled "Recognition of Occupational Health Hazards."

As the title implies, it is a supplement to the core course, rather than separate instructional material. For identification purposes, the materials of the supplement are labeled "modules." However, they are actually expansions of the following modules in the basic training course:

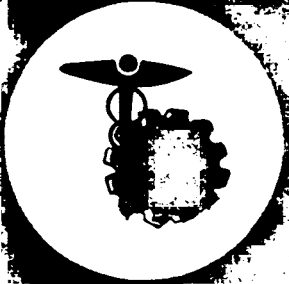
- Module 28. Ergonomics
- 25. Illumination
- 36. Vibration
- 33. Instrumentation

As supplements, these materials do not require, nor do they follow, the regular format of a "module."

Instructors may wish to use the supplementary material as reading assignments or reference material for lectures, discussion, and other classroom activities.

This material is not covered in the test and evaluation modules of the basic course.

COURSE MODULES



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Illumination NO. 25 TIME: 50 Minutes

Proper illumination is necessary for accurate work, accident prevention, and good industrial housekeeping.

Objectives. Enable the trainee to understand what constitutes good illumination and to arrange for good lighting at the workplace.

Content. Characteristics of good lighting
 Lighting measurements
 Lighting specifications
 Visual needs of workers
 Lighting maintenance
 Lighting surveys

Methods. Lecture, Exercises, and Discussion

Materials. Chalkboard, chalk, eraser
 Visuals 25-1 - 25-3

Special Terms.

Candle	Lamp
Footcandle	Lumen
Footlambert	Luminaire
Illumination level	Luminance
Intensity	Reflectance

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapter 7, pp. 230-235.
2. Industrial Environment - Its Evaluation & Control.
Chapter 27, pp. 349-356.
3. Industrial Toxicology. Volume I, Chapter 20, pp. 743-788.

Other References

1. Illuminating Engineering Society. IES Lighting Handbook. 5th ed.
New York: Illuminating Engineering Society, 1972.
2. Lighting Survey Committee of the IES. "How to Make a Lighting Survey."
Illumination Engineering, 57:87, 1963.

NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> If you were driving at night and the generator or battery in your car were not working properly, the first thing you would notice is your headlights growing dimmer and dimmer. Perhaps you've been in exactly that predicament--trying to drive with dying headlights. Have you ever tried to read in the dark by flashlight, firelight, or candle light? These are all exaggerated examples of trying to work by inadequate light. The dimmer the light, the greater the possibility of an accident and the greater the likelihood that your work in general will be sloppy. Inadequate light means that your work will slow down, you will probably become frustrated, and the whole situation will soon become intolerable. Imagine having to work eight hours a day in light that is too dim or in light so bright and glaring that you have to squint in order to see properly. Today's subject--industrial illumination--is one of the most basic in this course. If an employee can't see, he can't do his work properly. It's as simple as that. In this module, we will take a look at some of the principles good illumination and discuss ways in which those principles can be put into practice.

NOTES	INSTRUCTION
<u>Explanation - Lecture</u> Importance of good lighting Objective of good illumination in industry Characteristics of good illumination: quality and quantity Lighting levels should be brighter than "normal" Recommended lighting levels: Visual 25-1	<u>EXPLANATION - LECTURE</u> A. The provision of good lighting in industry--lighting that is properly designed, installed, maintained, and used--is essential to the accomplishment of work. It is also essential to the safety of workers and to the maintenance of good housekeeping. In short, it is a factor of primary importance in every industrial environment. Many jobs in modern technology involve difficult, precise, and critical visual tasks that demand excellent illumination. Therefore, the ultimate objective of good illumination is to provide adequate visibility for the task at hand and satisfactory eye comfort. Poor illumination may cause eye fatigue, resulting in decreased production, more rejects among finished products, increased accidents, and a decrease in the morale of workers. B. There are two broad characteristics that must be considered in the design of good illumination for a given task: the <u>quality</u> and <u>quantity</u> of lighting in the visual field. Illumination of a task should be of such quality and quantity as to enable the task to be done with a minimum of eye strain. Each task has its own illumination requirements. The quantity of light is the factor most often considered when correcting poor illumination, although in many cases quality factors may be more important than mere quantity of light. This is especially true whenever the minimum quantity of light has already been attained. B.1. Lighting specifications should exceed what may be considered as normal. Recommended levels of lighting, as shown in Visual 25-1, exceed the needs of normal visual

MODULE Illumination		NO. 25	
NOTES		INSTRUCTION	
Decisions as to lighting levels should consider the individual worker and the task he performs		capability necessary to perform given tasks with ease.	
Visual acuity declines with age		B.1.a. When deciding on the amount of light needed, we must not only consider the task to be performed, but also the individual performing the task. Visual capabilities vary considerably between individuals. Where one individual can readily see fine detail or can quickly adapt to changing focal distances or light intensities and colors, others may not be able to do so. Visual capabilities often decline with the age of the individual or as a result of illness. Thus, one may expect older workers to have less acute visual capabilities. To state this in another way, the experienced worker's visual capability probably changes with time and visual tasks become more difficult as age increases, requiring more assistance in the form of improved illumination in order to perform the same task in the same length of time.	
Set lighting level at brightest needed by workers with poorest vision		It would be a good policy, therefore, to set lighting at the brightest level needed by workers with least acute vision.	
Four other factors determining the quantity of illumination		B.1.b. In addition to individual visual capability, there are four other factors that determine the quantity of illumination necessary for a person to adequately and comfortably perform a specific task.	
Size of object		(1) Size of the object being viewed.	
Duration of task		(2) Time available to perform the task.	
Contrast factors		(3) Contrast (between the detail of the task and the immediate surroundings).	

MODULE Illumination		NO. 25
NOTES	INSTRUCTION	
Brightness level	(4) Brightness level to which the object is illuminated	
Brightness level is often the only controllable factor	Often the size, contrast, and time are fixed. The only really controllable factor is the brightness level or the level of illumination on the task. Here, workers with poor eyesight require a higher level of illumination than do those with average or normal eyesight.	
Visuals 25-1 and 25-2	The tables of recommended levels of illumination for given tasks, shown in Visuals 25-1 and 25-2, provide adequate lighting levels for most workers. Difficult "seeing tasks", where fine detail or poor contrasts are encountered, require very high levels of illumination. For example, where 100 footcandles on the task is recommended for reading good reproductions or regular office or shop work, 1,000 to 2,000 footcandles on the task is recommended for certain extra-fine assembly work or very difficult inspection tasks.	
Quality of illumination	B.2. In addition to the requirement for a sufficient quantity of light to permit the necessary details to be seen with ease, the quality of light is most important in providing good seeing conditions. The quality of illumination is dependent on these factors.	
Color of light	(1) Color of light or of reflecting surfaces.	
Direction of light	(2) Direction of light on the work.	
Amount of glare	(3) Amount of glare (direct or indirect) from surfaces in the field of vision.	
Brightness ratios	(4) Brightness and brightness ratios (contrasts).	
Amount of diffusion	(5) Amount of diffusion and uniform distribution of light in the field of vision.	

MODULE Illumination	NO. 25
NOTES	INSTRUCTION
Definition of glare Direct glare Reflected glare Reduction of glare: reorienting the light source; using diffused light Elimination of reflecting surfaces	All of these factors have significant effects on visibility and the ability to see easily, accurately, and quickly. B.2.a. Glare is defined as any brightness within the field of vision that causes discomfort, annoyance, interference with vision, or eye fatigue. When the condition is directly caused by the source of lighting, whether natural or artificial, it is referred to as <u>direct glare</u>. <u>Reflected glare</u> is caused by the reflection of high-brightness light sources on surfaces such as shiny desk tops, tile or high-gloss walls, metal equipment, glass, or any highly polished surface within the visual field. Reflected glare is frequently more annoying than direct glare, because it is so close to the line of vision that the eye cannot avoid it. Reflected glare may come from objects within the task itself or from other surfaces immediately surrounding the task. B.2.b. Elimination or reduction of glare may be accomplished by reorienting the light source relative to the working surfaces or relative to the worker's line of vision. But better than reorientation of the light source is the elimination of the high-brightness light and the use of a diffused, low-brightness luminaire. Another possibility for reducing glare is the elimination of the reflecting surfaces themselves. Where possible, shiny surfaces could be covered with a matte finish paint or some other material that will not glare. Desk tops that are too shiny could be covered with a non-reflective material, such as blotter paper. However, if the task itself involves looking at shiny, reflective objects, then the lighting itself will have to be changed to one of diffused light.

MODULE Illumination		NO. 25								
NOTES	INSTRUCTION									
Definition of brightness ratio	C. The brightness ratio, or luminance ratio, is the ratio between the photometric brightness of any two relatively large areas within the visual field. The brightness ratios within the environment should be carefully controlled, since the eyes function most comfortably and efficiently when the brightness of the environment is relatively uniform.									
Recommended brightness ratios: Visual 25-3	C.1. Visual 25-3 lists the recommended maximum luminance ratios for various visual areas within several types of environments. For example, the ratio of the luminances of the task and adjacent darker surroundings should not exceed 3 to 1 (where reflectance of surfaces can be controlled) and 5 to 1 in any case. A ratio of more than 40 to 1 should not be tolerated anywhere within the normal field of vision.									
Reflectance values for room surfaces	C.2. To aid in achieving the luminance ratios in Visual 25-3, the reflectance of room surfaces and equipment have been assigned recommended values as follows: <table><tr><td>Ceilings</td><td>80% to 90% reflectance</td></tr><tr><td>Walls</td><td>40% to 60% reflectance</td></tr><tr><td>Floors</td><td>over 20% reflectance</td></tr><tr><td>Desk and bench tops; machines and equipment</td><td>25% to 45% reflectance</td></tr></table>		Ceilings	80% to 90% reflectance	Walls	40% to 60% reflectance	Floors	over 20% reflectance	Desk and bench tops; machines and equipment	25% to 45% reflectance
Ceilings	80% to 90% reflectance									
Walls	40% to 60% reflectance									
Floors	over 20% reflectance									
Desk and bench tops; machines and equipment	25% to 45% reflectance									
Lighting maintenance	D. There should be a regularly scheduled system of maintaining the skylights, windows, lighting equipment, lamps, and room surfaces.									

NOTES	INSTRUCTION
Recommended guide to light loss factors: <u>IES Lighting Handbook</u> Lighting surveys Measurement of illumination, luminance, reflectance Measurement units	Luminaires should be kept in proper adjustment and in good repair. Even when this is done, illumination levels will drop 25% to 35% due to dust and air particles that accumulate under normal operating conditions. When illumination has decreased to two-thirds of its initial value, the lighting equipment should be washed. A thorough washing at least twice a year is recommended. In addition, the useful output of some lamps decreases with age long before they burn out. Therefore it is important that a regular maintenance program be set up whereby lamps and fixtures are cleaned, and dim or burned-out lamps replaced at suitable intervals. Guidance for the use of light loss factors in design and information on lighting maintenance can be found in the <u>Lighting Handbook</u>, 5th Edition, published by the Illuminating Engineering Society, New York, 1972. E. A lighting survey, beyond merely a visual inspection, involves the measurement of three essential quantities: (1) Illumination (measured in footcandles) (2) Luminance (measured in footlamberts) (3) Reflectance (measured as a percentage of the total luminance) The effectiveness of a lighting evaluation in an industrial environment depends upon the amount and type of information obtained during survey procedures and on the evaluator's knowledge and understanding of the industrial operations, the workers' habits and visual tasks, and the recommended good lighting characteristics as applicable to the work situation. E.1. In making a lighting study or survey the following units of measurement are employed:

NOTES	INSTRUCTION
Illumination/footcandles	(1) Illumination is measured in footcandles. One footcandle = 1 lumen/square foot. (One lumen = intensity of one standard candle.)
Luminance/footlamberts	(2) Luminance is the density of light emitted by a lamp or reflected by a surface in a given direction. It is measured in footlamberts. (One footlambert = $1/\pi$ candle per square foot.) A theoretical, perfectly diffusing surface emitting or reflecting flux at the rate of one lumen per square foot would have a luminance of one footlambert in all directions. (3) Luminance = illumination times reflectance.
Instrumentation	E.2. The two instruments used to obtain the necessary lighting measurements are (1) an illumination or light meter and (2) a luminance or brightness meter.
Light meters	Several kinds of color-corrected light meters are commercially available with cosine correcting elements. For highly accurate illumination measurements, special low-range sensitive and multi-cell light meters are commercially available.
Brightness meters	The most commonly used brightness meter has a battery operated internal light source, making it a self-contained unit. With it, the brightness of any surface can be measured within a range of 0.0025 to 50,000 footlamberts. The instrument has two eyepieces. One is a focusing telescope that is sighted on the surface to be measured. In the center of this field are a pair of silvered trapezoids, illuminated to a constant brightness by the internal light source. The brightness of the background is adjusted with a circular gradient filter until it matches the trapezoids in brightness. The second eyepiece views a scale that rotates with the gradient filter.

MODULE Illumination	NO. 25
NOTES	INSTRUCTION
	At the proper setting of the filter, the brightness can be read directly from the scale.

MODULE Illumination	NO. 25
NOTES	INSTRUCTION
<u>Summary of Key Points</u>	<u>SUMMARY OF KEY POINTS</u> A. The provision of good lighting in industry is essential to the accomplishment of work. It is also essential to the safety of workers and to the maintenance of good house-keeping. It is a factor of primary importance in every industrial environment. B. There are two broad characteristics that must be considered in the design of good illumination for a given task: the quantity and the quality of lighting in the visual field. C. Lighting specifications should exceed what may be considered as normal. D. When deciding on the amount of light needed, we must not only consider the task to be performed, but also the individual performing the task. E. Besides individual visual capability, the four factors that determine the quantity of illumination necessary are: (1) size of object being viewed. (2) time available to perform the task. (3) contrast between detail of the task and immediate surroundings. (4) brightness level to which the object is illuminated. F. The quality of light is dependent of five factors: (1) color of light or of reflecting surfaces. (2) direction of light on the work. (3) amount of glare from surfaces in the field of vision. (4) brightness and brightness ratios. (5) amount of diffusion and uniform distribution of light in the field of vision.

MODULE	NO. 25
Illumination	
NOTES	INSTRUCTION
	G. Glare is defined as any brightness within the field of vision that causes discomfort, annoyance, interference with vision, or eye fatigue. H. Elimination of glare may be accomplished by reorienting the light source relative to the working surfaces or relative to the worker's field of vision; or by eliminating high-brightness light and replacing it with low-brightness, diffused luminaires. I. The brightness ratio, or luminance ratio, is the ratio between the photometric brightness of any two relatively large areas within the visual field. J. There should be a regularly scheduled system of maintaining the skylights, windows, lighting equipment, lamps, and room surfaces to keep them clean. K. A lighting survey involves the measurement of illumination, luminance, and reflectance. L. The two instruments used to obtain the necessary lighting measurements are an illumination or light meter, and a luminance or brightness meter.

EXERCISES

1. An illumination survey of an office shows desk tops to have a luminance of 80 footlamberts. The illumination level in this office is 120 footcandles on the desk surfaces. What is the reflectance of these desk tops, and what recommendation should be made?

- _____ (1) 67% reflectance. This is satisfactory.
- _____ (2) 67% reflectance. Reflectance of the desk tops should be reduced to between 25% and 45%.
- _____ (3) 67% reflectance. The illumination level should be reduced to 100 footcandles as recommended for offices.
- _____ (4) 67% reflectance. This is too high. Desk tops should be resurfaced with a glossy varnish.

2. Levels of illumination were measured at various work surfaces in a shop as follows:

<u>Work Area</u>	<u>Footcandles</u>
_____ (a) Packing area	50
_____ (b) Drafting table	100
_____ (c) Small lathe	75
_____ (d) Polishing wheels	100
_____ (e) Sewing machine	150

Which of these tasks do you suspect to be inadequately illuminated?

3. A workman has difficulty in performing fine, detail work in the pattern-making shop. Other craftsmen have hardly any difficulty when doing the same task. The illumination on all surfaces in the room is 75 footcandles, including the location where fine detail work is done. What do you suggest should be done about the workman who has difficulties?

- _____ (1) Transfer the workman to another job.
- _____ (2) Ask the workman to get new glasses.
- _____ (3) Install supplemental lighting in this man's work area.

- _____ (4) Increase the general lighting to a level of 100 foot-candles.
- _____ (5) Shield or shade this man's task from reflected glare sources, if any.

NOTES	INSTRUCTION
<u>Discussion</u>	<u>DISCUSSION</u> 1. In the exercises you have just completed, explain the recommendation you made in problem 1. Why is the third recommendation unsatisfactory? In problem 3, explain why the worker himself should not necessarily be required to get new glasses or switch to another job. What would be the effect if suggestion number 4 were followed? 2. At your place of business, do you have some processes that require fine, detailed handwork? What are those processes or tasks? What kind of lighting is presently installed? Do you think it is adequate? How would you check it to be sure it <u>is</u> adequate? 3. Has a lighting survey ever been conducted at your place of work? Describe how it was conducted. What kinds of measurements were taken? Where (in which shops or work areas) were the measurements taken? What were the results of the survey? What was done to correct inadequate lighting? 4. In the past several years, as our technology and knowledge of visual requirements have increased, many changes have taken place with respect to lighting. Explain the reasons for the following changes: (a) In schools, blackboards have become green. (b) In hospital operating rooms, doctors and nurses now wear green, blue, and beige uniforms rather than white. Brushed and stainless steel fixtures have replaced chrome.

MODULE Illumination	NO. 25
NOTES	INSTRUCTION
	(c) The old incandescent street lamps have been replaced by lamps that give off a bluish glow; and some of these bluish lamps have been replaced with sodium lamps that give off a pinkish glow. (d) New overhead stop-lights are surrounded with a black "frame" on the sides. (e) Flourescent lights have replaced standard lightbulbs in offices and factories. Name some other lighting or visual changes that have occurred in recent years and explain why you think they were made.

**LEVELS OF ILLUMINATION
CURRENTLY RECOMMENDED**

Area	Footcandles on Tasks*
Clothing manufacture (men's)	
Receiving, opening, storing, shipping	30
Examining (perching)	2000**
Sponging, decating, winding, measuring	30
Piling up and marking	100
Cutting	300**
Pattern making, preparation of trimming, piping, canvas and shoulder pads	50
Fitting, bundling, shading, stitching	30
Shops	100
Inspection	500**
Pressing	300**
Sewing	500**

*Minimum on the task at any time.

**Can be obtained with a combination of general lighting plus specialized supplementary lighting. Care should be taken to keep within the recommended luminance ratios. These seeing tasks generally involve the discrimination of fine detail for long periods of time and under conditions of poor contrast. The design and installation of the combination system must not only provide a sufficient amount of light, but also the proper direction of light, diffusion, color and eye protection. As far as possible it should eliminate direct and reflected glare as well as objectionable shadows.

Source: NIOSH, The Industrial Environment—Its
Evaluation & Control, 1973, p. 350.

Visual 25-1

**MINIMUM* LEVELS OF ILLUMINATION RECOMMENDED
FOR TYPICAL TASKS**

<u>Industrial Tasks</u>	<u>Footcandles on Task</u>
Easy, large assembly work -----	30
Rough bench and machine work -----	50
Medium bench and machine work, rough grinding buffing and polishing, general fine inspection	100
Color inspection, highly difficult inspection grading and evaluation, finishing -----	200
Fine machine and bench work, fine polishing, sewing, very difficult inspection -----	500
Extra fine machine and bench work, welding, extra fine assembly, most difficult inspection	1000
 <u>Office Tasks</u>	
Corridors, elevators, escalators, stairways ----	20
Reading high contrast or well printed material, tasks and areas not involving critical or prolonged seeing such as conferences, interviews, inactive files and washrooms -----	30
Reading or transcribing handwriting in ink or medium pencil on good quality paper, intermittent filing -----	70
Regular office work, reading good reproductions, reading or transcribing handwriting in hard pencil or on poor paper, active filing, index references, mail sorting -----	100
Accounting, auditing, tabulating, bookkeeping, business machine operation, reading poor reproductions, proofreading, rough layout drafting -----	150
Cartography, designing, detailed drafting ----	200

* Minimum on task at any time

Source: ANSI A 11.1 1965 (R 1970) and ANSI A 132.1 1966.

**RECOMMENDED MAXIMUM
LUMINANCE RATIOS**

	Environmental Classification		
	A	B	C
1. Between tasks and adjacent darker surroundings	3 to 1	3 to 1	5 to 1
2. Between tasks and adjacent lighter surroundings	1 to 3	1 to 3	1 to 5
3. Between tasks and more remote darker surfaces	0 to 1	20 to 1	*
4. Between tasks and more remote lighter surfaces	1 to 10	1 to 20	*
5. Between luminaires (or windows, skylights, etc.) and surfaces adjacent to them	20 to 1	*	*
6. Anywhere within normal field of view	40 to 1	*	*

*Luminance ratio control not practical.

A—Interior areas where reflectances of entire space can be controlled in line with recommendations for optimum seeing conditions.

B—Areas where reflectances of immediate work area can be controlled, but control of remote surround is limited.

C—Areas (indoor and outdoor) where it is completely impractical to control reflectances and difficult to alter environmental conditions.

Source: NIOSH, The Industrial Environment—Its Evaluation & Control, 1973, p. 351.



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Heat Stress **NO. 26** **TIME:** 50 Minutes

Causes and effects of occupational exposures to heat and what to do about them.

Objectives. Enable the trainee to recognize, use with assistance, and recall factors and formulas related to heat stress.

Content.

- Adaptive Temperature Range
- Heat Physiology
- Biologic Effects
- Metabolic Processes
- Heat Stress Factors
- Heat Exchange Factors
- Criteria for a Recommended Standard

Methods. Lecture and Group Study/Discussion

Materials.

- Chalkboard, chalk, and eraser
- Visuals 26-1 through 26-4
- Case Studies (Supplements in this Module)

Special Terms. Environmental measurements and related terms

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapter 8, pp. 276 - 299.
2. Industrial Environment - Its Evaluation & Control. Chapters 30, 31, and 38.
3. Industrial Toxicology. Volume I, Chapter XXI.
4. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments. Washington, D. C.: U. S. Government Printing Office, 1972.

Other References

1. McCormick, E. J. Human Factors Engineering. New York: McGraw-Hill Book Company, 1970.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

Heat stress is a problem that most of us have experienced in our personal life, if not on the job.

This module will move very quickly from some general and familiar background information to the specifics of expressing and measuring heat stress in terms of equations.

At this point in your course, you should be able to refer directly to technical reports as your major source of information about topics of interest to industrial hygienists. Therefore, we will use the NIOSH criteria document on hot environments for the last part of the explanation-lecture and subsequent discussion.

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
<u>Explanation - Lecture</u>	<u>EXPLANATION - LECTURE</u>	
Adaptive range	A. Human biologic systems adapt to a rather narrow range of environmental temperatures. Humans function best at environmental temperatures between 65 and 85°F., with a relative humidity between 40 and 60%.	
Work ability	Our ability to work diminishes rapidly above temperatures of 90°F.	
Biologic stresses	Biologic stresses begin to develop above 95°F. Acute manifestations include heat exhaustion, dehydration, heat cramps, or heat stroke.	
Chronic signs	Chronic signs include fatigue, irritability, reduced resistance to disease, and nervous tension.	
Degree and duration	As with toxic agents, the extent of health damage is a function of degree of heat stress and duration of exposure.	
Environmental influences	The thermal environment is influenced by air temperature, air movement, humidity, and long wave radiation.	
Heat physiology	B. The body is basically a heat exchange system. There are a number of mechanisms that attempt to maintain a constant body temperature of 98.6°F. The two primary mechanisms are blood flow and sweat.	
Blood flow	B.1. Blood carries heat from the interior of the body, where it is produced, to the surface of the skin, where heat transfer occurs. The rate of blood flow increases as body temperature rises. Also, blood vessels on the surface of the skin dilate to aid in the dissipation of heat.	

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
Sweat	B.2. Sweating assists the body in heat loss by evaporation. Movement of air over the body evaporates the sweat and results in a cooling effect. Sweat rates should not exceed about a liter per hour for several hours a day, since sweating drains the water and salt balance of the body. When the water is not replaced, dehydration can occur, with serious physiological and clinical consequences.	
Heat input and output	C. If heat input is greater than heat output, or if the body's defenses fail to function properly, physiological breakdown and severe illness may occur. The four major types of heat-induced illness are heat exhaustion, dehydration, heat cramps, and heat stroke.	
Heat exhaustion	C.1. Heat exhaustion is a state of collapse caused by insufficient blood supply to the cerebral cortex. Heat exhaustion results from dilation of the blood vessels. The critical event is a low arterial pressure, caused from an inadequate output of blood by the heart.	
Dehydration	C.2. Dehydration, caused by water loss, reduces blood volume and promotes heat exhaustion. Signs of dehydration include muscular inefficiency, reduced secretion of body fluids, loss of appetite and nervous irritability. In extreme cases, it disturbs normal cell functions and thereby promotes body deterioration. Unless corrected by fluid intake, dehydration may result in fatal uremia and high fever.	

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
Heat cramps	C.3. Heat cramps are spasms in the voluntary muscles due to critical losses of sodium chloride in the blood. Heat cramps can usually be prevented by adding extra salt to the diet whenever heavy work is to be performed in hot environments. Maintaining fluid balance is, of course, the objective.	
Heat stroke	C.4. Heat stroke or hyperpyrexia occurs when the mean temperature of the body is so high that vital functioning is endangered. Heat stroke is the most serious condition resulting from heat exposure. It represents a marked failure of the body's regulating mechanisms to maintain a proper balance between heat input and output. Body temperature between 108° and 112°F. exceeds the critical value. The cause of tissue damage is probably a combination of protein denaturation, enzyme degradation, alterations in the physical structure of the cell membranes, and changes in the viscosity of cellular protoplasm.	
Metabolic processes	D. The body obtains energy from the conversion of chemical energy in foods to heat energy. Heat generated by this oxidation process is called metabolic heat. The body is a low thermal efficiency engine, as only about 25% of the available heat energy is converted to useful work. The remaining 75% is dissipated in the surrounding environment.	

MODULE Heat Stress		NO. 26																		
NOTES	INSTRUCTION																			
Heat and work	D.1. The heat generated is a function of work being done. The metabolic heat produced by a normal adult at rest is about 300 BTUs or 75 kilocalories (Kcal) per hour. During hard physical labor, this heat may reach 3000 BTUs or 750 Kcal per hour.																			
Body temperature	D.2. In normal healthy individuals, body temperature varies with physical activity, time of day, heat input and output, and heat storage. In normal thermal environments, the body can easily dissipate the excess heat through convection and evaporation. However, if heat is produced in excess, or if external thermal conditions are adverse, body stress occurs.																			
Heat storage	D.3. The body has limited capacity to store excess heat without causing serious biologic abnormalities. Body temperatures over 102°F. indicate excessive heat storage. Temperatures of 105°F. or greater will be fatal if immediate corrective action is not taken. The following chart shows the relationship between body temperature, stress, and condition in normal people. <table border="1"> <thead> <tr> <th>Body Temperature</th> <th>Stress</th> <th>Condition</th> </tr> </thead> <tbody> <tr> <td>98.6° F. (oral)</td> <td>None</td> <td>Core</td> </tr> <tr> <td>97 to 99° F.</td> <td>None</td> <td>Normal Range</td> </tr> <tr> <td>99 - 102° F.</td> <td>Mild</td> <td>Discomfort</td> </tr> <tr> <td>102 - 105° F.</td> <td>Severe</td> <td>Disease</td> </tr> <tr> <td>105° F. and above</td> <td>Critical</td> <td>Death</td> </tr> </tbody> </table>		Body Temperature	Stress	Condition	98.6° F. (oral)	None	Core	97 to 99° F.	None	Normal Range	99 - 102° F.	Mild	Discomfort	102 - 105° F.	Severe	Disease	105° F. and above	Critical	Death
Body Temperature	Stress	Condition																		
98.6° F. (oral)	None	Core																		
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102 - 105° F.	Severe	Disease																		
105° F. and above	Critical	Death																		

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
Heat exchange	E. The human body is essentially a heat exchange machine. Analogies can be drawn between the human body and a hypothetical machine. The heart is a pump and the blood is heat transfer fluid. Blood vessels are like movable coils that dilate and cause a greater flow of blood to the surface of the skin. The sweat mechanism is similar to a spray cooling system. Let's examine this machine concept in more detail.	
Heat machine	Refer to the description of the heat machine in the Supplements.	
Heat stress equation	E.1. Factors affecting heat stress in the human body can be expressed in an equation. Relationships between the cause and effect of heat stress can be shown in an equation, where H = Heat gain or loss M = Metabolic heat C = Heat transfer R_1 = Radiant heat R_2 = Solar heat E = Heat loss by evaporation	
Environmental changes	E.2. The effect of changes in the thermal environment on the human body can be expressed as plus (+) or minus (-) operations in the heat stress equation.	

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
	Let's explore this concept with some specific examples.	
Case 1	See Case 1 in the Supplement.	
Case 2	Case 2.	
Case 3	Case 3.	
Case 4	Case 4.	
Environmental factors	F. Heat exchange is affected by factors other than the temperature of the thermal environment. The preceeding discussion has identified environmental factors that influence the heat exchange process. Let's discuss each of these briefly. Note that there is more than one kind of temperature reading to be considered.	
Dry bulb temperature	F.1. Dry bulb temperature (DB) is a measure of temperature only. DB affects heat exchange primarily through convection. Air temperatures below body temperatures result in loss of body heat to the surrounding atmosphere. Air temperatures above body temperatures result in body heat gain. The sweat mechanism begins to work at about DB 75°F.	
Wet bulb temperature	F.2. Wet bulb temperature (WB) also measures the humidity in the atmosphere. WB has little effect on heat exchange at normal temperatures. However, at elevated temperatures, humidity has a very significant effect on comfort and physiologic tolerance.	

NOTES	INSTRUCTION
Effective temperature NIOSH, p. 419. Formula applications	F.7. Dry and wet bulb temperatures can be combined with air movement into an effective temperature index. This index is illustrated in your basic NIOSH reference on page 419. The effective temperature index was developed primarily as a comfort indicator for people in sedentary occupations. It has been used by some investigators for predicting heat stress, but it is not a reliable indicator for conditions involving heavy work. When radiant heat is omitted, the important factors in determining comfort are wet and dry bulb temperatures plus air movement. Obviously one is more comfortable at DB 90°F. and WB 65°F. (relative humidity of 25%) than at DB 90°F. and WB 80°F. (relative humidity of 65%). Not all individuals feel comfortable at the same effective temperature. Most people feel comfortable at an effective temperature of 70°F. Above an effective temperature of 75°F., the ability to perform hard work decreases rapidly. The effective temperature index was developed primarily as a comfort indicator for persons working under sedentary conditions. Although the index has been used in the past by some investigators for predicting heat stress conditions, it is not a reliable indicator for heavy work conditions. G. The heat stress formula is difficult to apply under field conditions. Application of the heat stress formula involves a number of complicated measurements, such as body and skin temperatures, sweat rate, and environmental conditions. Some predictive tables for metabolic heat production and sweat loss are available, but these do not simplify explication of the formula under actual work conditions.

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
Break into groups.	Break up into four groups. Each group will be responsible for reading a part of the criteria document and summarizing the highlights for the class.	
Group 1	Group 1 will take Part I about the standards. Be sure you cover environmental measurements in your presentation.	
Group 2	Group 2 will take Part III on biologic effects. Your presentation should focus on work performance under heat stress.	
Group 3	Group 3 will take Part IV. Your presentation should cover the five methods of heat stress control.	
Group 4	Group 4 will take Part V and highlight the considerations for a recommended standard.	
	Each group will have 10 minutes to prepare and 5 minutes to report.	

NOTES	INSTRUCTION
<u>Summary</u>	<u>SUMMARY OF KEY POINTS</u> A. Human biologic systems adapt to a rather narrow range of environmental temperatures. B. The body is basically a heat exchange system. C. If heat input is greater than heat output, or if the body's defenses fail to function properly, physiological breakdown and severe illness may occur. D. The body obtains energy from the conversion of chemical energy in foods to heat energy. E. The human body is essentially a heat exchange machine. F. Heat exchange is affected by factors other than the temperature of the thermal environment. G. The heat stress formula is difficult to apply under field conditions.

MODULE Heat Stress		NO. 26
NOTES	INSTRUCTION	
<u>Supplements</u>	<u>SUPPLEMENTS</u> The following pages illustrate the development of the heat stress equation.	

The Heat Machine

Assume there is a heat-producing machine in which the internal source of heat is due to the conversion of chemical energy to heat energy.

The problem faced by the engineer is to maintain the core temperature of the machine at 98.6° F. , with deviations no greater than $\pm 2^{\circ}\text{ F.}$

Deviations to any extent above 98.6° F. result in some stress on the machine. Deviations greater than 2° F. result in complete failure.

The machine is enclosed in a fairly large room with a fixed thermal environment. Sufficient air is introduced into the room to compensate for the heat gain or loss by the machine.

To maintain a constant temperature, the machine has a pump in the core which circulates a heat exchange fluid so that all eight sides of the enclosure become a heat exchange area.

A unique feature of the heat exchange coils is that they adjust automatically. They are closer to the surface when it is necessary to dissipate heat and closer to the interior when conservation of heat is essential. In addition, an automatic system sprays water on the machine whenever the core temperature exceeds 98.6° F.

The heat generated by the conversion of chemical energy to heat energy will be designated as M for metabolic heat. The heat loss or gain by the machine will be designated as H.

Case 1. External Thermal Environment of 75° F.

Refer to Visual 26-1.

The heat of the machine is greater than that of the environment, so the flow of heat is from the machine to the environment.

The pump is moving the heat exchange fluid at the rate of 1 X liters/minute. The coils have automatically adjusted so that the heat being dissipated by convection and conduction is equal to M. The greater proportion of the transfer is by convection.

The transfer of heat will be designated as C. Since the heat input is equal to the heat loss, the machine is not under stress. Thus, we can establish the heat transfer equation as :

$$H = M - C$$

If Case 1 is modified by adjusting the thermal environment to 40° F, there is an increased heat loss due to convection. Under this condition, the coils are moved toward the interior and the pump slows the circulation of heat transfer fluid to 0.75 X liters/minute. This readjustment permits the heat loss to be equal to the heat generated, so the machine is still in a no-stress condition.

A severe modification of the case is made when the external thermal environment is reduced to 0° F. Despite a significant adjustment of the coils away from the surface, the heat loss by convection is much greater than the heat generated. This causes the core temperature to drop, producing severe stress.

Conditions have now exceeded the limits of the machine to compensate and failure will result unless an outside force intervenes. The engineer could provide an insulating blanket to reduce the amount of heat being lost by convection and restore the machine to an equilibrium condition.

Case 2. External Thermal Environment of 100° F.

Refer to Visual 26-2.

The external environment is greater than the desired temperature of the machine, so there can be no heat loss by convection. In fact there will be a heat gain.

In an attempt to compensate for this condition, the pump rate increases to 1.25 X liters/minute. The coils move as close to the surface as possible to increase heat dissipation.

Despite these adjustments, the core temperature of the machine will gradually increase to 100 ° F and a mild stress condition will result.

Obviously, the stress on the machine increases in direct proportion to the external environment. C becomes a positive value, because of heat gain by the machine. The equation must be modified to reflect C as either a positive or negative value, so it becomes:

$$H = M \pm C$$

Case 3. External Thermal Environment of 110° F.

Refer to Visual 26-3.

The external thermal environment is such that there will be a constant gain by the machine until very soon its upper limits of tolerance will be exceeded.

The machine will compensate to its maximum extent, but failure is inevitable unless an external factor reduces the heat gain.

The automatic spray system operates when the core temperature exceeds 98.6° F. In this system, the excess heat from the machine goes into heat of evaporation. Therefore, another factor can be added to the heat transfer equation. If heat loss by evaporation is E, the equation becomes:

$$H = M \pm C - E$$

There is still another factor to be considered. If there is no air movement around the machine, the air will soon become saturated with water vapor and heat loss by evaporation will begin to approach zero. A constant flow of air will prevent saturation and allow the evaporative effect.

The rate of evaporation is a function of the relative humidity and the rate of air flow over the machine.

Case 4. External Thermal Environment of 85° F.

Refer to Visual 26-4.

An adjacent industrial process causes one wall of the enclosure to be heated.

A heated wall emits heat in the form of long wave radiation. This heat is transmitted through the atmosphere without absorption.

Heat is exchanged by radiation between a heated surface and other objects at a lower temperature in its surroundings.

The amount of heat absorbed by the cooler object is a function of the distance and the temperature differential between the two objects.

The intensity of radiant heat emitted by heated objects increases as the fourth power of its absolute temperature. Thus, a wall at 200° F would radiate approximately two times more heat than a wall at 100° F.

$$(460 + 200)^4 / (460 + 100)^4$$

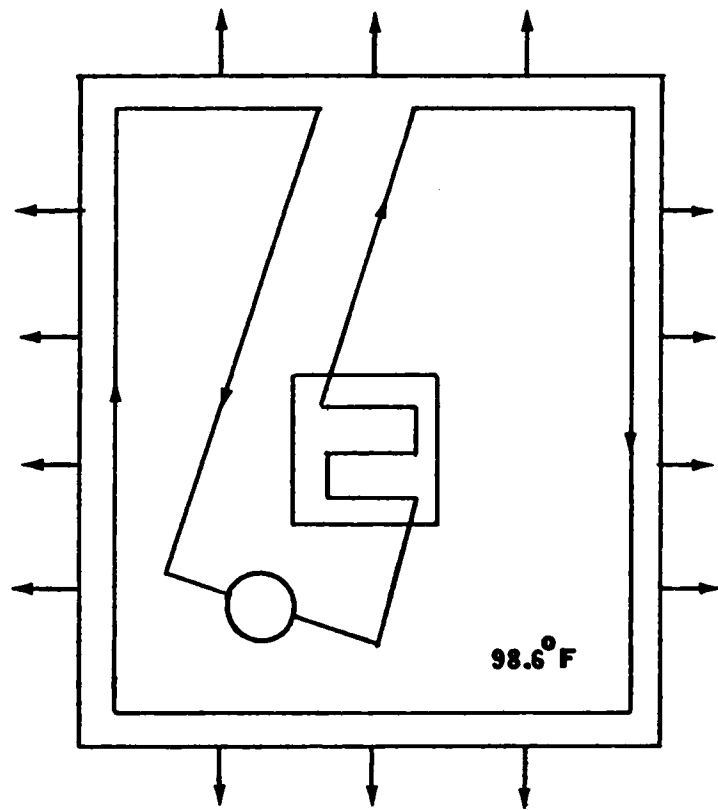
The amount of radiant heat received by an object can be critical. Since our machine is absorbing radiant heat, another factor can be added to the equation. With radiant heat designated as R_1 , the equation now becomes:
 $H = M \pm C - E \pm R_1$

The value of R_1 must be either positive or negative, since the object could be gaining or losing heat by radiation.

If the machine is exposed to solar radiation, this factor would also have to be added. The final equation becomes:

$$H = M \pm C \pm R_1 + R_2 - E$$

CASE 1

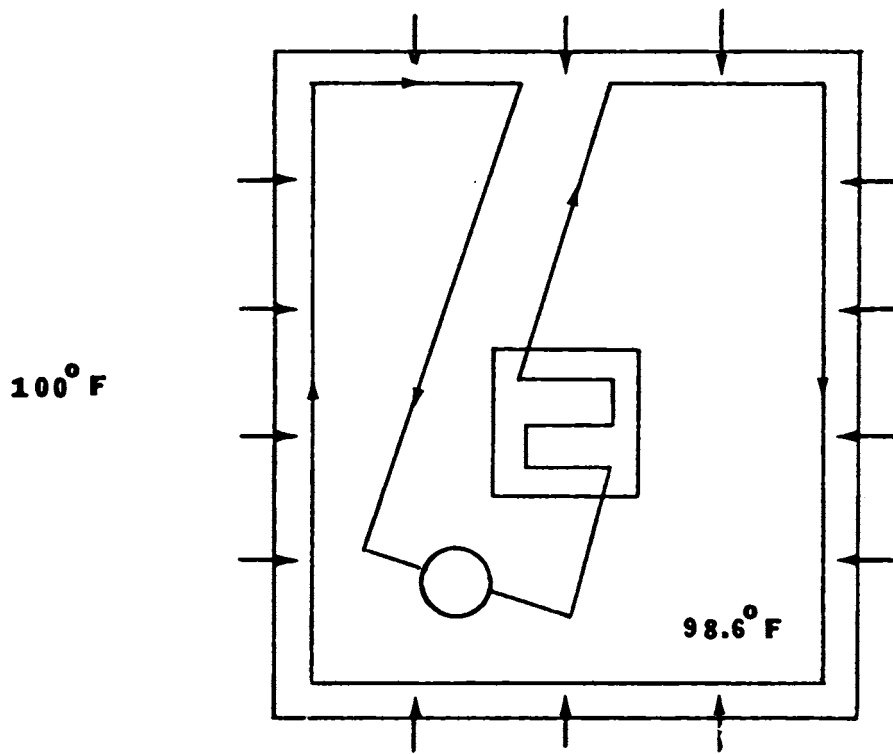


$$H = M - C$$

HEAT LOSS BY CONVECTION

Visual 26-1

CASE 2

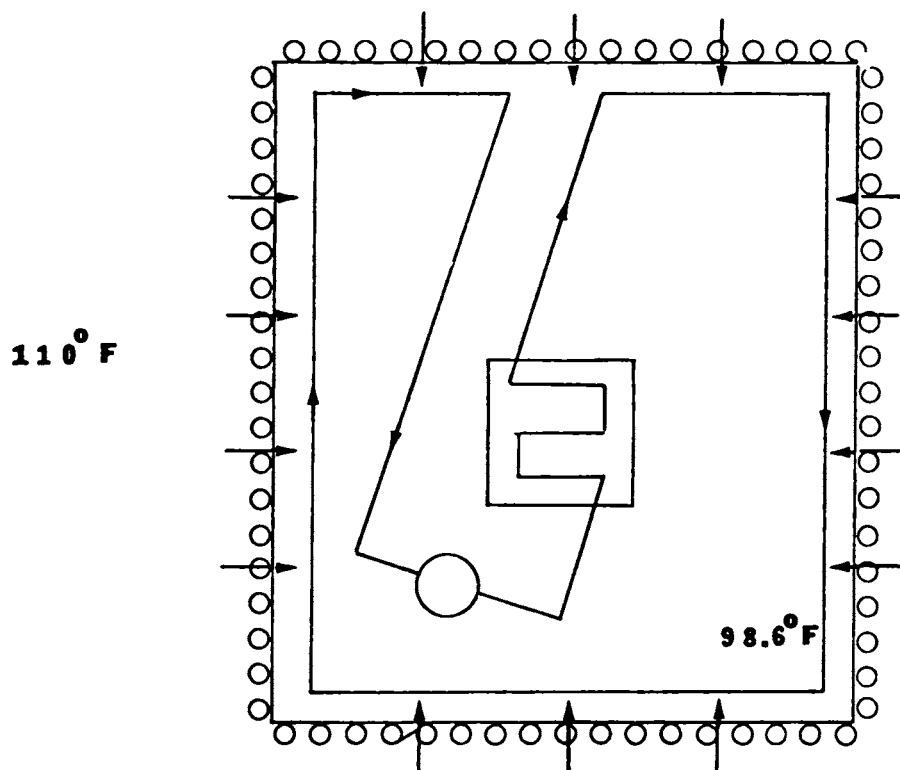


$$H = M - C$$

HEAT GAIN BY CONVECTION

Visual 26-2

CASE 3

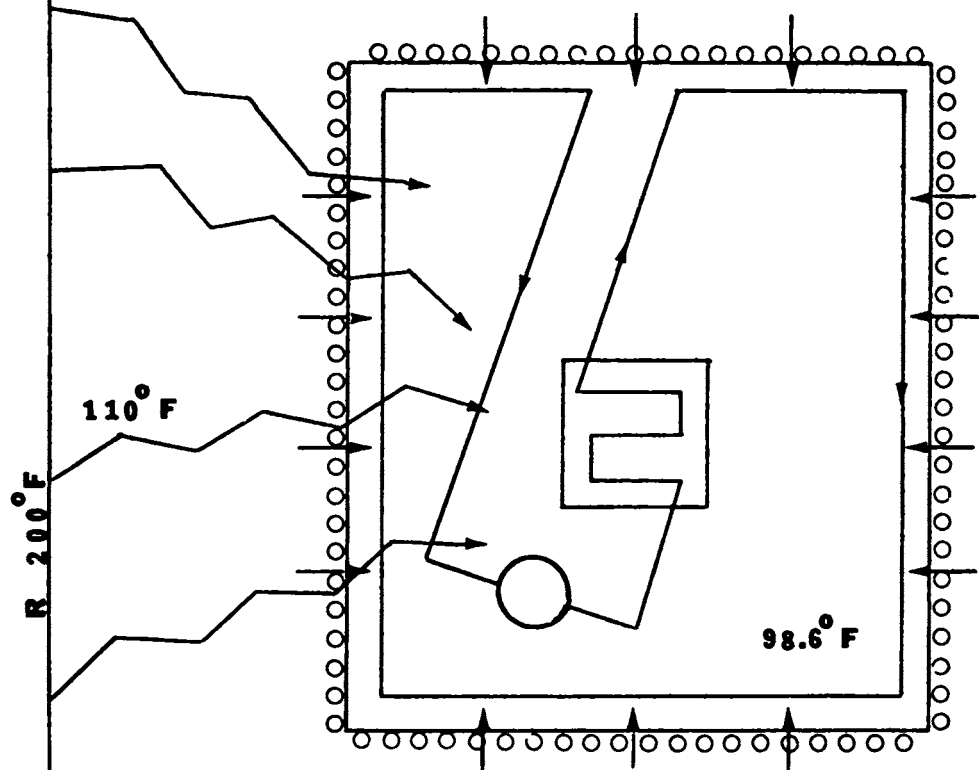


$$H = M \pm C - E$$

HEAT LOSS BY EVAPORATION

Visual 26-3

CASE 4



$$H = M \pm C - E \pm R$$

HEAT GAIN BY RADIANT HEAT

Visual 26-4



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Occupational Cancer NO. 27 TIME: 50 Minutes

Occupational exposure to carcinogenic substances must be severely restricted in order to prevent workers from developing cancer while on the job.

Objectives.

Enable the trainee to:

Understand the nature of cancer;
Recognize occupational hazards that may be cancer-inducing;
Use preventive measures to limit the possibilities for development of occupational cancer among workers.

Content.

History of occupational cancer
Characteristics of cancer
Cancer induction
Types of industrial carcinogens
Prevention of occupational cancer
Industrial medical surveillance of workers

Methods.

Lecture, Exercises, and Discussion

Materials.

Chalkboard, chalk, and eraser

Special Terms.

Aromatic amine	DNA
Bis-chloromethyl ether	Mesothelioma
Cancer	Occupational cancer
Carcinogen	Polycyclic hydrocarbon
Co-carcinogen	Precancerous lesion
Cytology	RNA
Cytopathologist	

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Pages 417, 606, 625, and 868.
2. Industrial Environment - Its Evaluation & Control. Chapter 34, pp. 503 - 510.
3. Industrial Toxicology. Volume I, Chapter XIV, pp. 468 - 469.
4. OSHA Act, 1970.
5. OSHA Regulations, June 27, 1974.
6. TLVs[®]: Threshold Limit Values, 1973.

Other References

1. Lloyd, J. W. "Long-Term Mortality Study of Steelworkers--Respiratory Cancer in Coke Plant Workers." Journal of Occupational Medicine, 13:53-68, 1971.
2. Selikoff, I. J.; Hammon, E. C.; Churg, J. Mortality Experience of Asbestos Insulation Workers. Republic of South Africa: Department of Mines, International Conference on Pneumoconiosis, 1969, pp. 97-103.
3. Shimkin, M. B. Science and Cancer. Public Health Service Publication 1161. Washington, D. C.: U. S. Government Printing Office, 1969.

NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> Cancer is one of the most prevalent and most potent diseases in our industrialized society. It kills almost as many people as does heart disease, and it can attack any organ, tissue, or fluid in the human body. Scientists have been working for years to find a cure for cancer. Although many facts about the disease have come to light, medical research has not yet discovered the cause of cancer or any sure-fire remedy for the disease. The various types of cancer are classified according to the organ(s), tissue(s), or fluid(s) that become cancerous. Leukemia, for example, is a general term for cancer of the blood--and there are many sub-types of leukemia. You have undoubtedly heard of skin cancer, lung cancer, breast cancer, cancer of the lymphatic system, bone cancer, and cancer of the liver, bladder, intestines, stomach, mouth, and uterus. The list could go on and on. Some types of cancer are rare, while others occur quite often. But all types of cancer have one thing in common--they involve body cells that literally go haywire. For reasons as yet unknown, some normal body cells suddenly become pathogenic. They start growing and multiplying all out of proportion to their normal state. This rapid, malignant growth of cells usually results in tumors that crowd out and destroy the surrounding healthy cells. If this abnormal growth is not stopped, the result can be, and often is, death. At the present time, the medical profession has very few weapons with which to combat cancer. The most common techniques for stopping the spread of this disease are surgical (removal of the tumor or cancerous tissue), chemical therapy (halting the cancer by killing the malignant cells with chemical agents), and radiation therapy (killing the cancer by bombarding malignant cells with radioactive particles).

NOTES	INSTRUCTION
	Unfortunately, none of these methods are fool-proof. Once a person has developed a cancer, there is no way that the medical profession can insure a complete or permanent recovery. In some cases the cancer is permanently halted; in other cases it crops up again after several months or years to attack the same or a different area of the body. There are strange aspects to this disease that doctors still do not understand. Why, for example, do some people develop cancer over and over again, while others are never touched by it? Why is it that some people who develop cancer subsequently have a spontaneous remission of the disease, wherein the cancer disappears completely of its own accord? And why do some substances seem to be carcinogenic--able to induce cancerous growth--while other substances seem to be harmless? These are all questions that only future medical research can answer. Once the causes of the disease are known, it may be possible to prevent it through inoculation or some other method. Meanwhile, the best we can do is to take care that we don't expose ourselves to substances already known to be carcinogenic. Let's take a look at some of the occupational hazards that can induce cancer, and discuss ways and means to prevent workers from acquiring the disease while on the job.

NOTES	INSTRUCTION
<u>Explanation - Lecture</u>	<u>EXPLANATION - LECTURE</u>
History of occupational cancer	A. The occurrence of occupational cancer has been known since 1775. In that year, an English physician, Sir Percivall Potts, identified an excessive incidence of scrotal cancer among chimney sweeps. Since then, many other chemical agents have been proved to be or implicated as carcinogenic compounds. Within recent years, asbestos, a material in industrial use for many centuries, has been associated with an increased incidence of lung cancer and mesothelioma, a rare form of cancer of the pleura. In fact, some investigators are able to associate a large percentage of non-occupational mesothelioma cases with a past exposure to asbestos. Even more recent studies substantiate excessive rates of respiratory cancer among coke plant workers in steel manufacturing and among workers exposed to bis-chloromethyl ether.
Occupational cancer shown to be a significant cause of death	A.1. As further research is undertaken, it becomes evident that occupational cancer may be a significant cause of mortality in many occupations.
Problems of differentiating occupational from non-occupational cancer	Epidemiologic studies of occupational cancer present many investigational difficulties, among these being that cancer occurs in the entire population, and those which may be occupational in origin are pathologically similar to those in which there is no occupational component. Therefore, proof of an occupational factor is related to an excessive incidence of a specific site cancer in an occupational group or within a particular industry. As man's total environment becomes more complicated, especially community air pollution, and with the growing number of chemical food additives, the etiology of specific site cancers also becomes more obscure and complex. Just as pneumoconiosis has been the focus of occupational health research for the last half century, occupational cancer will probably receive even greater attention during

NOTES	INSTRUCTION
History of occupational cancer since 1900	the next half century. With the advent of disability insurance plans and a national social security system, epidemiologic investigators now have a unique opportunity to determine cancer rates in various occupational groups. Studies involving the use of such records are underway in the United States.
	A.2. The prevalence of occupational cancer was first demonstrated in industries using coal tar products.
	Other than scrotal cancer among chimney sweeps, there was little evidence until about 1900 that other occupational cancers were a major cause of morbidity among industrial workers. At about the turn of the century investigators, especially in Switzerland and Germany, began to collect evidence that occupational bladder cancer was prevalent among workers in industries using coal tar products as an intermediate for the manufacture of chemicals, especially dyes. Further research in practically all of the major industrial countries following World War I demonstrated high rates of so-called aniline tumors among dye workers and others exposed to coal tar intermediates.
	Since World War II, it has become apparent that many chemical agents are either cancer producers or have carcinogenic potentials. Indeed, it is feared by some investigators that occupational cancer may be much more important in occupational mortality than is generally suspected. Limited studies of mortality rates among industrial workers are showing an excessive number of cancer deaths in many occupational groups. However, except in a few cases, insufficient epidemiologic evidence is available to definitely relate these increased rates to occupational factors.
Definition of cancer	B. Cancer is a disorientation of cells and can occur in any organ or tissue of the body. It is characterized by unrestricted growth of cells which invade and destroy contiguous tissue.

NOTES	INSTRUCTION
Synonyms for the term "cancer"	Frequently, a synonym is used such as malignant tumor or malignant neoplasm, or the term may describe the body tissue of origin, such as carcinoma, sarcoma, melanoma, or lymphoma.
Action of cancerous cells within the body	Cancer can arise in any organ or tissue of the body. Its abnormal growth, with the resultant mass, compresses, invades, and destroys normal tissues. Cancer cells then break off or leave the original mass and are carried by the blood or lymph to distant sites of the body. There they set up secondary colonies, or metastases, further invading and destroying the organs that are involved.
Induction of occupational cancer	C. Mechanisms for induction of occupational cancer are not fully understood.
Current medical theories about cancer induction	What causes a normal cell to become disorganized has been the subject of a tremendous research effort. Current theories relate to the invasion of a cell by a virus and a change in the DNA or RNA molecule of the cell. The mechanism which causes an occupational cancer to develop is even more remote. Whether the carcinogenic compound alters the internal chemistry of a cell, causing it to be more susceptible to invasion by a cancer causing virus, or whether the compound is toxic to the DNA or RNA molecule of the cell, resulting in its disorientation, is being investigated. Once the occupational cancer process has been initiated, the clinical course of the disease and its prognosis is for all practical purposes identical to that of a similar non-occupationally induced cancer.
Cancer induced at site of carcinogen deposition	C.1. Cancer may be induced at the site of deposition of the carcinogen, such as skin cancer due to the action of petroleum or coal tars and cancer of the respiratory system, especially the lung, resulting from the action of insoluble agents such as asbestos and chromates. Many organic compounds are metabolized in a manner that results in a specific site cancer, such as bladder cancer due to a metabolite of

NOTES	INSTRUCTION
Cancer induction by cocarcinogen action	beta-naphthylamine. Animal experiments have indicated that other occupational cancers result from the metabolite produced by the enzymatic process rather than the parent compound. C.2. Certain chemicals will not induce cancer unless another chemical is present to accelerate or stimulate the carcinogenic action. Such compounds are cocarcinogens. This principle was well demonstrated by I. Berenblum of Israel (cited in <u>Science and Cancer</u>, p. 50) in a series of ingenious experiments in which mice, painted just once with a powerful carcinogenic hydrocarbon, did not develop cancer. However, when the same skin site was painted months later with croton oil, a material usually without carcinogenic activity, cancers promptly appeared. The interpretation of this finding is that the hydrocarbon produced the initial cell change, but the completion of the biologic process required further steps which could be evoked by different chemicals.
Cigarette smoking as a possible cocarcinogen	In epidemiologic studies of asbestos workers, it was demonstrated that exposure to asbestos dust does not greatly increase the risk of broncogenic cancer if there is no regular cigarette smoking. Thus, cigarette smoke may be considered as a cocarcinogen, although its effect may be that of accelerating the carcinogenic action rather than stimulating the action. In the study of lung cancer among uranium miners due to radioactivity, it was found that a greatly increased rate of lung cancer occurred among these workers. However, lung cancer occurred rarely among non-smoking miners.
Cancer induction by chemical agents	C.3. Cancer induction by chemical agents is a function of the magnitude and duration of exposure.
Application of the dose concept	The dose concept appears to be valid for chemical carcinogens. This fact has been well demonstrated in animal studies.

NOTES	INSTRUCTION
Liver damage lowers body protection against carcinogens Importance of individual susceptibility to cancer Four factors that affect development of occupational cancer Carcinogenic properties of chemical agents Cocarcinogenic action	However, the nature of worker exposure to chemical carcinogens is such that the dose relationship has been difficult, if not impossible, to study through usual epidemiologic methods. C.4. Liver damage caused by chemical agents may affect the body's protective mechanisms against carcinogenic agents. The effectiveness of detoxication has been well demonstrated with experiments in which mice were given small doses of carbon tetrachloride before being injected with a carcinogenic hydrocarbon. Under these conditions, many more cancers of the lung were produced than with the same dose of the hydrocarbon alone. Carbon tetrachloride injures the liver, which is involved in the detoxication and elimination of these compounds from the body. Thus, animals with damaged livers were less able to protect themselves against the hydrocarbon. C.5. As in the case of other occupational diseases, not all exposed workers develop occupational cancer, although the attack rate for certain carcinogenic compounds, such as beta-naphthylamine, is very high. Thus, the factor of individual susceptibility must be significant in the etiology of occupational cancer. C.6. The development of occupational cancer from exposure to chemical agents is dependent on four factors. (1) The chemical agent must have carcinogenic properties, either inherent in the substance or in its metabolite. (2) The chemical agent can produce cancer through the process of cocarcinogenesis, or an action resulting from the combined effect of two or more substances.

NOTES	INSTRUCTION
Individual susceptibility	(3) The individual must be susceptible to the carcinogenic agents.
Exposure to carcinogen	(4) There must be contact between the agent and the worker. The duration of exposure can vary from one of short duration for a highly potent carcinogenic agent to prolonged exposure for an agent with a low potency.
Classes of carcinogens	D. The list of definite or suspected cancer-producing agents is too long to enumerate, but it is possible to group certain agents into classes which have either definite or potential carcinogenic actions.
Aromatic amines	D.1. Aromatic Amines.
Uses	The aromatic amines are derivatives of coal tar fractions and are used primarily in the manufacture of dyes, dye intermediates, or in the synthesis of other chemicals. Aromatic amines produce cancer of the urinary tract due to a metabolite action, rather than a direct carcinogenic effect of the aromatic amine.
Type of cancer produced	Those which have been identified as carcinogenic include alpha-naphthylamine, beta-naphthylamine, benzidine, 4-aminodiphenyl, auramine, and magenta.
Carcinogenic aromatic amines	
Beta-naphthylamine is especially dangerous	Beta-naphthylamine is so potent as a carcinogenic agent that the American chemical industry has determined that it is impossible to manufacture the chemical without undue risk to workers. Because of this, there is an agreement within the United States chemical industry that the compound will not be manufactured. There are a limited number of industries that do not subscribe to the agreement, so the product is still manufactured, but in small quantities.
Polycyclic hydrocarbons	D.2. Polycyclic Hydrocarbons.
Origins	Polycyclic hydrocarbons are widespread in both community and industrial environments. They result from the combustion of organic materials, such as gasoline and diesel fuel. They are

MODULE	Occupational Cancer	NO. 27
NOTES	INSTRUCTION	
Benzopyrene Carcinogenic products of polycyclic hydrocarbons Carcinogenic organic chemicals Vinyl chloride and bis-chloromethyl ether	also present in the distillation or pyrolysis products of petroleum and coal tar products. Because of this, they may be frequent contaminants of industrial work sites. In recent years, benzopyrene, a polycyclic compound ($C_{20}H_{12}$), has been shown to have unusual carcinogenic properties. It has been identified in a wide variety of tars, oils, soots, and products resulting from incomplete combustion of organic materials. Among the products which produce cancer are coal tar and pitch, paraffin and petroleum waxes, petroleum asphalts, bitumen, shale oil, soot, anthracene oil, creosote, and certain mineral oils. All of the above are associated with cancer, but some have been implicated as carcinogenic to the respiratory system. Since they are all derived from petroleum or coal tar by a heat process, it is possible that benzopyrene is the common etiologic agent. The inhalation of fumes from these products may deposit benzopyrene in the respiratory system, thus accounting for their carcinogenic effect. D.3. Organic Chemicals. In recent years, a wide variety of organic chemicals have proved to be carcinogenic to animals. Although animal carcinogenesis is not always indicative of a carcinogenic effect in man, such studies are sufficiently valid to justify their being handled with great care and treated as potential carcinogenic agents. Most of these chemicals are not those that would be encountered in heavy or light manufacturing plants, but might be associated with the synthesis of organic compounds, production of chemotherapeutic agents, and as complex organic solvents. Recently, bis-chloromethyl ether and vinyl chloride have been found to be carcinogenic to man.	

NOTES	INSTRUCTION
Carcinogenic inorganic chemicals Asbestos Arsenic, chromates, and nickel Beryllium Prevention of occupational cancer Eliminating contact Limiting exposure Difficulties in setting exposure limits	D.4. Inorganic Chemicals. Fortunately, a very small number of inorganic compounds are known to be carcinogenic to man in the form in which they are encountered in industry. However, further research and epidemiological studies may reveal that some of the chemicals used in industry may have carcinogenic properties. Within the last two decades, asbestos, a very common industrial substance, has been found to produce cancer of the lung and pleura. Since asbestos is a common contaminant of urban atmospheres (resulting from wear on automobile brakes, industrial discharges into the atmosphere, and use as a building material and for insulation), some investigators are fearful that it may be a significant factor in cancer production among the general population. Other inorganic compounds known to be industrial carcinogens are arsenic and its compounds, chromates, and nickel and its compounds. Beryllium has induced cancers in animals, but there is no evidence at this time to indicate carcinogenic effects in workers. However, beryllium has only been in general industrial use for about twenty-five years. It may have a low potency, making occupational cancer evident only after many years of exposure. E. Knowledge of the induction mechanism for occupational cancer, although of great scientific value, is not essential for prevention. Prevention can be accomplished either by eliminating contact with the agent or limiting the exposure to a value which is known to be within safe limits. Because of insufficient knowledge of dose relationships, it becomes difficult, if not impossible, to establish valid biologic limits. Thus, it becomes necessary to establish values which are known not to be cancer-inducing. In some cases, this may be a zero exposure and no skin contact. Thus, for purposes of setting exposure limit values,

NOTES	INSTRUCTION
Three types of chemical carcinogens Known carcinogens with assigned permissible exposures Known carcinogens without assigned permissible exposures Suspected carcinogens	chemical carcinogens are divided into three main categories. E.1. The first category comprises substances known to be occupational carcinogens with assigned permissible concentrations. These include asbestos, 5 fibers/cc. > 5 microns in length; certain insoluble chromates, 0.1 mg/m³; coal tar pitch volatiles, 200 ppb; nickel carbonyl, 1 ppb; and vinyl chloride, 50 ppm (emergency standard). E.2. The second category comprises substances known to be occupational carcinogens but without an assigned permissible concentration. These include 4-aminodiphenyl, benzidine and its salts, bis-chloromethyl ether, chloromethyl ether, beta-naphthylamine, and 4-nitrodiphenyl. For these substances no exposure by any route (respiratory, skin, or oral, as detected by the most sensitive methods) shall be permitted. No exposure contact means hermitizing the process or operation by the best practical engineering means, and protecting the worker by proper equipment that will insure no contact or entry of the carcinogen by any route. E.3. The third category comprises substances found to be of high potency in inducing tumors under experimental conditions in animals. These include 2-acetylaminofluorene, 3,3'-dichlorobenzidine, 4-dimethylaminoazobenzene, dimethyl sulfate, ethylenimine, 4,4'-methylene bis (2-chloroaniline), N-nitrosodimethylamine, and beta-propiolactone. For these compounds, worker exposure by all routes should be reduced to a minimum in light of the warning that these substances are potent enough to induce tumors in animals.

NOTES	INSTRUCTION
Basis for control of occupational cancer Exposures should be kept far below permissible limits Substitution of a non-carcinogenic substance for a carcinogenic one Isolation of processes using or producing carcinogens Totally enclosed system Collection of effluents to prevent atmospheric contamination	"Reduced to a minimum" means extraordinary care should be taken, both in manufacturing and in handling, so that the worker's exposure by all routes is kept to an absolute minimum. F. Control of occupational cancer is based on absolute minimal contact between the worker and the carcinogenic substances. Where permissible concentrations have been established, every attempt should be made to keep exposures to a value as far below those concentrations as possible, preferably to zero exposure. F.1. Wherever possible, a non-carcinogenic substance should be substituted for the carcinogenic one. Substitution is not always possible, especially when the carcinogenic substance is an essential component or by-product of the process. However, substitution should always be considered. In some cases, such as the manufacture of beta-naphthylamine, it may be necessary to decide whether or not the risk of cancer justifies the manufacture of the product. Humanitarian aspects aside, compensation costs for workers who develop cancer may be sufficiently high to offset profits. F.2. To the extent possible, operations which produce or use carcinogenic agents should be isolated so as to minimize the number of workers exposed. Wherever possible, these operations should take place in a totally enclosed system. Any effluents from the system should be collected before being discharged into the atmosphere. If this is not done, the general atmosphere of the plant and the surrounding community may be contaminated and perhaps cause cancer among persons not directly exposed to the process.

NOTES	INSTRUCTION
Ventilation of processes producing carcinogenic fumes or dusts Use of respirators Uniforms for workers exposed to carcinogenic substances Use and maintenance of uniforms Educating workers to the hazards of occupational carcinogens and importance of controls Do not give extra hazardous pay for working with carcinogens	Local exhaust ventilation should be used wherever there is a possibility of fume or dust exposure. If chemical tests show that the exposure is not well within safe limits, exposed workers should be required to use respirators approved for carcinogenic substances by the National Institute for Occupational Safety and Health. Workrooms in which cancer-producing substances are processed or generated should have positive pressure ventilation without recirculation of air so that air flow is away from work sites. Sufficient air should be provided so that the concentration of the agent is well below safe values. F.3. Workers should be provided work uniforms which cover as much of the body as is consistent with safe practices. Uniforms should be laundered regularly. Workers whose uniforms become unduly contaminated during a work shift should be required to change into fresh uniforms. Workers handling or exposed to carcinogenic materials should be provided with and encouraged to use readily available hand-washing facilities. They should also be required to take showers before changing into street clothes. F.4. Worker education is of utmost importance. A worker should never be exposed to a known risk, however remote, without full knowledge of the potential hazard. Despite the presence of engineering controls, the worker cannot be expected to cooperate in the maintenance and use of controls unless he has knowledge of their importance for his own protection. F.5. It is not uncommon for workers exposed to hazardous substances to request extra hazardous pay. As a general rule, extra hazardous pay for working with carcinogens is not a recommended procedure, as it encourages workers to increase the risk to their health.

NOTES	INSTRUCTION
Health education and medical surveillance Importance of early diagnosis	Funds spent for extra hazardous pay should be used for engineering and medical controls. The worker then would receive a greater degree of health protection. G. Health education and medical surveillance are important procedures for prevention and control of occupational cancer. Although medical procedures can do little in the prevention of occupational cancer, it is highly important that an occupational cancer be diagnosed in its early stages. Certainly, any business or industry concerned with carcinogenic substances would be well advised to seek assistance from an occupational health physician regarding the effectiveness of a medical control program. When a cancer has progressed to the stage which permits a positive diagnosis, it has reached an irreversible state and drastic therapeutic measures are necessary if its development is to be arrested. Early diagnosis for most cancers can result in a more favorable prognosis and it is generally accepted that the earlier a diagnosis is made, the more responsive the cancer will be to a therapeutic program.
Main types of occupational cancer	Occupational cancers most often occur on the skin, in the bladder, and in the lungs.
Skin cancer	G.1. Skin cancer first appears as precancerous lesions that can be detected and treated by a dermatologist.
Preventive measures	Since occupational skin cancers can be prevented, it is important that workers having contact with known skin carcinogens be instructed in and urged to practice frequent self-examination. They should be immediately referred to a dermatologist whenever suspicious lesions appear. Additionally, it would be good practice to have these workers examined at least annually by a dermatologist. This practice also serves as a health education device.

MODULE	Occupational Cancer	NO. 27
NOTES	INSTRUCTION	
Internal cancers	Frequent dermatological exams are essential for workers who have previously developed pre-cancerous lesions or who seem to have unusually sensitive skin.	
Methods of early detection: cytopathology	G.2. Internal cancers cannot be definitely diagnosed until they are apparent on a roentgenogram. At this stage, the prognosis is usually unfavorable. However, in recent years other techniques have been developed which may permit an earlier diagnosis.	
Bladder cancer	A developing cancer will slough off abnormal cells. If these cells are examined by a competent cytopathologist, it is possible to classify them in several different categories ranging from suspicion of cancer to a positive diagnosis.	
Lung cancer	For bladder cancers, a technique has been developed whereby cells contained in the urine can be collected and examined by cytologic techniques. Although the technique will permit an early diagnosis of bladder cancer, there is a critical shortage of cytopathologists to perform the test.	
Control of toxic and carcinogenic agents through prohibitive legislation	These cytologic techniques can also be applied in an examination for lung cancer. Continued improvements in cytology and the training of professionals to conduct these tests may result in more early, positive diagnosis of cancer and result in a significantly reduced mortality rate. H. Prohibitive Legislation. One method of controlling toxic agents is by prohibitive legislation, but few countries have resorted to this procedure. Prohibitive legislation may place economic restrictions on a firm or may result in the banning of a substance essential to the economy of a nation. Imagine the chaos which would exist if asbestos were to be prohibited. On the other hand, there are good reasons to use an asbestos substitute wherever possible.	

MODULE	Occupational Cancer	NO. 27
NOTES	INSTRUCTION	
Control preferable to prohibition, except where control methods prove ineffective	Most health authorities would agree that control is preferable to prohibition, except in those cases where all known control methods prove to be ineffective. Of the major industrial nations, only the United Kingdom and the USSR have prohibitive legislation, which includes a ban on the manufacture, use, and importation of certain carcinogenic substances. In the United States, the State of Pennsylvania prohibits the manufacture, use, and other human exposure to beta-naphthylamine without the express approval of the Pennsylvania Department of Health.	

NOTES	INSTRUCTION
<u>Summary of Key Points</u>	<u>SUMMARY OF KEY POINTS</u> A. The occurrence of occupational cancer has been known since 1775. In that year, an English physician, Sir Percivall Potts, identified an excessive incidence of scrotal cancer among chimney sweeps. Since then, many other chemical agents have been implicated as carcinogenic compounds. B. Cancer is a disorientation of cells and can occur in any organ or tissue of the body. It is characterized by unrestricted growth of cells which invade and destroy contiguous tissue. C. Mechanisms for induction of occupational cancer are not fully understood. Cancer may be induced: (1) at the site of deposition of the carcinogen; (2) by co-carcinogenic action; (3) by excessive exposure to carcinogenic agents; (4) by liver damage that destroys the body's protective mechanisms; (5) by individual susceptibility to cancer. D. Agents that have either definite or potential carcinogenic properties are: (1) aromatic amines; (2) polycyclic hydrocarbons; (3) some organic chemicals; and (4) some inorganic chemicals. E. Prevention of occupational cancer can be accomplished either by eliminating contact with the agent or limiting the exposure to a value which is known to be within safe limits. F. Control of occupational cancer is based on absolute minimal contact between the worker and the carcinogenic substances. G. Health education and medical surveillance are important procedures for prevention and control of occupational cancer.

EXERCISES

1. Name the three most common types of occupational cancer.

2. A coal tar dye worker mentions to you one day that he has a mosquito bite on the back of his hand that won't heal up. Must you, as an industrial hygienist, be concerned about this fellow's mosquito bite? Why or why not? If so, what should you do about it?
3. If the dye worker's "mosquito bite" turns out to be a precancerous lesion, what should you do to insure his safety and health as well as the safety and health of the other coal tar dye workers?

4. In a ferrous alloy foundry, you have detected worker exposure to the following substances. Identify those which have carcinogenic potential.

_____ Silica
_____ Asbestos
_____ Iron dust and fumes
_____ Decomposition products of coal tar
_____ Arsenic
_____ Vanadium
_____ Chrome salts

MODULE	Occupational Cancer	NO. 27
NOTES	INSTRUCTION	
<u>Discussion</u>	<u>DISCUSSION</u> Within recent months, it has been determined that vinyl chloride (used in the production of vinyl plastics) is carcinogenic. Based on present information, it produces angiosarcoma (a rare cancer of the liver) in exposed workers. So far, only about 20 to 25 cases have been detected among exposed workers, but the investigation is still in its early stages. Vinyl chloride had its first industrial use about 30 years ago. In those days, the exposure limit was set at 500 ppm because the substance induced only a slight narcotic effect at high concentrations. Since 1964, dramatic increases in the production rate of vinyl plastics have occurred. Increases in production meant increases in the number of workers exposed to vinyl chloride. Since the agent was considered to be relatively non-toxic, exposure records are very inadequate. However, for the purposes of this discussion let us assume that workers have been exposed to concentrations between 250-500 ppm, with peak concentrations going as high as 1000 ppm. Recent animal experiments indicate that liver cancer will develop in small rodents exposed for 8 hours a day, 5 days a week, at a concentration of 50 ppm. In creating a new standard for exposure to vinyl chloride, a wide difference of opinion is encountered. Some people propose a standard of 50 ppm; while others maintain that the permissible exposure should be the least amount which can be detected in the workroom atmosphere, something less than 1 ppm. Based on material presented in this module, develop the pros and cons for each proposal.	



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Ergonomics NO. 28 TIME: 50 Minutes

Human factors and man's relationship to his environment must be considered when designing workplace layout, facilities, tools, and equipment.

Objectives. Enable the trainee to understand the physiological and psychological stresses of the workplace environment; recognize how stress affects workers' abilities and productivity; understand the concept of ergonomics; and know how to apply ergonomic factors in planning a workplace environment.

Content. Definition of ergonomics
Relationship of ergonomics to industrial hygiene
Workings of the man-machine-environment system
Nature and effects of stress on workers
Application of biomechanics and ergonomic principles

Methods. Lecture, Exercises, and Discussion

Materials. Chalkboard, chalk, and eraser
Visual 28-1

Special Terms.

Anthropometry
Biomechanics
Ergonomics
Human engineering
Stress

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapter 9, pp. 301 - 343.
2. Industrial Environment - Its Evaluation & Control. Chapter 32, pp. 431 - 492.
3. Industrial Toxicology. Volume I, Chapter IV, pp. 57 - 116.

Other References

1. Singleton, W. T. Introduction to Ergonomics. Geneva: World Health Organization, 1972.
2. Stellman, Jeanne M.; Daum, Susan M. Work Is Dangerous to Your Health. New York: Pantheon Books, 1973. Chapter 3, pp. 76 - 92.

MODULE Ergonomics	NO. 28
NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> Ergonomics is a big fancy word for something we've been doing for a long time...adapting our surroundings to fit the people who live and work there. As our technology has advanced, so has our ability to change our environment for greater efficiency, comfort, and ease of work (or play). We can see this by comparing the architecture of the past with that of the present. Back in the 1700s, most buildings in the United States were pretty much alike in design. There wasn't much difference between a textile factory building and a rather large house with shuttered windows, pitched roof, a small door on the front, and many low-ceilinged rooms. Shop buildings also looked like houses. Warehouses along the wharves and newspaper printing establishments were shaped like houses. Public buildings (city halls, jails, taverns, inns, schools, libraries, etc.) were built in the shapes of houses. If you've ever visited a place like Williamsburg, Virginia, or Sturbridge Village in New England, you will probably have noticed this similarity in architectural design. Technology and the requirements of society in the 1700s had not yet dictated a need for specialization of architectural design. Now try to imagine a modern steel mill, textile factory, corporate office complex, or newspaper printing plant located in buildings shaped like domestic houses. It would be impossible. The types of manufacturing, the equipment and processes used, and the work needs of the employees who operate the equipment all dictate a special kind of architecture adapted to the necessities of the operation. The ergonomic factors involved in office work differ from the ergonomic factors involved in factory work. To take factory work a step farther, the ergonomic factors involved in a textile mill differ from those in a steel mill. And within a textile mill, the ergonomic

MODULE	Ergonomics	NO. 28
NOTES	INSTRUCTION	
	factors in the weaving shop differ from those in the color dying shop. Now, to use the weaving shop as our example, the ergonomic factors that affect one loom operator differ from those affecting another. So as you can see, the basic components of industrial ergonomics are (1) the individual worker, (2) the machines or tools he uses, and (3) the environment in which he uses them. A person who works is, by definition, under stress of some kind. The stress may be external to the worker, arising from the need to operate equipment correctly or get a report in on time. External stress may also come from the worker's surroundings--excessive noise, perhaps, or an uncomfortable chair. Internal stress arises from emotional or psychological sources, such as a fight with a co-worker or fear of the boss. Whether stress is physical or mental, external or internal, it has an important effect on how well the worker can do his job. The point of ergonomics is to adjust the design of equipment and processes of work to fit the normal, natural operations of the job in which the equipment or processes are used. By applying ergonomic principles, abnormal job stresses can be largely eliminated, resulting in greater productivity, better worker morale, and a more comfortable and efficient workplace environment.	

NOTES	INSTRUCTION
Man as monitor of the system Adjusting the system to man's physical and mental capacities Role of stress Effects of too much stress Effects of too little stress	B.1. In a system involving a person and other components such as machines, the person often serves as a monitor of the system and forms part of the "closed loop servo system" providing much of the feedback from the system. The person usually makes the decisions and plays an essential part in the efficiency of the system. The physical or mental activity involved in his actions must be within his physical and/or mental capacity. He must be able to function with a minimum of error or failure. The same can be said of the machine, since if its capacity is exceeded, the overload will cause it to fail. B.2. Many situations can make excessive demands upon an operator and overload his capacity to work. Therefore, information must reach him at a speed with which he can cope and in a form that he can easily understand. The demands on him should be properly spaced in time so that he can act upon them without undue mental or physical stress, considering his age, sex, and state of health. Excessive physiological and psychological stress of this nature can impair worker health and efficiency just as significantly as can environmental stress factors such as excessive heat, noise, vibration, toxic exposures, and the like. Of course, any activity or task involves some physiological or psychological stress. Most people can work for short periods under overload conditions, as when there are high production demands. However, people have limits to the amount of stress they can take. When overload reaches a certain indefinable point, a person may completely break down. On the other hand, very low levels of physiological and psychological stress put few

MODULE Ergonomics		NO. 28
NOTES	INSTRUCTION	
Human physical capabilities	demands on the individual. As a result, performance is also low, and the attendant boredom and inattention can lead to unnecessary errors and accidents. C. Man's physical capabilities relate to his anatomical dimensions and muscular strength. Excessive physical stress can result in physical injuries, some of these may be acute and readily observable, while others may be subtle in their development. Bursitis and tenosynovitis (inflammation of the tendon sheaths) are examples of the subtle effects of excessive physical stress. Simple fatigue and discomfort, often forerunners of soreness and pain, make a worker less able to perform his tasks properly and safely.	
Biomechanics and its application to the physical demands of work	C.1. Biomechanics, the mechanics of biological organisms, deals with the functioning of the structural elements of the body and the effects of external and internal forces on various part of the body. The application of biomechanics to the physical demands of work can be very effective in preventing excessive work stress.	
Biomechanics and the manual handling of objects	C.2. Injuries resulting from accidents in the manual handling of objects and materials are especially prominent in the total of all work injuries. This is an area where biomechanical data relating to lifting and carrying can be applied in the design of tasks and work layouts that require handling of materials.	
Functions of the man-machine-environment system	D. In every man-machine-environment system, various functions are carried out by the components of the system toward some purpose or objective. Four basic classes of functions are involved.	

NOTES	INSTRUCTION
Receiving information: sensing Role of the senses Remote and amplifying sensors Displays as sensory input Information storage: memory How information is stored and remembered Information processing and decision-making	D.1. The first function is that of receiving information of some kind. This initial sensing function involves the use of the five senses: sight, hearing, touch, taste, and smell. If the information cannot be directly received through the senses, remote and/or amplifying sensors may be used, with information communicated through a visual display or through an auditory or tactual display. The use of radar for locating objects beyond the immediate visual field constitutes an amplified sensing device. Displays are one of the most common types of sensory input. The use of displays that are designed in terms of human considerations help to clearly communicate essential information to the operator for accomplishment of his task. D.2. The second function within the man-machine-environment system is that of information storage or memory. Information received by an individual is not very useful if it is forgotten within minutes of acquisition. As a general rule, a person will remember information if (1) the information is seen to be in some way personally important or essential, (2) the information is readily useful or easily connected with previously acquired information, (3) the information itself seems unique or extraordinary and therefore hard to forget, or (4) the information (whether trivial or essential) is "catchy" and seems to "stick" in the person's mind for reasons not fully understood. D.3. The third function of the man-machine-environment system is one of information processing and decision-making.

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NOTES		INSTRUCTION	
Classifying information mentally		Mental information processing involves putting the facts received into one's personal mental hierarchy. An individual may classify a piece of information in several different ways—a kind of mental cross-referencing system. He can classify a fact according to its importance or its usefulness. He may classify it according to subject matter. He may classify it according to how it affects him emotionally or physically. If the fact is personally traumatic or unacceptable, he may repress it. Or if he cannot classify the fact at all, he will probably forget it.	
Applying values to information and interpreting it		Once the information is processed, the individual can make some sense out of it. By combining pieces of information from various levels in his mental hierarchy, he can interpret them according to the value system he holds. In applying values to facts he can make decisions based on what the facts are and what his values dictate he must <u>do</u> about these facts.	
Acting upon information		D.4. Decision-making, then, leads to the fourth function--action.	
Types of actions that may be taken		Action may be physical (such as the handling or alteration of materials); the action may be directional (such as the manipulation of people or processes); or the action may be mental (such as resolving to think over a problem).	
Importance of the layout and organization of workspace to efficiently and safely get jobs done		E. In addition to the optimum design of equipment to meet operational and human needs, the layout and organization of the workspace is important in increasing worker efficiency, decreasing errors, and reducing the incidence of accidents.	

NOTES	INSTRUCTION
Anthropometry Anthropometry in planning physical facilities Design of equipment and facilities to be compatible with biological and psychological characteristics of the operator Visual 28-1	In addition to a knowledge of the job requirements and equipment use, descriptive data on human body size and range (at rest and in motion), and biomechanical abilities and limitations of range, strength, speed, accuracy of motion, sensory abilities, and reactions to variable environmental factors, may be essential to the adequate design and subsequent use of the workspace. E.1. Anthropometry deals with measurements of the physical features of the human body, including linear dimensions, weight, and volume. These measurements are used to design or re-work special accommodations and physical facilities to fit people as they sit, stand, or move about in the conduct of their work. Much anthropometric data has been collected, but care must be taken when applying such data. The data should be from samples of people who are reasonably similar to those for whom present designs are being made. E.2. From the standpoint of human engineering, it is essential that the mechanical design of equipment and facilities and the organization of workspace be compatible with the biological and psychological characteristics of the operator. If design of facilities complicates the operator's task or makes it awkward or time-consuming to accomplish, then the burden becomes too great. The operator will exceed his limits of attention or ability, and thus become accident-prone. A wide margin of safety should be employed to eliminate any situation that places the operator near his maximum ability with regard to his aptitude or effort. Visual 28-1 shows typical human errors in equipment operation and their probable cause.

MODULE Ergonomics	NO. 28
NOTES	INSTRUCTION
Importance of work rate in terms of efficiency Fast, high-intensity work induces fatigue in workers Other factors inducing worker fatigue Effects of fatigue	F. The rate at which a physical activity is done materially influences (1) the duration of time that activity can be continued without causing excessive stress and (2) the efficiency of the activity. The human at work (or play) is about 25% efficient in terms of the ratio of output to input plus the heat generated. The most efficient rate will not necessarily be the least tiring work situation, nor will it necessarily be the most productive (except for high-effort, short-duration situations). In general, the rate of physical activity can easily exceed physiological stress limits, even with optimal environmental conditions. Thereafter, muscular fatigue will set in, causing the muscles to cease functioning at all until a sufficient rest period has elapsed. On the other hand, if the rate of physical activity is low, muscular fatigue is minimal and work continues without interruption. Muscle fatigue arises under conditions of high stress. F.1. Fatigue is the result of factors other than high work intensity. These fatigue factors are: (1) Illness, pain, poor eating habits. (2) Environmental stress (climate, air contaminants, noise, vibration). (3) Monotonous, tedious tasks. (4) Psychological factors (worry, conflict, responsibilities). Thus, fatigue is an accumulation of effects from various sources. A person who is fatigued feels tired. His physical performance decreases and he has no desire for either physical or mental work.

MODULE Ergonomics	NO. 28
NOTES	INSTRUCTION
Need for rest Chronic fatigue Physical effects resulting in clinical fatigue Survey guide for the collection of ergonomic information	The sensation of fatigue forces a person to rest and avoid further stress, allowing recovery to take place. Severe, continuous, daily fatigue leads to chronic fatigue. Under conditions of chronic fatigue, work not only intensifies a person's tiredness, but the tired feeling may also be present before work is begun. Other signs may be evident, too, such as increased irritability, depression, and dislike of work. F.2. In addition to the psychological effects of fatigue, non-specific physical complaints may arise, developing a condition called "clinical fatigue." Under conditions of clinical fatigue, it becomes difficult to distinguish between the cause and the effect of the persistent tiredness. A negative attitude towards work, superiors, or place of work can just as well be caused by clinical fatigue as <u>result</u> from it. In most cases, fatigue will vanish after an adequate rest period. In pathological cases, fatigue will persist. G. A survey guide has been designed to assist in the systematic collection of ergonomic information. Such a guide is useful in defining the demands made on a worker in the performance of his tasks in his particular environment. Information collected is used in designing machines and environmental conditions to fit the worker. More than 300 questions were developed in outline form--general questions followed by specific questions to be used if applicable. Sample questions may be found in <u>Fundamentals of Industrial Hygiene</u>, pages 339-341.

MODULE		Ergonomics	NO. 28
NOTES		INSTRUCTION	
<u>Summary of Key Points</u>		<u>SUMMARY OF KEY POINTS</u>	
		A. Ergonomics deals with the interactions between man and all of the factors that are a part of his environment. B. In any system of activity, a person receives and processes information and then acts upon it. C. Man's physical capabilities relate to his anatomical dimensions and muscular strength. D. Biomechanics, the mechanics of biological organisms, deals with the functioning of the structural elements of the body and the effects of external and internal forces on various parts of the body. E. In every man-machine-environment system, various functions are carried out by the components of the system toward some purpose or objective. These functions fall into four classes: (1) the receiving of information through the senses. (2) the storing of information in the memory (3) the processing of information and decision-making based on information received. (4) the action taken as a result of the above functions. F. In addition to the optimum design of equipment to meet operational and human needs, the layout and organization of the workspace is important in increasing worker efficiency, decreasing errors, and reducing the incidence of accidents. G. Anthropometry deals with measurements of the physical features of the human body, including linear dimensions, weight, and volume.	

MODULE Ergonomics	NO. 28
NOTES	INSTRUCTION
	H. It is essential that the mechanical design of equipment and facilities and the organization of workspace be compatible with the biological and psychological characteristics of the operator. I. The rate at which a physical activity is done materially influences (1) the duration of time that activity can be continued without causing excessive stress and (2) the efficiency of the activity. J. Fatigue is the effect of various physical and mental stresses. Physical performance decreases and there is no desire for either physical or mental work. Fatigue forces a person to avoid any kind of stress. K. Fatigue can be temporary or chronic. L. Survey guides have been developed to assist in the systematic collection of ergonomic information.

EXERCISES

Name the ergonomic factors that should be taken into consideration when designing each of the following:

- (a) child's tricycle
- (b) kitchen stove
- (c) beer can
- (d) portable television set
- (e) sleeping bag
- (f) secretary's work area
- (g) production deadline
- (h) hand tool (pliers, screwdriver, etc.)
- (i) floorplan for a loading dock area
- (j) lighting system for a print shop

NOTES

INSTRUCTION

DiscussionDISCUSSION

1. Be prepared to discuss and explain the answers you gave to the questions in the preceding Exercise section.
2. A number of experienced managers, supervisory people, and even union leaders think all this ergonomics and human factors stuff is a lot of baloney. Their argument is that (1) if you give a man decent pay and benefits, he will do his job well enough, and (2) if the design of equipment and processes and the scheduling of production deadlines becomes dependent on individual human eccentricities and foibles, then business and industry will never be able to get anything done efficiently or on time.

Do you think there is merit to either of these arguments? Explain.
3. As industrial hygienists, you too are under stress from the requirements of your job. What sorts of stresses do you encounter in your day-to-day work? How do you cope with them? Are there any ergonomic principles we've discussed that could help alleviate the unnecessary stresses?
4. At your place of work are there any especially good or bad examples of ergonomic planning? Describe them.
5. Did you have trouble thinking of good examples of ergonomic planning? If so, why? (Other than the fact that there may not be any.)

Table 5.1
Typical Human Errors in Equipment Operation and
Their Possible Causal Factors

Type of Error	Possible Causal Factors
Failure to detect signal	Input overload a. Too many significant signals b. Too many separate input channels Input underload a. Too little variety of signals b. Too few signals Adverse noise conditions a. Poor contrast b. High intensity of distraction stimuli
Incorrect identification of signal	Code form or typology unclear Lack of differential cues Inappropriate filtering set (expectation) Conflicting cues Conflicting identification requirements
Incorrect value-weighting or priority assignment	Nonlinear predictions required Multiple or complex value-scaling required Values poorly defined or understood Contingencies vaguely defined
Error in action selection	Matching of actual and required patterns faulty Consequence of courses of action not understood Appropriate action not available Correct action inhibited a. Cost considerations b. Procedural prohibitions
Error of commission	Correct tool or control not available Action-control relationship not understood by operator Action feedback unavailable or delayed

Source: Kidd, J.S. "Human Tasks and Equipment Design," Psychological Principles in System Development. Robert M. Gagne (Ed.). New York: Holt, Rinehart and Winston, 1962, p. 182.
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Visual 28-1



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: **Monitoring** **NO. 29** **TIME: 50 Minutes**

Ways and means of gathering data on occupational exposures.

Objectives. Enable the trainee to recognize needs for monitoring the causes and effects of exposures to contaminants.

Content. Control by Monitoring
Environmental Monitoring
Biologic Monitoring
Program Planning
NIOSH and OSHA Roles

Methods. Lecture and Exercises/Discussion

Materials. Chalkboard, chalk, and eraser
OSHA Regulations are Required Reading.
Examples of Recommended Standards (Supplements Section)

Special Terms. Monitoring, sampling, and related terms, including

Biologic monitoring	Environmental monitoring
Criteria	Quantitative
Dose	Promulgated standard
Empirical reference	Recommended standard

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapter 20.
2. Industrial Environment - Its Evaluation & Control.
See Table of Contents and Index for topics of interest.
3. Industrial Toxicology. Volumes I and II.
See Table of Contents and Index for topics of interest.
4. OSHA Act, 1970.
5. OSHA Regulations, June 27, 1974. Section 1910.93a Asbestos.
6. TLVs[®]: Threshold Limit Values, 1973.

Other References

1. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Asbestos. Washington, D. C.: U. S. Government Printing Office, 1972.
2. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Carbon Monoxide. Washington, D. C.: U. S. Government Printing Office, 1972.
3. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Inorganic Mercury. Washington, D. C.: U. S. Government Printing Office, 1973.

MODULE Monitoring		NO. 29
NOTES	INSTRUCTION	
<u>Introduction</u>	<u>INTRODUCTION</u>	
Definition	In the field of occupational safety and health, the term "monitoring" means to check, measure, and sometimes regulate the causes and effects of hazardous exposures to workers.	
Job requirement	Preparing plans and making recommendations for monitoring may be a critical part of your job, in the future if not at the present time.	
Purpose of this module	The subject is complex, and most of the techniques are beyond the scope of this course. However, this module will introduce you to some basic concepts and general methodology.	
Examples in Supplements	Specific examples of considerations and standards are used to illustrate program planning aspects and legal requirements of monitoring. These examples are grouped in the Supplements section at the end of the module for convenience in referencing.	
OSHA Reference	You will also need to reference the OSHA Regulations, so be sure your copy is at hand.	
Discussion and Exercises	Exercises will form the basis of discussion, but don't hesitate to bring up other matters of interest to the class.	

MODULE Monitoring		NO. 29	
NOTES		INSTRUCTION	
<u>Explanation - Lecture</u>		<u>EXPLANATION - LECTURE</u>	
Monitoring as control		A. Industry uses biologic and environmental monitoring as an auxiliary method of control. The decision to monitor is generally left to the company. The industrial hygiene recommendation usually is to control the contaminant within the TLV.	
Main considerations		A.1. Toxicity and pathologic effect are the main considerations in deciding whether or not to monitor. In certain situations, the toxicity of the contaminant is so great that the TLV leaves only a narrow margin of safety, such as beryllium (TLV=0.002 mg/m³) and asbestos (TLV=2 fibers/cc). Some substances are so toxic that it is essential to detect pathology in its very early stage. Substances of this type which require biologic monitoring include silica (or other pneumoconiosis-producing dust), lead, beryllium, carbon disulfide, benzene, carbon tetrachloride, nitroglycerine, and trinitrotoluene.	
OSHA requirements		A.2. The Federal Occupational Safety and Health Act states that monitoring can be required Either environmental or biologic monitoring, or both, can be required of establishments handling toxic materials. Standards for monitoring appear or will appear in the OSHA Act or Regulations. As of June 1974, the only adopted standard is for asbestos. Therefore, enforcing agencies may have to establish their own. Before requiring monitoring, however, the enforcing agency should seek advice from NIOSH.	
NIOSH criteria		NIOSH criteria for recommended standards are presented in item E of this explanation and in examples D, E, and F.	

MODULE Monitoring		NO. 29
NOTES	INSTRUCTION	
Environmental monitoring	B. The purpose of environmental monitoring is to establish dose and peak concentrations.	
Criteria	B.1. Several criteria should be considered before recommending environmental monitoring. The average concentration of the contaminant is at or near the TLV and engineering methods to reduce the concentration to a lower level are not technically feasible. The toxicology of the contaminant is not fully known in human terms, but it is suspected to be highly toxic. The TLV of the substance is so near zero that a small error in sampling would significantly affect the dose (i.e., TLVs of less than 0.1 mg/m³). The substance is so highly toxic that concentrations above the TLV may result in serious pathology. A daily or continuous evaluation of control systems is desirable.	
Basis for method and frequency	B.2. The method and frequency of monitoring must be based on the physical and chemical characteristics of the substance. For most gases and vapors, continuous recording instruments are available or can be modified to meet special purposes. Dust concentrations or metallic content of particulates can be monitored with electronic instruments. Weighing and staining are then used for quantitative measurements of dust. Chemical analysis is necessary for measuring metal concentrations.	

MODULE Monitoring		NO. 29
NOTES	INSTRUCTION	
Dose-effect comparisons	B.3. Dose rates of workers under environmental monitoring are compared with biologic abnormalities. Dose rates are usually expressed in monthly or annual rates. Although such data are important in evaluating health hazards, biologic data are also necessary for determining cause-effect relationships.	
Cost effectiveness	B.4. Environmental monitoring is expensive so all relevant factors should be considered before recommending this procedure. Manpower and capital requirements of environmental monitoring make the procedure very costly. If not done properly, the findings may be useless. Therefore, criteria should be carefully considered and possible alternatives should be explored before such a recommendation is made.	
Biologic monitoring	C. Biologic monitoring is used to measure the effect of contaminants on the exposed workers. Biologic monitoring is conducted to: Test the effectiveness of environmental controls, Determine the adequacy of the TLV, Detect early changes in exposed workers.	
Value	C.1. Biologic monitoring has little value unless accompanied by environmental monitoring. Practically the same criteria apply to biologic monitoring and environmental monitoring. The difference is that workers now become the reference point.	

NOTES	INSTRUCTION
Criteria	Frequent tests may also be indicated for re-search purposes or for substances with an unknown severity. Some organizations also require biologic monitoring for documenting cases for Workmen's Compensation. C.3. Several criteria should be met before recommending biologic monitoring. The scientific and biologic reasons for monitoring relate to at least one of the criteria for environmental monitoring. A meaningful biologic test is available. Workers understand and cooperate in biologic monitoring. The program and data interpretation are supervised by competent medical personnel. Medical data on individual workers are confidential. The yield of meaningful data or the preventive effort justifies the cost of the program.
Program planning	D. Program planning is affected by several dimensions of monitoring. Factors to be considered in planning a program of monitoring include objectives, frequency, procedures, applications, instrumentation, duration, and biologic tests. Most of the dimensions of monitoring are inter-dependent, with objectives being the most critical parameter.

NOTES	INSTRUCTION
Concerned participants	D.1. All concerned professional groups should participate in planning for monitoring special situations. Monitoring may be desirable for special purposes, such as the determination of toxic effects that have not yet been identified or perhaps even suspected. Professional groups to be represented will, of course, include industrial hygienists and specialists from various branches of medicine. Government, labor, management, and perhaps even consumers may also be represented.
General patterns	D.2. Monitoring for certain kinds of known contaminants and toxic agents may follow the same general pattern. Certain dusts and toxic metals, gases, and vapors have been monitored often enough to establish useful guidelines for program planning.
Example A	Example A covers pneumoconiosis-producing dusts.
Example B	Example B presents guidelines for highly toxic metals.
Example C	Example C gives planning aspects for highly toxic gases or vapors.
NIOSH recommendations	E. NIOSH criteria documents for occupational exposure to chemical and physical hazards contain recommendations for environmental and biologic monitoring. To date, only one of these proposed standards has been promulgated by OSHA. However, as others are adopted, industry will be required to establish monitoring programs based on criteria in the official standards.

MODULE Monitoring		NO. 29
NOTES	INSTRUCTION	
Good practices	Meanwhile, the proposed criteria represent good practices for employers who want to provide protection from hazardous occupational exposures.	
Examples D, E, and F	Monitoring requirements for asbestos and two proposed standards are reported in Examples D, E, and F. However, the criteria documents should be referenced for complete details.	

NOTES	INSTRUCTION
<u>Summary</u>	<u>SUMMARY OF KEY POINTS</u> A. Industry uses biologic and environmental monitoring as an auxiliary method of control. B. The purpose of environmental monitoring is to establish dose and peak relationships. C. Biologic monitoring is used to measure the effect of contaminants on the exposed workers. D. Program planning is affected by several dimensions of monitoring. E. NIOSH criteria documents for occupational exposure to chemical and physical hazards contain recommendations for environmental and biologic monitoring.

EXERCISES FOR DISCUSSION

A large chemical plant has exposures to the substances and conditions listed below, along with the 8-hour TWA.

Assume that these are the lowest levels attainable in this plant.

Be prepared to discuss and justify environmental or medical monitoring for each substance, based on the explanation-lecture for this module.

Lead	0.18 mg/m ³
Manganese	0.40 mg/m ³
*Vinyl chloride	2 ppm
Asbestos	5 fiber/cc
CO	45 ppm
Iron oxide fume	5 mg/m ³

*The temporary standard for vinyl chloride is 1 ppm.

MODULE Monitoring		NO. 29	
NOTES		INSTRUCTION	
<u>Supplements</u> Examples A, B, and C Examples D, E, and F		<u>SUPPLEMENTS</u> This section contains six examples of two types of information about monitoring. Examples A, B, and C present program planning aspects of monitoring dusts, highly toxic metals, and highly toxic gases or vapors. Examples D, E, and F refer to monitoring requirements in standards for asbestos, carbon monoxide, and inorganic mercury.	

Example A. Pneumoconiosis-Producing Dusts

1. Frequency. Pneumoconiosis is a disease that develops slowly, even at relatively high dust concentrations. Therefore, worker exposures can be monitored at infrequent intervals, such as one day per month.
2. Procedure. Personal and area samples should be taken. An occasional environmental survey of the total environment would be desirable to confirm the results of the monitoring program.
3. Application. Monitoring can be used to (a) construct annual dose rates for research purposes and (b) determine the efficiency of control measures. However, this procedure is not suitable where dust concentrations are subject to extreme fluctuations, such as the application of asbestos insulation in the construction industry. For these situations, adequate controls must be used.
4. Instrumentation. Personal samplers are desirable, but not always practical. The personal sampler can be used for area samples, too. Large volume filter samples without pre-size selectors may be used. For quantitative data, these samples require a particle size analysis. Total dust is related to respirable dust. These samples could be used as a guide, but they should not be used for dose calculations. They would indicate control efficiency.

Tape samplers require less manpower, but give only an empirical value. This value could be converted to a dose value, but without significant accuracy. Tape samplers are excellent for control purposes.

Light scatter instruments offer the same advantages and disadvantages as tape samplers.

5. Duration. For research purposes, a monitoring program would have to be continuous for years to be biologically meaningful. For control purposes, a monitoring program could be discontinued after it has been determined that controls are effective and dose rates are not exceeded.
6. Biologic Test. A chest X-ray is the only biologic test. The frequency of X-ray must be determined by a physician. Usually, a test is made at one to five year intervals.

Example B. Highly Toxic Metals, such as Lead, Beryllium, and Manganese

1. Frequency. Poisoning by metals can develop in a short time period, so monitoring must be done at frequent intervals. Frequency is a function of objective, whether that be research or control.
2. Procedure. A detailed industrial hygiene study should be done before a monitoring program is planned to (a) identify locations of worksites where monitoring is necessary, (b) establish the range of concentration, and (c) determine whether area or personal sampling is necessary.
3. Application. Monitoring can be used to (a) determine dose and the relationship of dose to biologic changes for research purposes and (b) determine the efficiency of control procedures.
4. Instrumentation. Instrumentation for monitoring dusts and metals is the same except that filters must be analyzed for contamination. Paper tape or sequential samplers would be practical, but analytical work must be performed to make samples meaningful. A light scatter instrument will not give the desired results.
5. Duration. For research purposes, biologic monitoring must be continued until the objective has been attained. For control purposes, the program could be discontinued after it has been determined that controls are effective and dose rates are not exceeded.
6. Biologic Test. The proper test must be determined by a physician, but it would probably relate to the presence of metal or a metabolite in the blood or urine. Such a test could be done at frequent intervals, as it involves no risk to the worker. Some metals, such as beryllium, may require chest X-rays.

Example C. Highly Toxic Gases or Vapor with Acute Effects

1. Frequency. Toxic gases and vapors have serious acute and chronic effects, so special precautions in monitoring must be observed. The most frequent objective is to maintain the concentration below a critical level. Since gases and vapors may diffuse throughout several work areas by ventilation systems, the area of potential hazard must be defined. Unless there is an overriding factor, monitoring should be continuous, on an area basis.
2. Procedure. Generally, a warning device is activated when a dangerous concentration has been exceeded. This procedure is used for carbon monoxide, carbon disulfide, arsine, organic lead and mercury compounds, hydrogen cyanide, nitrogen dioxide, and explosive gases.
3. Application. Monitoring can be used to (a) establish dose rates for research purposes, (b) detect failures in the control system before dangerous concentrations are established, (c) warn personnel to take evasive action, and (d) continuously monitor the effectiveness of the control system.
4. Instrumentation. The only practical instrument is one which allows continuous monitoring and recording of results. Many manufacturers offer such instruments, or existing instruments can be modified to accommodate a specific contaminant. These instruments can be designed to activate a warning device when the concentration reaches a predetermined point.
5. Duration. As long as the hazard exists, a monitoring program must be in operation.
6. Biologic Test. Unless the procedure has an objective, such as the determination of biologic effects or dose relationships, biologic testing is not essential or necessarily desirable.

Example D. Asbestos

References:

- a. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Asbestos. Washington, D. C.: U. S. Government Printing Office, 1972.
- b. Occupational Safety and Health Standards, Title 29, Code of Federal Regulations, Part 1910, Section 1910.93a Asbestos. In Federal Register, 39(125), June 27, 1974.

NIOSH recommendations have been adopted as the OSHA standard.

Monitoring requirements are specified in Section (f) of the standard.

Example E. Carbon Monoxide

Reference:

NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Carbon Monoxide. Washington, D.C.: U.S. Government Printing Office, 1972.

Section 8 - Monitoring and Recordkeeping Requirements

(a) Employers shall monitor environmental exposures of employees to CO as follows:

(1) Personal exposure ("breathing zone") samples shall be collected in accordance with procedures specified (in Appendix I) in all work places where employees are significantly exposed to CO. (Elsewhere in the document, a significant exposure is defined as an eight-hour TWA exposure exceeding 25 ppm but excluding such exposure as may be self-administered through smoking.)

(2) Frequency of monitoring should be at least annually. It is recognized that more frequent monitoring may be indicated in certain circumstances depending upon the nature of the process, the rate of production, the effectiveness of control measures, the time of day, and seasonal variation.

However, more frequent monitoring requirements cannot be recommended until there are effective studies of specific operations in industry.

(3) Blood analysis for COHb, as specified (in Appendix II), shall be performed on all persons in the work area when, in the judgement of the OSHA Industrial Hygienist, biologic standards are needed to evaluate borderline exposure to CO.

(4) Determination of the CO concentration for borderline exposure, as judged by the OSHA Industrial Hygienist, shall be accompanied by continuous monitoring of the work environment. Such continuous monitoring shall be accomplished by means of monitoring equipment capable of determining the concentration in the work environment within 5% of the actual value.

(5) Affected employees, or their representatives, shall be given a reasonable opportunity to observe any monitoring required by this action.

(b) Every employer shall maintain records of any personal or environmental monitoring required by this section. Records shall be kept for a period of at least three years. Every employee and former employee shall have reasonable access to any record required to be maintained which indicates the employee's own exposure to CO.

Example E. Carbon Monoxide (continued)

Section 2 - Medical Recommendation

This is a recommendation and not a requirement.

Because employees with overt cardiovascular diseases may not be protected by an occupational exposure to 35 ppm of CO, a medical program should be instituted consisting of preplacement and periodic examinations with special attention to the cardiovascular system and to medical conditions which could be exacerbated by exposure to CO. Such a medical study could also provide the opportunity for conducting anti-smoking programs for high-risk employees.

Example F. Inorganic Mercury

Reference:

NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Inorganic Mercury. Washington, D.C.: U.S. Government Printing Office, 1973.

Section 8 - Monitoring and Recordkeeping Requirements

Workroom areas where it has been determined, on the basis of an industrial hygiene survey or in the judgement of a compliance officer, that environmental levels do not exceed 40% of the environmental standard shall not be considered to involve worker exposure to inorganic mercury. An additional survey shall be made if there is a change in process or engineering controls. Records of these surveys, including the basis for concluding that air levels are below 40% of the standard, shall be kept.

Requirements set forth below apply to inorganic mercury exposures.

(a) Employers shall monitor environmental levels of inorganic mercury at least every six months. Breathing zone samples shall be collected to permit calculation of a time-weighted average exposure for every operation.

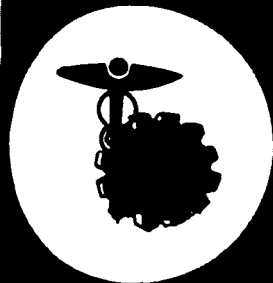
(b) When any time-weighted average exposure is at or above the environmental standard, immediate steps shall be taken to reduce environmental levels. Samples shall be taken every 30 days until the environmental level has been reduced below the standard.

(c) Records shall be maintained for all sampling schedules to include the sampling and analytical methods, types of respiratory protection in use (if applicable), and the air concentrations of mercury in each work area. Records shall be maintained so that each employee shall be able to obtain information on his own environmental exposure.

Section 2 - Medical

Comprehensive medical examinations (which should include complete urinalysis) shall be made available to all workers subject to "exposure to inorganic mercury" prior to employee placement and annually thereafter. (Elsewhere in the document, "exposure to inorganic mercury" is defined as exposure to a concentration of inorganic mercury greater than 40% of the recommended level in the workplace.) These examinations should place emphasis on any symptoms or signs of unacceptable mercury absorption such as loss of weight, sleeplessness, tremors, personality changes, or other evidence of central nervous system involvement.

Medical records shall be available to the medical representative of the employer and of the employee at his request. These records shall be kept for at least five years after the employee's last occupational exposure to inorganic mercury.



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Welding, Metal Processing, and Controls NO. 30 TIME: 50 minutes

Familiarization with hazards arising from welding and metal processing and with their controls.

Objectives. Enable the trainee to identify hazards associated with common metal processing operations and with metal fume producing processes; recognize the factors used to estimate hazards and the controls to put into effect.

Content.

- Dusts
- Common metal processing operations
- Metal fume producing processes
- Factors used to estimate hazards
- Controls in effect

Method. Lecture

Materials.

- Chalkboard, chalk, and eraser
- Slide Projector (35mm) and Screen or Suitable Wall
- Slides 25 - 46
- Visuals 30-1 through 30-6

Special Terms.

- Brazing
- Galvanizing
- MIG
- Plasma Spray
- Resistance Welding
- Soldering
- TCE vapor
- TIG

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Pages 566 - 576, 612 - 616.
2. Industrial Environment - Its Evaluation & Control. Pages 609 - 623.
3. Industrial Toxicology. Volumes I and II, pp. 190 - 204, 787, 1309, 2266, 2291, 2258 - 2266, 2302, 2304.

NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> Welding and metal processing produce a variety of hazards and contaminants including metal fume, gases, ultraviolet radiation, dusts, high noise levels, and heat stress. Toxicity of contaminants is a function of the materials involved, and exposures may vary greatly. Engineering control measures are primary and include: exhaust and dilution ventilation; surface preparation of metals; isolation of individual and incompatible operations; and operational and administrative measures. Protective equipment, a secondary control measure, includes hoods, shields, eye and ear protective equipment, special clothing, and respirators used in connection with a respiratory control program.

NOTES	INSTRUCTION
<u>Explanation-Lecture</u> Metal processing hazards Airborne dusts Evaluating dust exposures Particle size	<u>EXPLANATION - LECTURE</u> A. Metal processes encompass a variety of hazards inasmuch as they produce fumes, dusts, mists, gases, and vapors as well as certain physical stresses. A.1. Industries with extensive metal processing (i.e., aluminum, steel, automotive, battery manufacturing, and shipbuilding) run the gamut of hazards. Emphasis in this module is given to the metal fume produced by melting, cutting, and welding of metals. A.2. Airborne dusts arise from a variety of sources. (a) Grinding, cutting, machining, blasting of metals. (b) Handling of ores, powders, dry chemicals, sand, and asbestos. (c) Processing in industries such as mining, refining, cotton, asbestos, stone, and glass manufacture. A.3. When evaluating dust exposures, particle size must be considered because dusts have a wide range in size. Their size is dependent upon the source of generation. The penetration and retention of particles in the lungs is also dependent on particle size. Thus, the human physiological response is dependent on the size of the dust particles to which the particular worker is exposed.

NOTES	INSTRUCTION
Wet process methods Types of metal processing Metal fume Arc welding Slide 25 Types of arc welding	A.4. Dusty processes have a common potential for control in the application of water in the process and the employment of so-called "wet" process methods wherever possible. A.5. Welding, cutting, brazing, and soldering are quite common in industry. Metalizing, galvanizing, foundry and forge operations are also widely used. The hazards, stresses, and contaminants produced by these operations are discussed in this module. They exist amid others from auxiliary processes in the same environment. The industrial hygienist must consider the combined effects of all contaminants and stresses in making his evaluations. B. All processes that heat metal above the melting point produce metal fume. When temperatures of the metal exceed the boiling point, greater quantities of fume are generated. Each of the following metal-working processes are potential contaminant/stress generators. All of them generate fumes. B.1. Arc welding processes are those where the coalescence of metal is produced by heat developed from an electric arc between an electrode and the base metal (work piece). The processes may be with or without the use of filler metal or the application of pressure. Slide 25 shows the components of a typical arc welding circuit. There are a number of varieties of arc welding (shielded metal arc, submerged arc, gas-tungsten arc (TIG), gas metal arc (MIG), arc-spot, and carbon arc).

NOTES	INSTRUCTION
Arc welding hazards	In general, potential contaminant/stresses produced by arc welding may include:
	(1) <u>Metal fume</u> from base metals or coatings, electrode filler metal, or coating material. (2) <u>Gases</u> from electrode coating, flux. (3) <u>Ultraviolet</u>. (4) <u>Ozone and oxides of nitrogen</u>. (5) <u>Thoria</u> (alpha and some gamma radiation).
Gas welding	B.2. Gas welding processes are those where coalescence of metal is produced by heating with gas flame or flames, with or without filler metal or application of pressure. Slide 26 shows the internal make-up of a typical gas torch.
Types of gas welding	Types of gas welding include oxyacetylene, oxyhydrogen, oxygen-propane, natural gas, and methylacetylene propadiene. Potential contaminants/stresses produced by gas welding are: (1) fuel gases, usually simple asphyxiants with high TLVs; (2) fuel gases, potentially explosive if they leak in confined spaces; (3) metal fumes from base metal, metal coating such as paint, or filler metal (welding rod); (4) gases from flux.
Resistance welding	B.3. Resistance welding processes are those where coalescence of metal is produced from heat generated by resistance of the work to electric current. Filler metals and fluxes are not used.

NOTES	INSTRUCTION
Slide 27 Types of resistance welding Resistance welding hazards Brazing Soldering Types of brazing and soldering Brazing/soldering hazards Metal cutting Types of metal cutting	Examples of three types of resistance welding using the application of pressure, and the heat generated by the resistance to the flow of electricity, are shown in Slide 27. Types of resistance welding include spot, seam, projection, flash, and upset welding. Potential contaminants are: (1) Metal fume from base metal. (2) Metal dusts from grinding or machining of the welded area (flash removal). B.4. Brazing is a process wherein metal coalescence is produced by heating a filler metal above 800°F but below the melting point of the base metals. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action. Soldering is distinguished from brazing by use of a filler metal with a melting point below 800°F. The following types of brazing and soldering are in common use: torch, induction, dip, resistance, and soldering iron processes. Potential contaminants from these processes are: (1) Metal fumes from the base metal, coatings, filler, or solder. (Cadmium and lead are commonly used in solders.) (2) Gases from fluxes (commonly fluorides and halides). B.5. Metal cutting by heating methods employs gas flames or electric arcs. Types include oxyacetylene, propane, natural gas, plasma arc, and air arc.

NOTES	INSTRUCTION
Metal cutting hazards	Potential contaminants/stresses include: (1) Large quantities of metal fume. (2) Fume particles with high velocity and specific direction. (3) Intense ultraviolet light. (4) Ozone and oxides of nitrogen. (5) High noise levels.
Metallizing	B.6. Metallizing or thermal spraying is a process of increasing importance. The process deposits fine particles of metals, oxides, or plastics in a molten or semimolten condition to form a coating on a substrate.
Types of metallizing	For materials with a melting point below 5000°F, oxyfuel flame under pressure is used. For materials with a melting point over 5000°F, plasma spray is used. Potential contaminants/stresses include:
Metallizing hazards	Potential contaminants/stresses include: (1) Large quantities of metal fume. (2) High noise levels. (3) Intense UV (with plasma arc). (4) Ozone (with plasma arc).
Galvanizing	B.7. Galvanizing is a process that deposits molten zinc on a substrate (usually iron) through dipping. Potential contaminants/stresses include:
Galvanizing hazards	Potential contaminants/stresses include: (1) Fume and heat (molten zinc). (2) Silica and other dusts from abrasive blasting for surface preparation.

NOTES	INSTRUCTION
Foundry and forging operations Foundry hazards Forging hazards Hazard estimation Composition of the metal determines type of air contaminant	(3) Chemical treatment for surface preparation produces acid or caustic mist, gases, and liquids. B.8. Foundry and forging operations present a variety of hazards. Hazards involved in foundry operations are: (1) Melting operations—dusts, gases (CO, NO₂), heat stress, and metal fume. (2) Mold and core making—silica dust, solvent vapors, mists, and smoke. (3) Pouring—heat, aldehydes, fume, and hot metal. (4) Shake-out of molds—heat, gases, dust, and noise. Forging operation hazards are: (1) Heat stress. (2) Noise. (3) Vapors and contact—chemicals for treatment of forgings. (4) Carbon monoxide. (5) Lead fume and aldehydes from the vaporization of leaded oils used to lubricate dies. C. Various factors/hazard variables are inherent in metal-working processes and have a use in estimating the associated hazards. C.1. The metal composition influences the composition and the quantity of air contaminants.

MODULE Welding, Metal Processing, and Controls		NO. 30
NOTES	INSTRUCTION	
Alloys	Virtually any metal or combination of metals can be found in industry in the form of fume. Widely used metals are iron, copper, zinc, tin, nickel, and aluminum.	
	C.1.a. Most industrial metals are in the form of alloys (mixtures of metals). The following table shows common alloy compositions and examples of their use.	
	<u>Alloy Composition</u>	<u>Example of Industrial Application</u>
	Steels (Ni-Cr-Fe)	Virtually all industry
	Brass (Cu-Zn)	Plumbing, shipbuilding
	Bronze (Mn)	Artwork
	Be-Cu (commonly 2% Be)	Space vehicles, non-sparking tools
	Ni-Cu, -Cr, -Al, -Mn, -Mo, -Sn	Aircraft parts, jewelry, coinage
	Mg-Th-Zn	High strength-to-weight alloys
	Zn-Sn	Hydraulic brakes
Slide 28	Slide 28 illustrates the pouring of lead. Handling of an alloy of molten lead and tin is an operation involved in the casting of dies. Notice the personal protective equipment.	
Slide 29	Slide 29 illustrates TIG welding of aluminum. This is gas-tungston arc welding. To be effective as local exhaust ventilation, the duct end should be positioned closer to the fume source (within 18") and should be flanged.	
Slide 30	Slide 30 shows the composition of weldingfume from metal coatings.	

NOTES	INSTRUCTION								
Metallic and non-metallic coatings	C.1.b. Many objects are coated with another material. Coatings may be metallic or non-metallic.								
Metallic coatings	Examples of metal-plated coatings and their industrial uses are: <table><tr><th>Material</th><th>Purpose</th></tr><tr><td>Zinc, Cadmium, Tin</td><td>For corrosion resistance</td></tr><tr><td>Copper</td><td>For electrical or thermal conductivity</td></tr></table>	Material	Purpose	Zinc, Cadmium, Tin	For corrosion resistance	Copper	For electrical or thermal conductivity		
Material	Purpose								
Zinc, Cadmium, Tin	For corrosion resistance								
Copper	For electrical or thermal conductivity								
Paints and primers	Two examples of paints/primers and their industrial uses are the lead-based paints/primers for corrosion prevention and the mercury-based paints/primers for fungicidal and anti-fouling paints.								
Other Coatings	Examples of non-metallic coatings are teflon (polytetrafluoroethylene) for high-temperature applications and epoxy, polyurethane plastics, cosmoline and other greases for inhibiting corrosion								
Electrode and weld rod composition	C.2. Electrode and weld rod composition is important since some of the electrode or welding rod metal is vaporized and produces fumes.								
Slide 31 (Visual 30-1)	Slide 31, electrode and welding rod filler materials, shows examples of metals that may be found in welding electrodes.								
Elevated heating of solders	C.3. Elevated heating will cause solders to produce metal fumes. Commonly used solders have the following compositions: <table><tr><td>Sn-Pb</td><td>Sn-Ag</td><td>Pb-Ag</td><td>Cd-Zn</td></tr><tr><td>Sn-Sb</td><td>Sn-Zn</td><td>Cd-Ag</td><td>Zn-Al</td></tr></table>	Sn-Pb	Sn-Ag	Pb-Ag	Cd-Zn	Sn-Sb	Sn-Zn	Cd-Ag	Zn-Al
Sn-Pb	Sn-Ag	Pb-Ag	Cd-Zn						
Sn-Sb	Sn-Zn	Cd-Ag	Zn-Al						

MODULE	Welding, Metal Processing, and Controls	NO. 30
NOTES	INSTRUCTION	
	Those that contain lead or cadmium pose the more significant potential health hazard.	
Slide 32	Slide 32 shows spools of solder. These are spools of 40/60 lead-tin solder and soldering tools. Solder composition may not be clearly identified. Fluxes are contained in the cores.	
Flux materials for surface preparation	C.4. Flux materials are used to clean the metal surface, to enhance metal flow and bonding, and in some cases to envelop the weld with a non-oxidizing atmosphere.	
	Flux materials are found as electrode coatings and in granular, paste, liquid, and gaseous form. Some solders include the flux in the metals. More detailed information may be found in the flux manufacturer's data.	
Slide 33 (Visual 30-2)	Slide 33 shows fluxes used in metal processes. These are the general categories of fluxes used in weldings, soldering, and brazing.	
Other factors in hazard estimation	C.5. Other factor/variables considered in hazard estimation include:	
Toxicity of contaminants	(a) Following are examples of the toxicity of contaminants.	
Slide 34 (Visual 30-3)	Slide 34 shows examples of metal oxide fume. Common metal oxide fumes produced by welding are listed along with their inhalation toxicological effects.	
Slide 35 (Visual 30-4)	Slide 35 illustrates welding contaminants and examples of gases. These are all common gases produced by welding operations with their common source and inhalation effects.	
Intensity of hazard	(b) Indications of the amount or intensity of the hazard may be obtainable. For example, in the case of welding, cutting, or	

NOTES	INSTRUCTION
Characteristics of the contaminant Respirability Velocity and direction Toxicity of metal dust Slide 36 Slide 37 Role of contaminant characteristics in hazard evaluation Ozone production	soldering, temperatures and amperage used and the rate of rod, filler metal, and flux consumption are indicators of the hazard for a given area. (c) Another factor/variable important to recognize is the characteristic(s) of the contaminant/stress. 1. Virtually all fume is respirable. 2. Fume that has velocity and direction may be more difficult to control. 3. Toxicity of a metal dust may be different than that of a metal fume (for example, cadmium TLV). Slide 36 shows manual air arc cutting. This operation utilizes a copper clad rod under compressed air, which produces a high degree of metal fume from the base metal and from the copper coating. Noise from high-pressure air and high-velocity particles are present. In Slide 37, high-velocity compressed air creates a noise hazard for workers involved in plasma spray operations. Other hazards are ultraviolet radiation and air contaminants. C.6. Characteristics of the contaminant/stress must be considered in hazard evaluation. Control of gases at the point of welding is normally accomplished by local exhaust ventilation used to capture fume. However, ozone may be produced at distances away from intense ultraviolet arcs (MIG, plasma arc).

NOTES	INSTRUCTION
Noise exposure Inhalation of toxic materials Slide 38 (Visual 30-5) OSHA control standards Surface preparation of metals in enclosed areas Visual 30-5 Ventilation requirements	Noise exposure may be continuous or intermittent. Welding or grinding of thoriated tungsten electrodes may result in inhalation exposure to radioactive thoria. Slide 38 shows controls for fume-producing operations. This summarizes engineering controls required for the application of heat to some metals. D. OSHA control standards require that feasible engineering and administrative controls be implemented wherever practicable prior to use of respiratory protective devices. Requirements include surface preparation of metals with toxic coatings and provision of local exhaust and/or dilution ventilation. Surface preparation of metals with the following coatings is required prior to heat application in enclosed spaces: lead, cadmium, chromium, mercury, and highly flammable coatings. D.1. Visual 30-5 shows controls for welding, cutting, and fume producing operations for eight selected metals. Note that controls which are required by OSHA are indicated by the letter "R". The letter "A" indicates good practice. Surface preparation of metals with the following coatings should be done prior to heat application as accepted good practice: organic coatings, epoxies, urethane, antimony, copper, zinc, polytetrafluorethylene (Teflon), and cosmoline. D.2. Minimum ventilation requirements are established for some toxic and non-toxic metal fumes, as shown in Visual 30-5. These requirements are applicable to any process which produces fumes (i.e., metal-pouring, galvanizing, melting, welding, and cutting).

NOTES	INSTRUCTION
Slide 39	Slide 39 shows a typical weld shop with operator positions and local exhaust provisions.
Contaminant velocity	Some processes impart such high velocities to contaminants that more than 100 linear feet per minute capture velocity is required for ventilation, and consideration must be given to particle direction. Two hundred feet per minute capture velocity is recommended for metallizing booths.
Isolating incompatible operations	D.3. It is important to recognize that certain operations are mutually incompatible and must be isolated from one another. Examples of this are as follows.
Halogenated hydrocarbons	D.3.a. Halogenated hydrocarbons. (1) The use of chlorinated solvents is prohibited within 200 feet of inert gas metal arc welding. Surfaces prepared with chlorinated solvents shall be thoroughly dry prior to welding. The potential contaminant is phosgene resulting from the action of ultraviolet or heat on the chlorinated solvent. (2) The same criteria is valid for other areas where intense ultraviolet is present (for example, in plasma spray). (3) Trichloroethylene and perchloroethylene, when present in air at the TLV and near welding operations, decomposes to form phosgene in dangerous quantities. (4) It is accepted good practice to restrict the use of other halogenated hydrocarbons in

NOTES	INSTRUCTION
Slide 40 Flammables Shields and barriers Slide 41 Booths and ventilated enclosures	welding areas, even though not chlorinated, because they decompose to form acid gases. Slide 40 shows a trichloroethylene vapor degreaser. Isolate the typical vapor degreaser from arc welding and/or any other ultraviolet source (for example, some photo reproduction processes). D.3.b. Flammables may be used only where there are no open flames or other sources within a minimum of 50 feet of the operation. D.3.c. Shields, barriers, booths, and enclosures for isolation of incompatible operations. (1) Shields and barriers are used to isolate ultraviolet radiation from areas where unprotected personnel may be working or where chlorinated hydrocarbons may be used. Slide 41 shows a MIG welding barrier. In MIG welding behind ultraviolet barriers, the barriers block ultraviolet from the outside area. Light-colored barriers reflect more ultraviolet than dark-colored barriers, which increases the operator's skin exposure. (2) Booths and ventilated enclosures provide local exhaust ventilation as well as some ultraviolet shielding. Ventilating walk-in welding booths or hoods are a preferable control method in fixed welding shops. A completely ventilated enclosure is preferable for heating, grinding, and machining on highly toxic materials such as beryllium.

NOTES	INSTRUCTION
Personal protective equipment	D.4. Protective equipment, where applicable, should be used in emergency situations or where abnormal excursions of contaminant or stress occur.
Welding helmets and hoods	<u>Protective equipment should not be used as a primary control method.</u> All feasible engineering and administrative controls should be employed first. Some work requires use of protective equipment during normal operations in addition to all other controls in use. For welding and cutting workers, the following protection equipment is necessary.
Slide 42	D.4.a. Welding helmets or hoods provide eye and face protection from ultraviolet, sparks, and slag. <u>They do not provide respiratory protection</u> from metal fume, dust, or gas.
Welding hoods for high-intensity ultraviolet	Slide 42 shows a welder's hood. The operator is doing shielded metal arc welding with appropriate ultraviolet protection by hood. Note absence of welding gloves.
Face shields	D.4.b. Welding hoods for high intensity ultraviolet are those using darker lenses and are required with MIG, TIG, plasma arc, and other sources of intense ultraviolet.
Placards denoting areas where eye/ear protection needed	D.4.c. Face shields are required when working with molten metal, particulate matter from grinding, and spatter from other metal working operations. If face shields are not used, eye protection must be provided for <u>all</u> personnel around welding, cutting, melting, and grinding areas.
	<u>Operations and areas requiring eye/ear protection shall be conspicuously marked. Use Eye Protection Placards.</u>

NOTES	INSTRUCTION
Slide 43 Special protective clothing Slide 44 Hearing protection equipment Slide 45 Respiratory protective equipment	Slide 43 shows an eye protection placard. Note the conspicuous warning of the need for employees to use eye protection devices. D.4.d. Special protective clothing may be needed for some workers. Usual work clothing, including long-sleeved shirt and gloves, will normally provide body protection from ultraviolet. High-intensity ultraviolet requires additional protection. Leather aprons provide some protection from sparks and slag. More complete protection is provided for foundry personnel by special clothing. Slide 44 shows protective equipment for lead pouring. The protective equipment used during the pouring of molten lead and tin is comprised of hard hats, aluminized asbestos jackets, gloves, face shields, and metal fume cartridge respirators. D.4.e. Hearing protection equipment, such as ear plugs or ear muffs, are required for noise exposures above standards. Air arc and plasma arc operations are high noise level processes. Some modern welding hoods are constructed so that ear muffs may also be worn. Slide 45 shows hood and ear muffs—compatible ear and ultraviolet protection. D.4.f. Respiratory protective equipment can provide valuable supplementary respiratory protection for work situations where other control measures are not feasible or adequate. Such protection should be available for abnormal, emergency situations and should be of the approved type for such situations. In all cases, the use of respiratory equipment shall be in accordance with an established

NOTES	INSTRUCTION
Slide 46 (Visual 30-6) Respiratory protection program Types of respirators	respiratory protection program. The employer is responsible for establishing and maintaining a respiratory protection program. Slide 46 shows welding respirators suitable for use under welding hoods. The airline respirator has an advantage in that environmentally controlled air is supplied. The cartridge respirator allows more operator mobility. (See also Visual 30-6.) Prescription of respiratory protective devices or other control measures to maintain exposures below permissible limits must be performed by a competent industrial hygienist or other technically qualified person. A good respiratory protection program includes: (1) Written procedures and employee instruction. (2) Cleaning and maintenance of respirators. (3) Surveillance of work area conditions and of employee exposure. (4) Use of respirators approved or accepted by the U. S. Bureau of Mines/U. S. Department of Agriculture. There are two general types of respirators: airline respirators and cartridge respirators. The airline respirators are full-face, air-supplied respirators. They are not generally suitable for use by welders. Cartridge respirators must be used within the limits of their approval. There are some cartridge respirators designed for use with a welder's hood. However, many respirators will not fit under welding hoods.

NOTES	INSTRUCTION
Temporary control measures Visual 30-6	Secondary or temporary control measures for respiratory protection requires the availability and proper use of good respiratory equipment. If engineering controls are not feasible or while they are being instituted, some work with toxic metal requires the use of respirators. (See Visual 30-6 for examples.) <u>Imminently dangerous exposures should have respiratory protection prescribed immediately.</u> For example, workers handling molten cadmium in the absence of ventilation controls need immediate respiratory protection.

NOTES	INSTRUCTION
<u>Summary</u>	<u>SUMMARY OF KEY POINTS</u> A. Metal processes encompass a variety of hazards inasmuch as they produce fumes, dusts, mists, gases, and vapors as well as certain physical stresses. B. All processes that heat metal above the melting point produce metal fume. C. Various factors/hazard variables are inherent in metal-working processes and have a use in estimating the associated hazards. D. OSHA control standards require that feasible engineering and administrative controls be implemented wherever practicable prior to use of respiratory protective devices.

TYPE OF ELECTRODE	AWS REF	FILLER MATERIALS PRESENT																			
		Ag	Al	B	Be	Cd	Cr	Cu	Fe	Mg	Mn	Mo	Ni	P	Si	Sn	Th	Ti	W	Zn	Zr
Mild Steel	A5.1-69						T		P		S	T	T		T			T			
Aluminum & Aluminum Alloy	A5.3-69		P					T	T		T				T					T	
Brazing Filler Metal: Silver Cu-P Mg Ni Cu & Cu-Zn	A5.8-69	P																			
		S	S			S		S	P	P			T	S						S	
Tungsten	A5.12-69																T		P		T
Titanium & Titanium Alloy	A5.16-T		S				S					S				S		P			
Magnesium & Magnesium Alloy	A5.19-69				T			T	T	P	T										
P - Predominant Metal		S - Significant Amounts (>1%)										T - Trace Amounts (<1%)									

P - Predominant Metal S - Significant Amounts (>1%) T - Trace Amounts (<1%)

EXAMPLES OF ELECTRODE AND WELD ROD FILLER MATERIALS (AWS)

CATEGORY	TYPES OF FLUXES		REFERENCES
Brazing Fluxes	Borates (Na, K, Li, etc) Fused borax Fluoborates (Na, K, Li, etc) Fluorides (Na, K, Li, etc) Chlorides (Na, K)	Acids (boric, calcined boric) Alkalies (KOH, NaOH) Wetting Agents Water	"Brazing Manual" AWS, Ch. 4; "Welding Handbook" Sect 3B, 6th Ed., AWS, Ch. 10
Soldering Fluxes	<u>Highly Corrosive</u> Aluminum Chloride, NH ₄ Cl, NaCl, KCl, LiCl, Stannous Chloride, HCl NaF, KF, BF ₃ , HF Fluoboric Acid	<u>Intermediate</u> Organic Acids - Lactic, Citric, Oleic, Benzoic Organic Hydrohalides - Hydrazine, Hydrochloride Cetyl, Trimethyl Ammonium Bromide Amines - Urea, Glycerol	"Soldering Manual" AWS, Ch. 3 "Welding Handbook" Sect 3A, 6th Ed., AWS, Ch 46
Powdered & Granular Welding Fluxes	<u>Fused Fluxes</u> Silica Metal Oxides Halide Salts	<u>Bonded Fluxes</u> Oxides of Mn, Al, Si, Ti, Zr Silico-manganese, ferro- manganese, ferro-silicon Halide Salts	AWS A5.17-69
Welding Electrode/rod Flux Cores, Coatings, & "Gas Fluxes"	<u>Flux Cored Electrodes</u> Al Cr Mn Ni	<u>Coated Electrodes</u> Cellulose Ti, Cu "Mineral Coating" Fe Powder "Lime" (sodium carbonate)	AWS 5.20-69 "Welding Handbook" Sect 3B, 6th Ed AWS Ch 58, Ch 60 Ibid, Sect 2, 6th Ed, AWS, Ch 22, 23

EXAMPLES OF FLUXES USED IN METAL PROCESSES

Visual 30-2

METAL OXIDE FUME (From base metal or alloy; metal coating; electrode filler metal or coating)	TLV (mg/m ³)		INHALATION TOXICOLOGICAL EFFECTS*	
	OSHA (29 CFR Part 1910.93)	ACGIH (1971)	ACUTE	CHRONIC
ALUMINUM	-	10.0	Relatively inert	Relatively inert; aluminum oxide fume and/or dust may be a contributor to "Shaver's Disease", but not proven.
BERYLLIUM	0.002 (8 hr avg) 0.005 ("C") 0.025 (max peak)	0.002	Respiratory irritation including pneumonitis. Sometimes fatal.	"Berylliosis". Dyspnea and chronic cough, weight loss, anorexia, systemic effects. Sometimes fatal.
CADMIUM	0.1 (8 hr avg) 3.0 ("C")	0.1 ("C")	"Metal fume fever" with severe lung irritation which may result in death due to pneumonitis. Irritation is a poor index of exposure.	Emphysema, kidney injury, anemia. Sometimes fatal.
COPPER	0.1	0.1	"Metal fume fever" with respiratory irritation.	Liver, kidney, spleen effects. Anemia.
IRON	10.0	10.0	Relatively inert	"Siderosis", a benign pneumoconiosis.
LEAD (OSHA Target contaminant)	0.2	0.15 (intended)	Primarily a chronic poisoning. Early signs: blood changes, colic, neuritis.	Chronic poisoning may cause encephalopathy, changes in bone marrow and blood cells, palsy, chronic kidney disease. "Lead Line".
TIN	-	10.0 (as SnO ₂)	Relatively inert	"Stannosis", a benign pneumoconiosis.
ZINC	5.0	5.0	"Metal fume fever" or "Zinc chills" from which recovery occurs within 24 hours.	No significant chronic effects reported.

*Reference: Patty, Vol II, and Hygienic Guide Series, AHA

WELDING CONTAMINANTS - EXAMPLES OF METAL OXIDE FUME

Visual 30-3

GAS	TLV (ppm)		CONTAMINANT SOURCES	INHALATION TOXICOLOGICAL EFFECTS*	
	OSHA (29 CFR, 1910.93)	ACGIH (1971)		ACUTE	CHRONIC
Fluoride gases (as HF)	3.0	3.0	Flux materials, decomposition products of fluoride-containing coatings.	Nasal irritation and nosebleeds, possibly leading to pulmonary edema.	"Fluorosis", including increased radiographic density of bones and possibly anatomical abnormalities.
Other acid gases	eg, HCl 5.0-"C"	eg, HCl 5.0-"C"	Flux materials, decomposition products of coatings.	Respiratory irritation sometimes leading to pulmonary edema.	Respiratory damage, possible systemic effects with some acid gases.
Oxides of Nitrogen (as NO ₂)	5.0	5.0-"C"	Arc or shielded arc welding on stainless steel.	Respiratory irritation sometimes leading to fatal pulmonary edema and hemorrhage. 200-400 ppm is rapidly fatal.	Respiratory damage, possible blood effects.
Ozone	0.1	0.1	From UV produced by arc welding, plasma arc, and notably inert gas shielded arc.	Respiratory irritation sometimes leading to pulmonary edema. Headaches. Exposure to 50 ppm for >1hr is likely to be fatal.	Chronic bronchitis, emphysema, acceleration of lung diseases. Radiomimetic effects.
Phosgene (carbonyl-chloride)	-	0.1	Decomposition products of chlorinated hydrocarbons in the presence of heat or UV.	Severe respiratory irritation sometimes resulting in delayed pulmonary edema, emphysema or bronchitis. Exposure to >50ppm is likely to be fatal.	Emphysema and lung fibrosis.

*Reference: Patty, Vol II, and Hygienic Guide Series, AIHA

WELDING CONTAMINANTS - EXAMPLES OF GASES

METAL:	CONTROLS				
	Surface preparation prior to heat application (coatings)	Local exhaust ventilation or booths (100fpm capture velocity)	2000cfm general dilution per operator	Airline respirators	None
Base metal or alloy					
Metal coating					
Electrode filler metal or coating					
Solder					
ALUMINUM			1		1
BERYLLIUM	R	R		R 2	
CADMIUM	R	R		3	
COPPER	A	A	1		1
IRON			1		1
LEAD*	R	R		3	
TIN		A	1		1
ZINC	A	R		3	

*OSHA "Target" R = Required by OSHA (29 CFR Parts 1910 and 1926)
 A = Not required by OSHA, but is accepted good practice

1 No ventilation is required for "non-toxic" metals when:

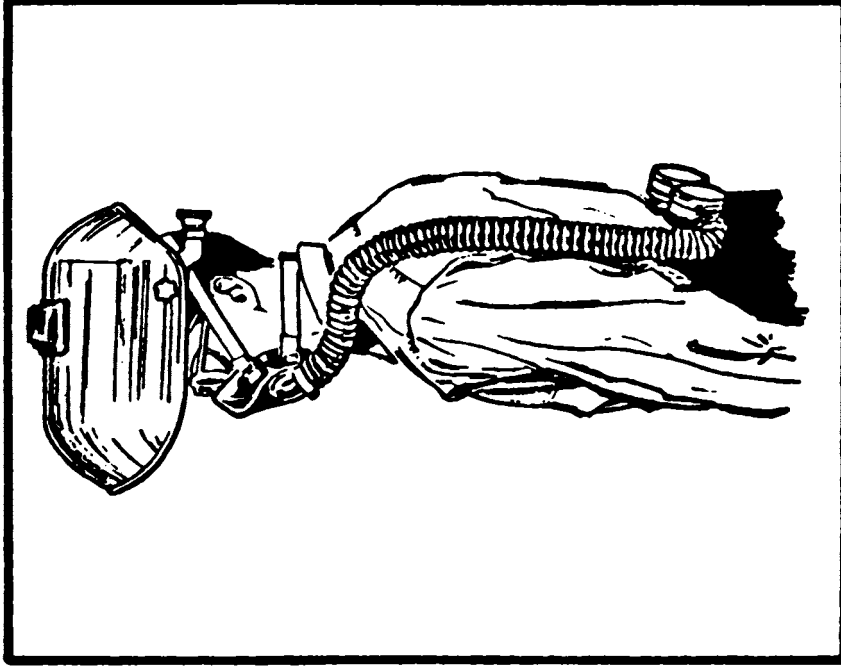
- (1) Volume of area is at least 10,000 cubic feet per welder, and
- (2) Ceiling height is at least 16 feet, and
- (3) There are no significant restrictions to air movement.

If any of the above are not satisfied, a minimum of 2000 cfm general ventilation per welder is required. Additionally, respiratory protection is required if exposures exceed the TLV.

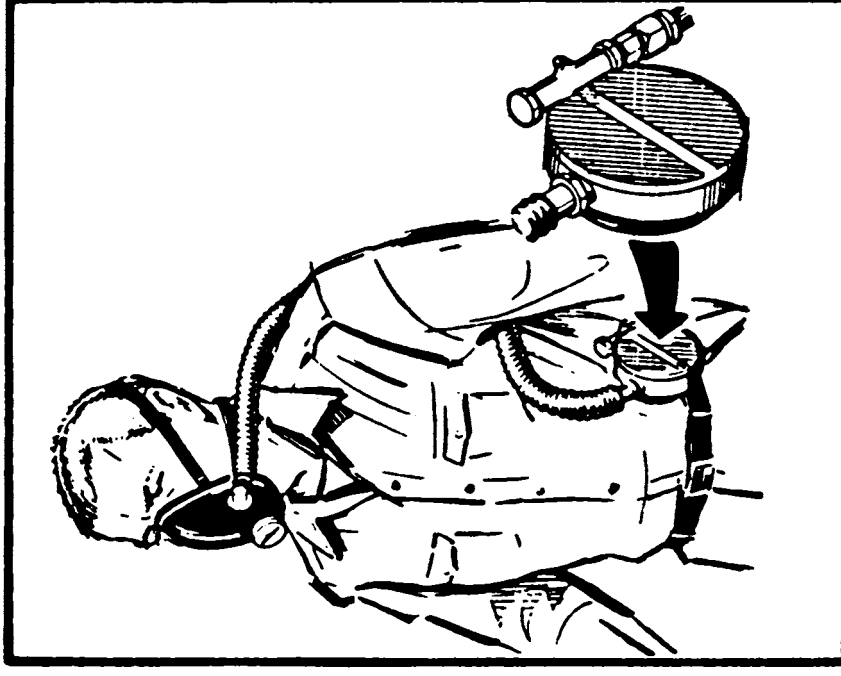
2 Air supplied respirator is required in addition to local exhaust ventilation for heating of beryllium, unless atmospheric sampling under "worst case" conditions reveals exposures below TLV. Total enclosure is recommended whenever possible.

3 Air supplied respirator is required if surface preparation of toxic metal coating is not performed to 4 inches from the area of heat application, or if the use of local exhaust or booth is not feasible.

CONTROLS FOR WELDING, CUTTING AND FUME PRODUCING HEAT APPLICATION FOR SELECTED METALS



WELDING FUME CARTRIDGE
DUST AND FUME PROTECTOR



AIR LINE, HALF MASK,
CONSTANT FLOW, LOW PRESSURE

WELDING RESPIRATORS

Visual 30-6



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Welding and Metal Workshop **NO. 31** **TIME:** 50 minutes

Practice in surveying welding and metal operations.

Objectives. Enable the trainee to evaluate hazardous processes through

Knowledge of typical conditions;
Recognition of hazardous conditions;
Application of survey techniques;
Recall of information from other sources.

Content. Case studies of the following welding and metal processes:

Gas Cutter
Weld Booths (TIG Welding)
Open Welding
Plasma Spray

Methods. Lecture-Demonstration (Optional)
Simulated observation and group problem-solving

Materials. Chalkboard, chalk, and eraser
Slide Projector (35mm) and Screen or Suitable Wall
Slides 53 - 81
Visuals 31-1 - 31-3

Optional Movie Projector
Film "Industrial Exhaust Hoods" (6 minutes)
Ventilation Smoke Tubes

Special Terms. Welding and metal processes and related terms, including

MIG
Plasma Spray

TIG
Ventilation Smoke Tube

REFERENCES

Basic References

Refer to Module 30.

1. OSHA Regulations, June 27, 1974. Part 1910.252(e)iii.

Other References

1. ACGIH. Industrial Ventilation - A Manual of Recommended Practice. 12th Edition. Lansing, Michigan: Edward Brothers, Inc., 1972.
2. Carson, Gordon B. Production Handbook. 2nd Edition. New York: The Ronald Press Company, 1959.

If not available, select another similar reference.

MODULE	Welding and Metal Workshop	NO. 31
NOTES	INSTRUCTION	
<u>Introduction</u> Metal processing Followup of Module 30 Six problems Directions Work Plan Separate into groups. Read the problem. Watch and listen. Do the evaluation. Prepare for discussion. (May follow each problem or the entire set.) Start.	<u>INTRODUCTION</u> This workshop concentrates on welding, cutting, metal processing and controls. It builds upon and lets you apply some of what you have learned in Module 30. There are six problems in this workshop that give you the chance to practice surveying metal processing operations that are typical in manufacturing. <u>DIRECTIONS</u> Since this workshop contains 6 problems, we will work in groups. This will permit us to finish in 50 minutes. Here is the plan of action: 1. Separate into small groups around the room in places convenient for viewing slides and doing paperwork. 2. Read the information about the first problem quickly to get an idea of what is to be done. 3. Watch and listen while the slides are being projected. 4. Work on the problem exercises for about 5 minutes or so. 5. Be prepared to answer and discuss the questions in the class group as a whole. You may want to select a spokesman for this purpose. Ready? Let's begin.	

NOTES	INSTRUCTION
<u>Lecture - Demonstration</u> Film (optional) Demo (optional) Slide 53 <u>Caution!</u> Estimating Techniques ACGIH, 1972 Slide 54 Hanging Hoods Slide 55 (Visual 31-1)	<u>LECTURE - DEMONSTRATION</u> The film "Industrial Exhaust Hoods" shows typical uses of exhaust hoods. Factors affecting ventilation efficiency are distance, cross currents, and relationship of the worker to the contaminant. We can estimate velocities and capture efficiency with Ventilation Smoke Tubes. MSA Ventilation Smoke Tubes The mine safety appliance shown here is used to estimate the velocity of air flow. <u>CAUTION.</u> Ventilation smoke tubes contain titanium tetrachloride which decomposes upon air contact to hydrochloric acid gas. Keep the smoke away from your faces. Estimating velocity should be done at the face of hoods, point of work, and/or worker's exposure area. Check several points. These are <u>ESTIMATING TECHNIQUES ONLY</u>. One hundred linear feet per minute is a widely used control velocity. You can find specific control velocities in "Industrial Ventilation - A Manual of Recommended Practice." Smoke Tube at Face of Hood This is an example of little or no capture by a ventilation system. A method for estimating effectiveness of freely hanging hoods for welding follows: A capture velocity of 100 fpm towards the hood is required in the zone of welding. Estimating Velocities You can estimate air velocity at the face of a duct by using the ventilation smoke tube.

NOTES	INSTRUCTION
Slide 56 Slide 57 Slide 58 Slide 59 Slide 60 (Visual 31-2) Slide 61 (Visual 31-3)	A smoke tube may be used (as previously discussed) at varying distances from the centerline of the duct. Viewing of the capture success of welding fume may also be used. The distance where 100 fpm velocity is estimated is the <u>greatest distance</u> that the welder may place the duct away from his work and still have the required control velocity. TIG Welder with Freely Hanging Hood This is an example of a freely hanging hood that you may see in use. This hood is probably too far away from the work to capture the fume. Velocity over 100 fpm: Air velocity is probably over 100 feet per minute. Velocity about 100 fpm: Air velocity is probably about 100 feet per minute. Velocity under 100 fpm: Air velocity is probably under 100 feet per minute. Estimating velocities - Composite All three velocity examples are combined in this slide. <u>SURVEY OF WELDING AND CUTTING OPERATIONS</u> We will now start work on solving some problems. First, we will describe and illustrate the situation. The following description will enable you to assess this operation for industrial hygiene hazards. The problem centers around the welding building in the plant of the ABC Metal Works. ABC Metal Works Layout This is a plan view of the plant in which the problems are located.

NOTES	INSTRUCTION
Description	<u>Description</u> ● The building has 70-foot ceilings, and two large equipment doors which are left open in favorable weather. (Volume: approximately 7 million cu. ft.) ● No mechanical dilution ventilation is provided, although 5 heater-fan assemblies are provided for heating the area. ● There are routinely from 10-15 simultaneous manual MIG, TIG, and shielded metal arc welding operations as well as manual oxyacetylene cutting and air arc cutting operations. ● All welders are provided with welders' hoods, coveralls and gloves. No respiratory protection is provided. ● The natural gas cutter in the main bay is provided with local exhaust ventilation but the cutter in the adjacent shed is not. ● An exhaust plenum and drop is provided for four permanent weld booths. Only one weld booth is in use, with the remainder of the activity being performed in the open bay with no local exhaust. ● Plasma spray operations are isolated, and will be discussed in Problem 31-F. ● The metals used are mild steel and aluminum.

Problem 31-A. Gas Cutter (Main Bay)

1. How would you evaluate the industrial hygiene hazards in this situation?

<u>Potential Hazards</u>	<u>None</u>	<u>Recommended Action</u> <u>Further Study Req'd.</u>	<u>Immediate Corrective</u> <u>Action/Specify</u>

Noise	_____	_____	_____

Metal Fume	_____	_____	_____

Comments: _____

Problem 31-B. Weld Booths (TIG Welding)

For each of the following, indicate with comments the recommended action in terms of "none", "further study required", and/or "immediate corrective action required."

1. Metal Fume: _____

2. Ozone: _____

3. Thorium: _____

4. UV: _____

5. Ventilation Use Recommendations: _____

Comments: _____

NOTES	INSTRUCTION
Problems 31-C and 31-D Description Slide 70 MIG Welding TIG Welding Slide 71 Slide 72 Personnel Hazards	PROBLEMS 31-C and 31-D. OPEN WELDING AREA <u>Description</u> Semi-Automatic MIG Welding A semi-automatic MIG welding unit is welding steel. ● Between 8 and 13 individuals are performing simultaneous MIG welding on stainless steel, TIG welding (non-thoriated) on aluminum, and shielded metal arc (with mild steel electrodes). One individual is air arc cutting mild steel with copper clad rods. ● All MIG and TIG welding uses argon as the shielding gas and predominantly iron and aluminum (respectively) as the filler metals. The MIG and TIG welding areas have UV barriers in place. Electrical odor is faintly noticeable from time to time. Air Arc Cutting (Personnel Exposed) There is no UV protection, no respiratory protection and no hearing protection on bystander. Air Arc Cutting Operator is using copper clad rod. Fume would be from base metal and rod. Other hazards are ozone, UV and high noise. ● Air arc cutting is performed by one individual. Copper clad rods are used to cut mild steel. There are no barriers around the operation. The operator has a suitable hood, but wears no respiratory or hearing protection. At 5 feet away, you must shout to be heard at arm's distance and you observe a noticeable metallic taste and odor.

MODULE Welding and Metal Workshop		NO. 31
NOTES	INSTRUCTION	
Problem 31-E Description Slide 73 Outside View Slide 74 Inside View Slide 75 Cutting Operation	- You can feel air movement from the two open doors, but there is some accumulation of smoke at the ceiling level. Away from the air arc area, there is a noticeable but not strong metallic odor. PROBLEM 31-E. NATURAL GAS CUTTER (OUTSIDE SHED) <u>Description</u> The cutter is located in a shed measuring 36' x 45'. The roof is slanted, being 25' at its highest point and 10' at its lowest point. (Volume approximately 10,500 cu. ft.) Outside - Gas Cutting Shed The natural gas cutter is located in this building. It is the gas cutter which will be discussed in this section of the example. - Two doors are located on the north and south walls. The front door is open and the back door is partially open, with 2 man-cooling fans positioned in front of it. You can feel some air movement at the doorway. The cutter does not have local exhaust. Inside - Gas Cutting Shed The cutter has no local exhaust. Notice the poor illumination. - The room is dark in all corners and dimly lit at the work. Shadows are evident. Here the gas cutting unit has just started a pass. - The operator has just started cutting as you enter. He is wearing dark goggles. After about 5 minutes, a visible fume accumulation is noticeable at the ceiling level, as well as a strong metallic odor.	

Problem 31-C. Open Welding Area (Except Air Arc)

Indicate with comments if the following controls are: adequate, marginal (needs evaluation), or requires immediate corrective action.

Ventilation for fume: _____

Ventilation for ozone: _____

Ultraviolet (UV) Barriers: _____

Problem 31-D. Open Welding Area (Air Arc Cutting)

Consider the situation of Problem 31-C and evaluate to include Air Arc Cutting. Indicate with comments the recommended action for the following potential hazards, in terms of: None, Requires further study, and/or Immediate corrective action required.

Iron and Copper Fume: _____

Noise: _____

Visitor or transient exposures to UV and noise: _____

Problem 31-E. Natural Gas Cutter (Outside Shed)

Evaluation Exercises.

1. Comment, giving recommended action in terms of: none, further study, and/or immediate corrective action for the following operations. (Assume the operator performs cutting for 5 hours a day, with 2 hours spent in the room for layout, etc.)

Natural Gas Cutting of Mild Steel: _____

Cutting of Steel With Lead Primer: _____

Illumination? _____

MODULE	Welding and Metal Workshop	NO. 31
NOTES	INSTRUCTION	
Problem 31-F Plasma Spray Survey Description Slide 76 Slide 77 Slide 78	PROBLEM 31-F. SURVEY OF PLASMA SPRAY OPERATIONS In this problem you are asked to survey plasma spray operations and evaluate conditions from an industrial hygiene standpoint. <u>Description</u> The plasma spray room is isolated from other operations. A walk-in hood is provided. It is difficult to open the outward opening door to this room with the hood operating (negative pressure). Plasma Spray Room The industrial hygienist enters the plasma spray room. Eye protection warning sign on door for intense UV. Note absence of noise placarding. - Aluminum parts to be coated with a chromium carbide-nickel aluminide coating. The plasma spray gun is water cooled and uses Argon (150 cfh @ 120 psi) as the primary gas. It is placed in a fixed position in the hood and applies the coating to parts rotating on a lathe. The plasma arc temperature is in excess of 12,000° F. Plasma Arc Hood A photo of a walk-in hood for isolation of the plasma spray equipment. - Prior to metallizing, the aluminum parts are abrasive blasted with silicon carbide grit (0.85% by weight free silica, max.) in an exhaust ventilated glove box. Plasma Arc Spray Gun The plasma arc spray gun in a close-up.	

NOTES	INSTRUCTION
Slide 79 Observations Blasting Talking Slide 80 Sound Pressure Odor	Glove Box This shows the exhaust-ventilated glove box used for abrasive blasting of parts prior to metallizing. The access door is open. Notice the gloves on the left. <u>Observations</u> • There is no noticeable escape of dust from the glove box during abrasive blasting. • With only the hood in operation, it is not necessary to shout at arm's length to be heard but a raised voice is necessary. Plasma Spraying The plasma spray gun is in operation. • During plasma spray operation, it is impossible to talk at arm's distance even when shouting. When you remove your ear plugs, you do not feel pain but have a "pressure-like" feeling in your ears. The noise is a hissing, high-frequency sound. • The arc, even viewed through protective goggles, is very intense. There is no noticeable electrical or metallic odor next to the operator at the face of the hood. Visible particulates remain in the hood. • A ventilation smoke tube test at the face indicates greater than 100 fpm and approximately 100 fpm velocity is estimated several feet in front of the hood.

NOTES	INSTRUCTION
Slide 81	Operator With Hood and Ear Muffs This is a compatible equipment combination. Plasma spray operator wearing UV hood, ear muffs, aluminized asbestos jacket and work gloves for hand plasma spraying. Only hood and ear protection are needed when unit is remotely operated. ● The operator is wearing a hood with very dark glass (he says shade 12) and ear muffs.

Problem 31-F. Plasma Spray Operation

Indicate recommended action in terms of: none, further study, and/or immediate corrective action required, and comment on the following potential hazards.

1. Abrasive blasting: _____

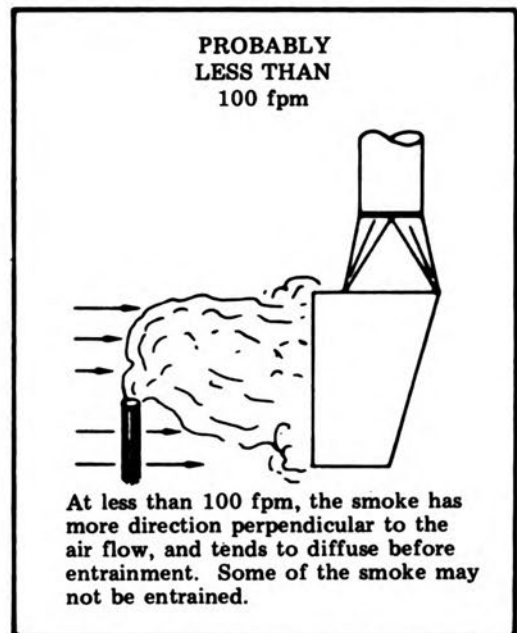
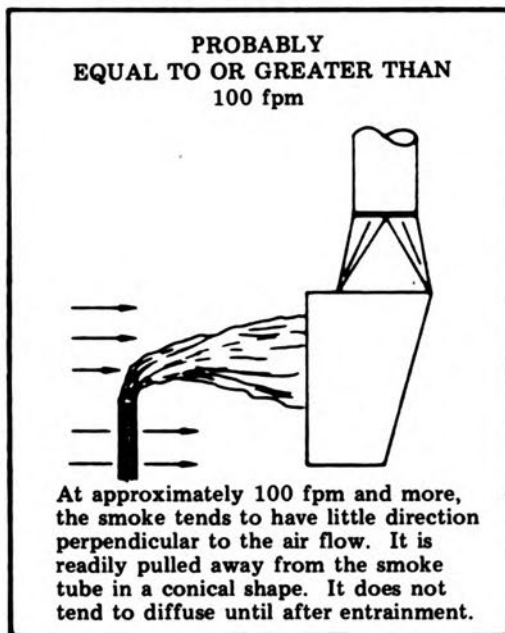
2. Hood noise (if ear muffs were not worn): _____

3. Plasma spray noise (if ear muffs were not worn): _____

4. Fume, ozone and NO_x: _____

5. 200 fpm is the recommended capture velocity of the hood; comment on hood adequacy: _____

6. If open pan of trichloroethylene were on work bench 10 feet from hood:

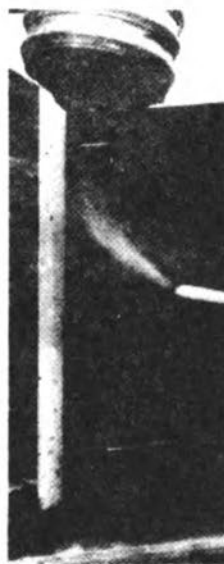


ESTIMATING VELOCITY - HOOD

Visual 31-1



>100 ft/min



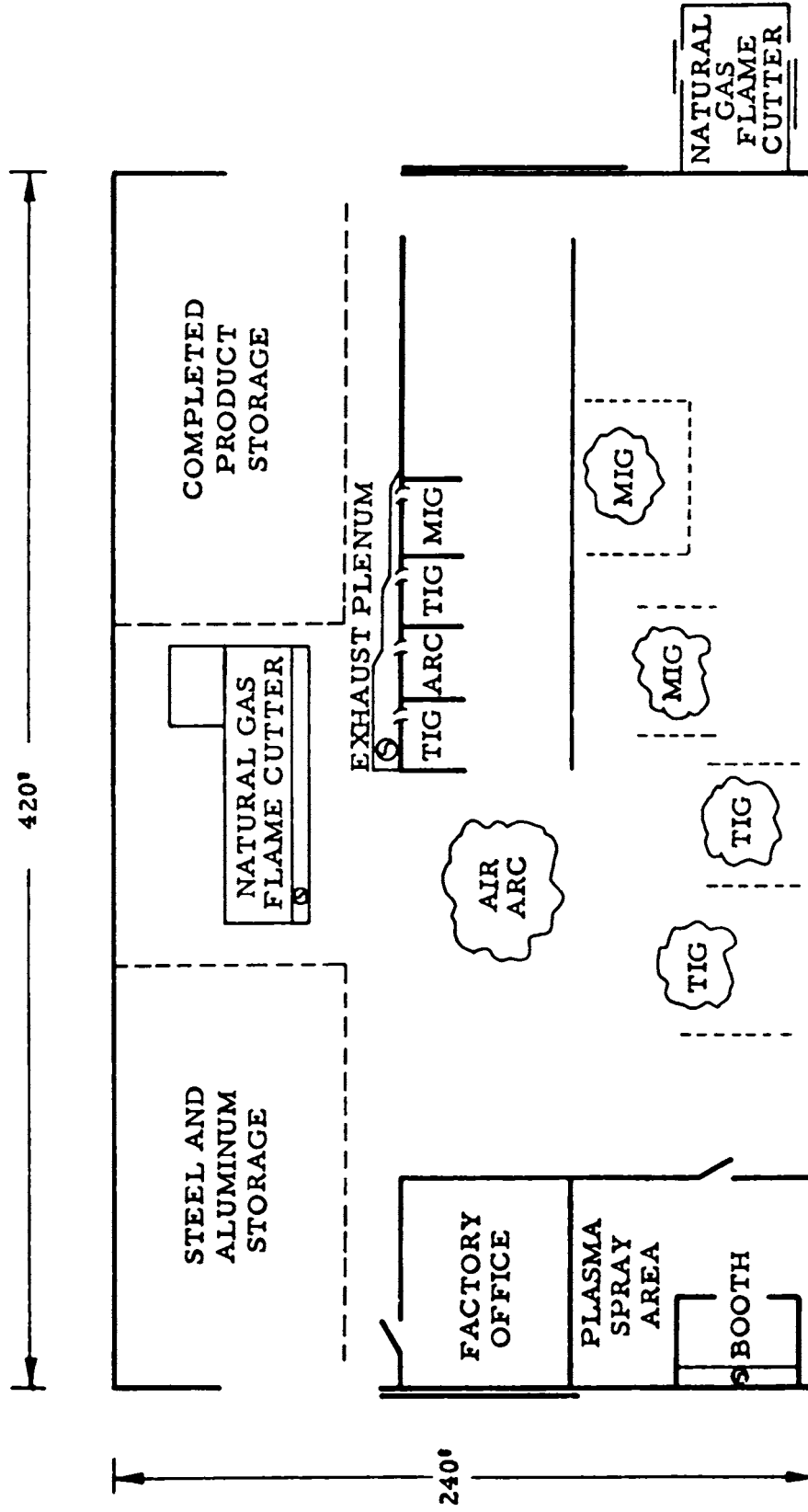
≈100 ft/min



<100 ft/min

ESTIMATING VELOCITY - DUCT

Visual 31-2



ABC METAL WORKS LAYOUT



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Review 4 NO. 32 TIME: 50 minutes

Classroom or homework opportunity to review the fourth day of instruction.

Objectives. Enable the trainee to achieve the terminal objectives of the course through practice in identifying hazards and applying proper concepts and terminology to the recognition, evaluation, and control of factors that affect occupational disease.

Content. Modules 25 through 31

Methods. Self-Check Exercises and study with a partner

Materials. Only the course manual is required.

Special Terms. See the Modules in review.

REFERENCES

See Modules 25 through 31.

You will need to refer to the OSHA Regulations in the Self-Test.

NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> This review is similar to Modules 8, 16, and 24. Your instructor will tell you when the material should be covered. As always, be prepared for a group discussion of questions and answers.
<u>Directions</u>	<u>DIRECTIONS</u> Follow the specific directions for each part and question. This time, select a partner to study with. Check each other's work.

NOTES

A. Module Summaries and Applications

Read the summary of key points in each review module.

Select the most difficult module for you from 25 through 29.

Go over this module carefully with your partner. Use whatever study method works best for you, such as questions and answers, discussion, etc. Note below the concepts you need to review again by yourself.

B. Special Terms

Play a game of "Jeopardy" with your partner. That is, your partner gives you definitions from the glossary and you supply the proper terms.

You can do this by selecting modules as Jeopardy contestants choose categories of information. Or you can let your partner choose definitions at random from the glossary in the appendices.

Note below the terms you need to review again by yourself.

C. Self-Test

Answer each of the questions, as directed.

Check your (partner's) work against the correct answers on the last page.

Review Modules 30 and 31 for any questions you miss.

Match the following (more than one may be correct)

1. Shielded metal arc welding	_____	a. Wire feed
2. TIG welding	_____	b. Inert gas
3. Plasma arc spray	_____	c. UV
4. Oxyacetylene cutting	_____	d. Coated electrodes
5. Carbon arc cutting near trichloroethylene	_____	e. Flammable gas fuel
6. MIG welding	_____	f. Heat by electric arc
7. Flash welding	_____	g. Heat by electrical resistance
		h. High noise level
		i. Phosgene
		j. Thoria
		k. Particle velocity and direction

8. In general, fuel gases are simple asphyxiants or have high TLVs.

T F

9. There is little or no UV produced from a properly operating submerged arc welder. T F

10. Which of the following may be sources of metal fume?,
- a. Copper plating
 - b. Antifouling paint
 - c. Carbon electrode
 - d. Teflon^R
 - e. "Lead pots"
11. Indicate the correct statement(s).
- a. In a large, open bay welding area visibility would have to be quite restricted before sampling for iron oxide would be necessary.
 - b. The absence of visible fume from a TIG welder (using a thoriated tungsten electrode) would indicate no adverse exposure exists.
 - c. Heating cadmium-plated steel with an oxyacetylene torch for 10 minutes in an unventilated area might result in a delayed fatal exposure.
12. Which of the following are likely to produce ozone?
- a. Shielded metal arc welding
 - b. MIG welding
 - c. TIG welding
 - d. Carbon arc
 - e. Plasma spray
 - f. Projection welding
13. The amount of ozone produced is directly related to which of the following?
- a. Welding amperage
 - b. Inert gas used
 - c. Intensity and wave length of UV
 - d. Base metal
14. The amount of nitrogen oxides produced is directly related to which of the following?
- a. Welding amperage
 - b. Welding temperature
 - c. Intensity and wave length of UV
 - d. Base metal

15. Indicate the correct statement(s).
- a. Respiratory irritation is not a good index of exposure to cadmium fume.
 - b. In the absence of data showing beryllium exposures to be below TLV, airline respirators are required, in addition to local exhaust ventilation, for all heating of beryllium.
16. Which of the following are OSHA requirements for control of lead exposures?
- a. Removal of lead primer prior to heat application
 - b. Use of local exhaust ventilation indoors
 - c. Use of cartridge respirators in lieu of a and b
 - d. Use of airline respirators when a or b are not feasible
17. In an area 60' x 60' with 20-foot ceilings and good natural ventilation, three welders are MIG-welding mild steel.
- Which of the following are true?
- a. 2000 cfm dilution ventilation per welder is required.
 - b. Local exhaust is required
 - c. Airline respirators are required
 - d. Mechanical ventilation will be necessary if exposures to ozone or NO_x exceed the TLV.
18. On the first visit to a newly opened plant, you observe a welder brazing a copper-colored metal, using a local exhaust duct. You later find out the metal is a 2% BeCu alloy.
- What action should you take?
- a. Tell the welder to stop work because he is endangered.
 - b. Inform management that the welder and nearby personnel should immediately start wearing cartridge fume respirators during this work.
 - c. Inform management that the welder and nearby personnel should immediately start wearing airline respirators during this work.
 - d. Recommend air sampling.
 - e. Consider isolation or enclosure of this work.

19. In a lead hammer shop, lead is melted in large, unventilated pots and then poured into molds. In a visit, you note that all personnel are wearing approved cartridge fume respirators.

What action would you recommend?

- a. Since personnel are protected with respirators, no further action is required.
- b. Plan a detailed air sampling program for lead fume.
- c. Consider a combined medical/industrial hygiene survey.
- d. Consider exhaust ventilation controls for lead pots and lead pouring.

20. Indicate protection not required by OSHA.

- a. Removal of antifouling paint (mercury based) prior to air arc cutting.
- b. Use of 2000 cfm dilution ventilation per welder in a building with 10-foot ceilings during shielded metal arc welding of mild steel.
- c. Use of cartridge fume respirators when welding indoors through lead primed metal.
- d. Use of local exhaust ventilation for welding indoors on zinc-plated surfaces.

21. Who is responsible for establishing and maintaining a respiratory protection program?

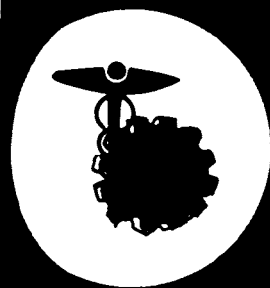
a. Employees	c. U.S. Bureau of Mines
b. Employers	d. U.S. Dept. of Labor

22. In surveying soldering operations, which of the following might be potential hazards?

a. Fluoride gases	d. Lead fume
b. Cadmium fume	e. Tin fume
c. Ozone	

Answers to Self-Test

1. c, d, f
2. b, c, f, j
3. a, b, c, f, h, k
4. e, k
5. c, f, h, i
6. a, b, c, f
7. g
8. T
9. T
10. a, b, e
11. a, c
12. a, b, c, d, e
13. a, b, c
14. a, b, d
15. a, b
16. a, b, d
17. d
18. c, d, e
19. b, c, d
20. c
21. b
22. a, b, d, e



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Instrumentation NO. 33 TIME: 50 minutes

Introduction to one of the most rapidly expanding aspects of industrial hygiene.

Objectives. Enable the trainee to recognize and use with assistance the fundamental concepts and terminology of measuring devices used by the industrial hygienist.

Content. Measuring Contaminants in the Workplace Atmosphere
Selection of Sampling Instruments
Types of Sampling
Types of Available Instruments
Special Purpose Instruments

Methods. Lecture/Discussion and Exercises
Equipment Demonstration (Optional)

Materials. Chalkboard, chalk, and eraser
Visuals 33-1 through 33-7
Instructor Equipment for Demonstrations

Special Terms. Types of sampling, sampling instruments, and related terms

REFERENCES

Basic References

Industrial Environment - Its Evaluation & Control. Chapters 13, 15, and 16.

Other References

American Conference of Governmental Industrial Hygienists. Air Sampling Instruments For Evaluation of Atmospheric Contaminants, 4th edition. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1972.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

In recent years, great advances have been made in the measuring tools and techniques used by the industrial hygienist.

This module is merely an introduction to the subject. The most eye-opening way to learn the state-of-the-art is to attend a meeting or conference with commercial exhibitions. The amount and kind of available instruments will astound you!

Unfortunately, like many other kinds of hardware, industrial hygiene devices and instruments don't always work as well as they are touted.

This module will give you some guidelines to keep in mind whenever you have the opportunity or responsibility for instrument selection or evaluation.

A few pertinent illustrations are included at the end of the lesson material. You will find more complex descriptions and illustrations in your basic NIOSH text.

Your instructor may be able to assemble and demonstrate some of the instruments you are most likely to use in the preliminary stages of your career.

For assistance back on the job, see the module with this name (No. 37).

NOTES	INSTRUCTION
Instrument selection Type of sample Degree of accuracy	Industrial hygiene chemistry has become a specialty. The industrial hygienist, or the person taking the sample, should collaborate with the chemist who does the analysis. In this way, the chemist will know the limitations of the sampling procedures utilized and the possible presence of other contaminants which might interfere with the analysis. B. The selection of a sampling instrument depends on a number of considerations. The evaluation of these factors is the first step to perform in the selection of an instrument. B.1. The appropriate type of sample must be selected. First, it is necessary to determine whether or not a general environmental sample will suffice. If the contaminant is equally dispersed throughout the work area, an accurate sample of the area would represent the exposure to all workers. On the other hand, if the work area includes several different operations and a number of contaminant sources, each worker might have his own micro-environment to be sampled for determining individual exposure. B.2. The necessary degree of accuracy must be determined. Instruments have varying degrees of accuracy. For example, under ideal circumstances, colorimetric indicator tubes have an accuracy range of $\pm 20\%$. If it were obvious that the TLV was being exceeded by a significant factor (1.5), the colorimetric indicator tube would be quite satisfactory. If the concentration were suspected to be in the magnitude of half the TLV, the indicator tube would still be acceptable. However, if the concentrations were in the range of 0.5 to 1.5 of the TLV, a more accurate instrument would be needed. Investigative research would also require a high degree of accuracy.

NOTES	INSTRUCTION
Program requirements Presence of other contaminants Safety	B.3. Program requirements determine the necessary frequencies of sampling. Will an eight-hour integrated sample meet the requirements of the program or will interval samples be necessary? First, it must be determined whether or not the TLV for the contaminant has a ceiling or "C" designation. If so, interval or continuous instantaneous sampling must be used. If it is likely that the excursion factor would be exceeded for more than 15 minutes during an eight-hour shift, an integral sample would be required to determine the extent of the maximum excursion. B.4. The possibility of other contaminants in the atmosphere that might invalidate the effectiveness of the instrument or analytical procedure must be considered. The chemist should be advised of this possibility before analytical methods are selected. Direct reading instruments, both colorimetric and electronic, are often invalidated when multiple contaminants are present in the atmosphere. For example, if an electronic benzol indicator is calibrated specifically for C_6H_6, the presence of other combustible gases or vapors will cause an erroneous reading. B.5. The safety of the workplace must be assured during sampling. Some instruments cannot be used in certain operations, such as coal mines, where an explosive mixture of methane may be present. In certain industrial situations, there is a possibility of other gases or vapors in the explosive range being present. Certain instruments are approved by the U.S. Bureau of Mines for use in explosive atmospheres.

NOTES	INSTRUCTION
Inspection and experimentation Types of samples Visual 33-1 Instantaneous sampling Integrated sampling	B.6. Inspection and experimentation may be necessary as part of instrument evaluation. Careful inspection of contemplated selections will help in an evaluation. Sometimes, a few experimental samples may also be required. However, in any case, the sampler's experience is also critical. C. The industrial hygienist is concerned with instantaneous or grab, integrated, and interval samples. Each of these types of samples has a specific purpose. Each requires a different kind of instrument. C.1. Instantaneous or grab sampling is made at a particular time, either by a direct reading instrument or by trapping a definite volume of air for analysis. Samples of this type cannot be used for dose calculations, as the time factor is insufficient. However, they can be used to determine the magnitude of the concentration. Assuming sufficient mass of the substance is present, a grab sample can be used for a qualitative analysis. A large number of instantaneous samples taken over a certain period provides a good measure of average, maximum, and minimum concentrations. For example, instantaneous samples taken at five-minute intervals for one hour would have a high probability of representing conditions during that hour. C.2. Integrated sampling is done over a long period of time, such as a full work cycle.

NOTES	INSTRUCTION
Interval sampling	Integrated samples provide the greatest degree of accuracy in evaluating an exposure, as maximum and minimum values are included, and a time-weighted exposure is established. The primary objection to integrated sampling is that it fails to identify maximum and minimum values which are important to TLV interpretation. When there is only a small probability that the excursion factor would be exceeded, integrated sampling is an acceptable procedure. It is especially useful in evaluating exposures to pneumoconiosis-producing dusts. C.3. Interval sampling is performed for a definite time period each hour or for the entire work shift. Interval sampling is the procedure generally used by industrial hygienists. It has the most advantages, including the potential of probability sampling. Shorter and more frequent sampling permits a more accurate determination of maximum and minimum. Longer duration allows for greater analytical accuracy. Interval sampling permits the determination of dose and time-weighted averages. Where a worker performs multiple tasks, the procedure should be used for exposures in each task.
Types of instruments	D. Several types of instruments are available to industrial hygienists for measuring contaminants. These will be discussed in the following paragraphs.
Visual 33-2 Impinger	D.1. The impinger was the first satisfactory instrument developed for evaluating dust exposure.

NOTES

INSTRUCTION

Impinger theory

The need to accurately evaluate dust exposure prompted the development of the first satisfactory instrument for this purpose in 1920. The Greenburg-Smith impinger became the work-horse instrument of industrial hygiene. Later, it was modified to the midget impinger.

D.1.a. The theory of the impinger is that a particle impacting on a surface loses its kinetic energy and can be trapped in a liquid medium.

Impinger tubes are standardized for all variables so that the velocity through the jet is 70 meters per second at a flow rate of 0.1 cfm and a suction of 12 inches of water. The collecting tube holds 10 cc of collecting fluid.

The midget impinger was designed to be operated with a hand-turned, four-cylinder pump. When coupled with the impinger tube, the pump provides a constant air flow of 0.1 cfm. The power source may be any other air mover, if it is calibrated to move 0.1 cfm when attached to the impinger tube.

Impinger use

D.1.b. The primary use of the impinger is for evaluating pneumoconiosis-producing dusts.

A standardized technique uses an aliquot of the 10 cc collecting fluid, making it possible to express the dust concentration in million particles per cubic feet of air sampled. Generally, the instrument is operated for a 10-minute period to collect 1 cubic foot of air.

The impinger has other uses, now rarely applied, such as evaluating lead and other metals in particulate form. The impinger is not efficient for particles less than about 0.2 micron, so it has little value in collecting fumes. When used for collecting metals, the fluid should be 5% nitric acid solution.

MODULE Instrumentation		NO. 33
NOTES	INSTRUCTION	
Impinger disadvantages	D.1.c. Disadvantages of impingers include the length of the procedure, the difficulty in obtaining consistent findings, and the large investment necessary to do the job. Most American dust standards were based on measurements made by the impinger. However, it has a number of disadvantages, beginning with the long, laborious procedure for counting dust particles. Other criticisms relate to the fracturing of particles due to impingement at high velocities, thereby creating more particles than actually existed in the atmosphere.	
Visual 33-3 Filters	D.2. Filter instruments are widely used for sampling particulates and fumes. Filters of high efficiency and low resistance were developed in the early 1950's.	
Filter operation	D.2.a. Filter instruments depend on the movement of a measured volume of air through a filter. Filter holders and special air movers are available for this type of sampling. The filters can be weighed before and after sampling, so that the total mass of the contaminant per unit volume of air can be ascertained. Non-hygroscopic filters can be used, so moisture absorption need not be a factor. However, an equilibration period before weighing is desirable.	
Filter disadvantage	D.2.b. The primary disadvantage of filter sampling is the lack of size selectivity. After the filter is weighed, it can be dissolved in a suitable solvent, leaving behind the collected contaminant. The residue can then be analyzed both qualitatively and quantitatively, or a physical analysis can be made to determine particle size distribution.	

NOTES	INSTRUCTION												
Filter sizes	D.2.c. Filter holders come in various sizes to meet investigative needs. Sizes range from 25mm to 100mm and larger for special investigations. While any air mover could be used, manufacturers offer air movers especially designed for filter samplers. The air-flow rate should be reasonably constant, at about 2.5 liters per minute. Therefore, if large volumes are required, large filter holders should be selected.												
Visual 33-4 Respirable dust samplers	D.3. Respirable dust samplers are used for sampling particulates that may be deposited in the lungs. Standards for pneumoconiosis-producing dusts are generally based on particles in the respirable range. Several commercial instruments for this purpose meet the specifications of the American Conference of Governmental Industrial Hygienists, the organization which establishes Threshold Limit Values. Such instruments are referred to as personal samplers, since they can be attached to individual workers to evaluate their exposures.												
Sampler operation	D.3.a. A unit consists of a battery pack and air mover, attached by belt to the waist of the worker and connected to the sampling instrument fixed to the worker's lapel by a flexible hose. The battery operates the instrument at the recommended flow rate for eight hours. It may be recharged overnight. The sampling instrument has a pre-size selector with the following specifications: <table> <tr> <th><u>Aerodynamic Diameter</u> <u>(microns) (unit density spheres)</u></th><th><u>Percent</u> <u>Passing</u> <u>Selector</u></th></tr> <tr> <td>< 2</td><td>90</td></tr> <tr> <td>2.5</td><td>75</td></tr> <tr> <td>3.5</td><td>50</td></tr> <tr> <td>5.0</td><td>25</td></tr> <tr> <td>10.0</td><td>0</td></tr> </table>	<u>Aerodynamic Diameter</u> <u>(microns) (unit density spheres)</u>	<u>Percent</u> <u>Passing</u> <u>Selector</u>	< 2	90	2.5	75	3.5	50	5.0	25	10.0	0
<u>Aerodynamic Diameter</u> <u>(microns) (unit density spheres)</u>	<u>Percent</u> <u>Passing</u> <u>Selector</u>												
< 2	90												
2.5	75												
3.5	50												
5.0	25												
10.0	0												

NOTES	INSTRUCTION
Other instruments Gas washers (bubblers)	used for detecting combustible gases in the explosive range. All heat of combustion detectors operate by drawing an air stream over a heated wire. If a combustible gas is present, the gas is burned. The additional heat upsets the balanced electric circuit, and the degree of unbalance is registered on a scale for percentages of the explosive mixture. These instruments can be calibrated in ppm for specific gases, such as ethylene, propane, and methane. In the past, such instruments were calibrated in ppm for certain commonly encountered solvent vapors, such as benzene. However, colorimetric indicator tubes are now used for practically all solvent vapors. Carbon monoxide is an exception. E. Some instruments have specific and often limited uses. These will be discussed briefly in the following paragraphs. E.1. Gas washers can be used if direct reading instruments are not accurate enough or otherwise satisfactory. Fritted or sintered gas washers (bubblers) are made by chemical glassware manufacturers. The collecting agent must be especially selected for the contaminant to be sampled. Air is drawn into the gas washer at a rate of 1-15 liters per minute (1 pm). The gas or vapor is absorbed as it passes through the collecting medium. When used properly, the system has a collection efficiency of 90-100%. After a sampling cycle, the collecting fluid may be analyzed chemically or by gas chromatography.

NOTES	INSTRUCTION
Charcoal and silica gel	Since a long sampling period is usually required, the procedure would not be useful for determining maximum and minimum concentrations. It would be useful, however, for identifying all gaseous components in the atmosphere when these are soluble in the collecting fluid. E.2. Gas or vapor can be collected by absorption on activated charcoal or silica gel.
Container or bag	The mass of the collected material is determined by weight difference and the absorbed gases can be identified with a gas chromatograph. E.3. A sample of the atmosphere can be trapped in an evacuated container or plastic bag. Subsequent laboratory analyses must be performed, of course.
Air pollution studies	E.4. Direct reading instruments for airborne particles are used largely in community air pollution studies. Direct reading instruments are used to a limited extent in industrial hygiene work. Lack of portability limits their use to fixed-site locations for monitoring purposes.
Paper tape samplers	E.5. Paper tape samplers also have limited use in industrial hygiene work. They can be used for monitoring or in special situations where maximum and minimum concentrations need to be identified in some way. At pretimed intervals, these samplers draw air through a paper tape with the characteristics of filter paper. The paper can be impregnated with a chemical which reacts with the contaminant and produces a stain. The instrument then measures the degree of light reflectance from the stained area. The ratio of reflection from the stained area to reflection from an unstained area is a measure of the concentration of the contaminant. Instrument manufacturers usually supply calibration curves for specified dusts and contaminants.

NOTES	INSTRUCTION
<u>Summary</u>	<u>SUMMARY OF KEY POINTS</u> A. An essential requirement of industrial hygiene is the ability to measure minute concentrations of contaminants in the atmosphere of the workplace. B. The selection of a sampling instrument depends on a number of considerations. C. The industrial hygienist is concerned with instantaneous or grab, integrated, and interval samples. D. Several types of instruments are available to industrial hygienists for measuring contaminants. E. Some instruments have specific and often limited uses.

Exercises

1. Indicate the appropriate instrument(s) for evaluating exposures to the following substances:

A. Benzene.	_____	a. Bubbler
B. Carbon tetrachloride.	_____	b. Charcoal tube
C. Chronic acid mist.	_____	c. Colorimetric indicator tube
D. Iron oxide fume.	_____	d. Electrostatic precipitator
E. Lead fume and dust.	_____	e. Filter
F. Mercury vapor	_____	f. Impinger
G. Mixture of toluene, butyl/alcohol, and butyl acetate.	_____	g. Mercury vapor indicator
H. Silica dust.	_____	
I. Sulfuric acid mist.	_____	
2. What should be used as collecting fluid for the sulfuric acid mist above?

3. If you were conducting a preliminary survey of an industrial plant, which of the following instruments would you use to estimate a benzene hazard?

_____	a. Charcoal tube
_____	b. Colorimetric indicator tube
_____	c. Combustible gas indicator
_____	d. Impinger
4. Why not use a combustible gas indicator to estimate an exposure to carbon tetrachloride?

INSTANTANEOUS SAMPLING

Contaminants	Instruments
Gases and Vapors	Electronic direct reading, colorimetric tubes, evacuated flasks or plastic bags, and containers which trap a definite volume of contaminated air.
Dusts and Particulates	Impingers, electrostatic precipitators, and filtration instruments.
Fumes	Electrostatic precipitators and filter instruments.
Fogs and Mists	Impingers and filter instruments.

INTEGRATED SAMPLING

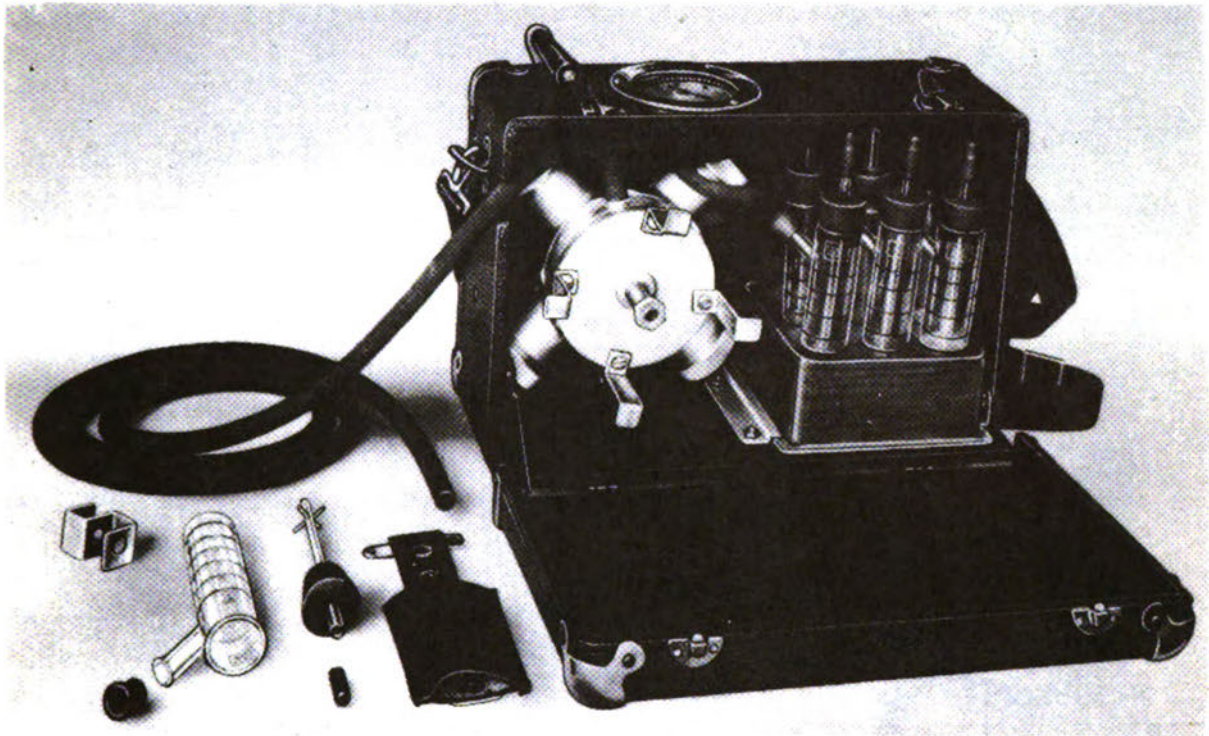
Contaminants	Instruments
Gases and Vapors	Bubblers and continuous recorders which also show maximum and minimum concentrations.
Dusts and Particulates	Filter instruments.
Fumes	Filter instruments are not recommended, but can be used. (Small particles tend to clog filters and added resistance upsets airflow rates.)
Fogs and Mists	Impingers.

INTERVAL SAMPLING

Contaminants	Instruments
Gases and Vapors	Bubblers and charcoal tubes.
Dusts and Particulates	Impingers, filters thermal and electrostatic precipitators.
Fumes	Filters and electrostatic precipitators.
Mists	Bubblers, impingers, and filters.

SAMPLING INSTRUMENTS

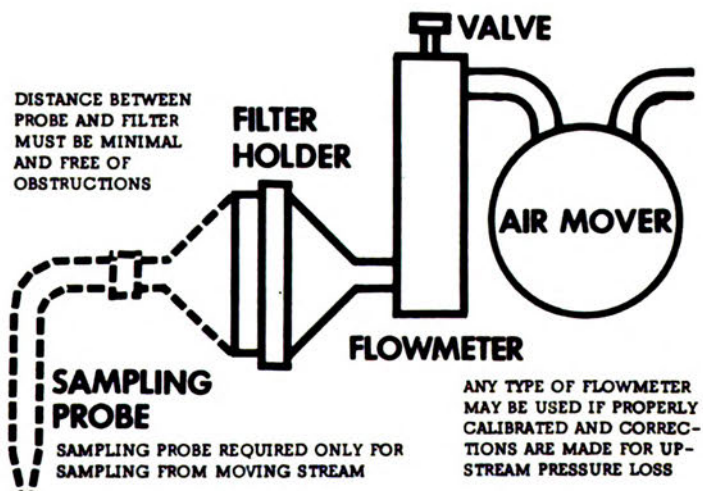
Visual 33-1



MIDGET IMPINGER AND ACCESSORIES

Visual 33-2

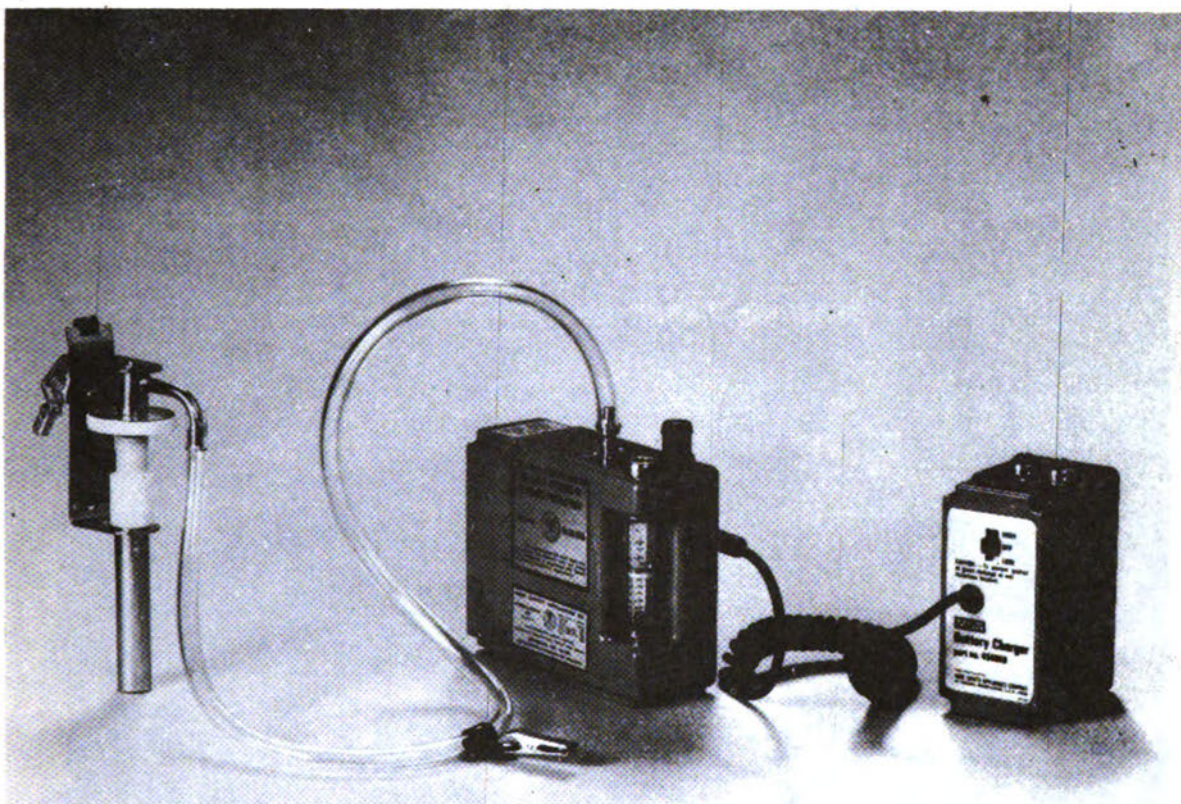
Source: Mine Safety Appliances Co.



ELEMENTS OF A FILTER SAMPLING SYSTEM

Visual 33-3

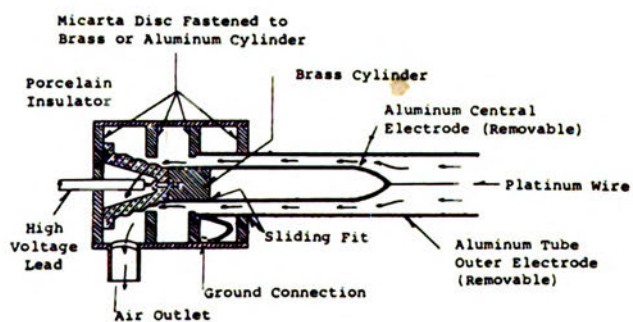
Source: ACGIH, Air Sampling Instruments, 1972, p. N-2.



Source: Mine Safety Appliances Co.

RESPIRABLE DUST SAMPLER

Visual 33-4



Source: Journal of Industrial Hygiene and Toxicology. Vol. 20, 1938, p. 259.

SAMPLING HEAD ELECTRODE CROSS SECTION BARNES AND PENNEY PRECIPITATOR SAMPLER

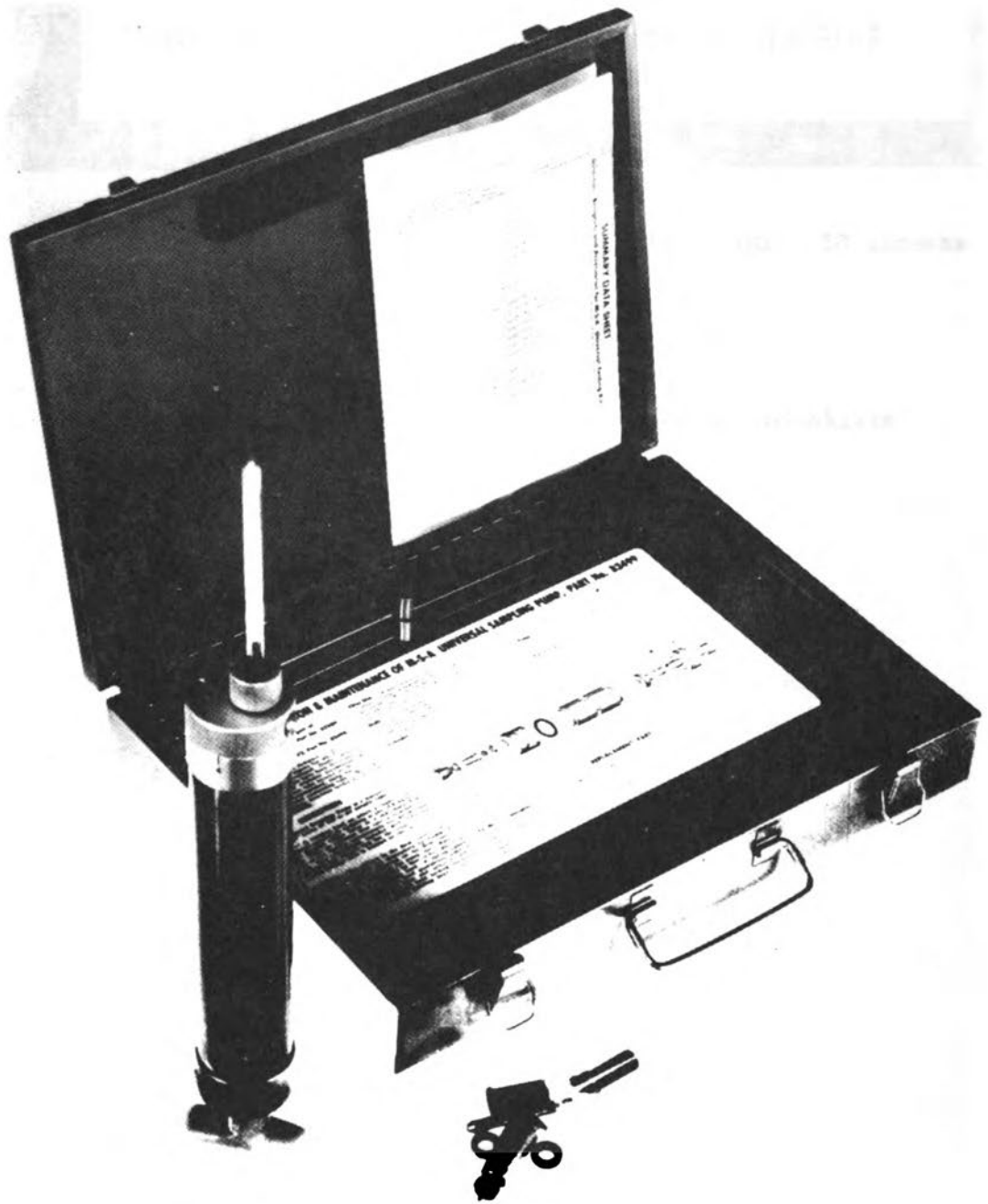
Visual 33-5



Source: Mine Safety Appliances Co.

SQUEEZE-BULB COLORIMETRIC SAMPLER

Visual 33-6



Source: Mine Safety Appliances Co.

SAMPLING PUMP
Visual 33-7



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Physical Hazards

NO. 34 TIME: 50 minutes

Review of physical hazards and their control.

Objectives. To enable the Trainee to reinforce concepts and skills learned with respect to controlling

- (1) noise hazards;
- (2) illumination hazards;
- (3) heat stress hazards;
- (4) ionizing and non-ionizing radiation hazards.

Content. Noise hazards and their control
Application of good industrial lighting
Heat stress hazards and their control
Radiation hazards and their control

Methods. Lecture and Optional Supplements

Materials. Chalkboard, chalk, and eraser
Slide Projector (35mm) and Screen or Suitable Wall
Slides 170 - 196
Visuals 34-1 - 34-15
Film Clip and Film (Optional Supplements)

Special Terms. See Modules 18, 19, 20, 25, and 26 or check the Glossary in Appendix C.

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapters 5 - 8.
2. Industrial Environment - Its Evaluation & Control. Chapters 27, 29, 37, 38.
3. Industrial Toxicology. Volume I, Chapters 17 - 21.

Other References

See Modules 18 - 20, 25, and 26.

NOTES	INSTRUCTION
<u>Introduction</u> Definition of physical hazards Scope of this module	<u>INTRODUCTION</u> Physical hazards are those that can be attributed to agents that are physical in nature, rather than chemical. Excessive heat, noise, vibration, pressure, illumination, and radiant energy are common physical hazards. All except pressure are often encountered in industrial operations. Problems associated with high or rapidly changing pressures are encountered only in such special jobs as caisson work, diving, and some aircraft piloting. Specific physical hazards have been discussed in detail in previous modules. This module constitutes a short review before proceeding to the Physical Hazards Workshop.

MODULE Physical Hazards		NO. 34
NOTES	INSTRUCTION	
<u>Explanation - Lecture</u>	<u>EXPLANATION - LECTURE</u>	
<u>Noise</u>	A. Noise is unwanted sound.	
Sound	Sound is the effect on the ear of repetitive (cyclic) variations in air pressure. Loudness results from large air pressure variations. The higher the pitch of the sound, the higher is its frequency (cycles per second or hertz). The human ear is capable of hearing frequencies in the range of about 20 Hz to 20,000 Hz at sufficient and varying intensities as shown in Slide 170. (See also Visual 34-1.)	
Loudness		
Frequency (hertz)		
Slide 170 (Visual 34-1)		
Measuring sound intensity	A.1. Sound intensity is measured at a given frequency or band of frequencies (octave band) in terms of its strength (sound pressure level) relative to a reference sound pressure level of one millibar (0.0002 dyne/cm ²). This reference level is about at the lower threshold of man's hearing sensitivity.	
Octave band		
Sound pressure level		
Measuring sound in decibels	A.2. Sound measurements are stated in terms of the ratio of the sound pressure level measured as compared to the reference level. Twenty times the number of factors of ten represented by this ratio is the number of decibels (dB) or the relative intensity of the sound.	
Combining decibel measurements	A sound pressure level one million times the level of audibility is about (20 x 6 factors of ten) or 120 dB. The decibel is a logarithmic unit, and cannot be directly summed. If two identical machines are in a room, and one machine alone produces a noise level of 90 dB, then both machines together produce a noise level of 93 dB. Slide 171 shows a chart for combining or subtracting decibels. (See also Visual 34-2.)	
Slide 171 (Visual 34-2)		
Effects of various noise levels	A background noise level of about 45 dB will allow intelligible conversation at normal voice levels at a distance of 9 feet. Sixty dB, however, will require a raised voice to be	

MODULE Physical Hazards	NO. 34
NOTES	INSTRUCTION
Slide 172 (Visual 34-3) Types of noise Continuous noise Impact noise Slide 173 Sound weighting Purpose of sound weighting Slide 174 (Visual 34-4) Sound level meters "A" weighting scale for permissible noise exposures Permissible noise exposures Slide 175 (Visual 34-5) Physical stress and hearing loss from noise exposure	heard at 3 feet. At about 120 dB, the noise level will cause discomfort, and at 145 dB it will cause pain. Slide 172 shows a chart for rating office noise in terms of decibels. (See also Visual 34-3.) A.3. Noise can be classified as continuous or impact noise, depending on its origin. If the noise originates from continuously operating equipment, it is of the continuous or steady-state type. If the noise occurs at intervals greater than one second, it is classified as impact noise. Slide 173 illustrates an impact noise source--a sheet metal cutter. A.4. Permissible noise levels are determined by sound weighting. The purpose of weighting is to confine noise to the speech frequency spectrum. Slide 174 (and Visual 34-4) show the ANSI criteria for A weightings assigned to frequencies of standard sound level meters. Frequencies above 10 K are cut off, and frequencies below 500 Hz are sharply attenuated electronically so that the meter responds (on the A scale) primarily to frequencies between 500 and 10,000 Hz. OSHA permissible noise exposures are based on sound level measures using the A weighting scale (dBA). A plot of permissible, unprotected noise exposures from the OSHA standards is shown here in Slide 175 and also in Visual 34-5. Maximum permissible exposure ranges from 90 dBA for 8 hours per day of exposure to 115 dBA for 15 minutes per day. Impact noise exposures should not exceed 140 dB peak sound pressure level without ear protection. A.5. Noise induces a physical stress. Excessive noise is capable of and does cause total deafness or various degrees of hearing loss.

NOTES	INSTRUCTION
Noise-induced hearing loss Aging causes some hearing loss Other adverse effects from excessive noise exposure Engineering controls are most effective Other ways to reduce noise levels	Hearing losses due to excessive industrial noise occur most frequently and severely at about 5,000 Hz. The normal aging process produces a hearing loss throughout the audible frequency spectrum, with the most pronounced losses occurring in the higher frequencies. This loss of hearing due to aging is known as presbycusis. Noise-induced hearing loss from exposure to high noise levels for several years is irreversible. Other adverse effects of noise are: (1) impairment of performance due to speech interference. (2) fatigue due to noise stress. (3) safety hazards due to misunderstood instructions or unheard warnings. (4) performance quality deterioration due to stress and fatigue. A.6. Engineering controls for noise are most effective when incorporated in equipment design before manufacture and installation. However, there are other ways to quiet a noise source. Often, refitting and repair and generally good maintenance (lubrication, tightening of loose parts, replacing warped shafts and rotating parts, using good bearings, etc.) will reduce, if not eliminate, many industrial noises. Some industrial operations are inherently noisy due to the need for high speeds, fast cutting, or high velocity impacting. In these cases, either the noise source or the exposed personnel must be isolated or relocated to reduce noise exposure. The use of noise and vibration insulation and damping materials may also help reduce noise levels. Sometimes it is possible to reduce certain operating characteristics such as speed, velocity, or turbulence, to lessen the resulting noise.

NOTES	INSTRUCTION
Personal protective equipment Slide 176 Ear plugs Ear muffs Plug/muff combination Special helmet plus ear plugs High noise level warning signs Visual 34-6 Hearing conservation program	A.7. Personal protective devices are available to reduce noise exposures. Slide 176 shows a selection of some common hearing protection devices. Moving clockwise from the top, we see custom molded ear plugs, four types of fitted ear plugs, 2 types of "universal fit" ear plugs, 2 types of disposable ear protection (the cotton shown here is usually unacceptable), and ear muffs. Ear plugs may be fitted or molded to the ear size and usually give 20 to 40 dB attenuation. Use of ear plugs requires care in handling, use, and storage, since they are a potential source of infection if not kept clean. Ear muffs provide about the same protection as ear plugs, and the probability of infection is far less. Muffs cost more, however, and may interfere with other protective equipment. A combination of plugs and muffs may be needed for noise levels above 120 dBA. For high-intensity noise with frequencies greater than 1,000 Hz, a special helmet plus ear plugs may be necessary. Warning signs must be posted around high noise level areas where special protective devices must be worn. A typical warning sign is pictured in Visual 34-6. A.8. A hearing conservation program should be initiated in noisy industries. Such a program would perform the following functions: (1) determine levels in high noise areas (above 90 dB). (2) provide initial audiometric testing of exposed employees. (3) prescribe engineering controls, employee education, and protective measures and devices.

NOTES	INSTRUCTION
Slide 177 Slide 178 (Visual 34-7) ANSI illumination standards Quantity and quality of light are equally important Slide 179 (Visual 34-8) Estimating lighting needs Slide 180	Slide 177 illustrates a well-illuminated area. This inspection area has good general illumination. Note that there is reflection on parts which indicates a need for diffusers. Slide 178 and Visual 34-7 show an extract from the ANSI standards that give recommended levels of lighting for various industrial operations. B.1. In addition to the amount of light, the quality of light is of equal importance. The glare, reflected light, angle of illumination, contrasts, and color ratios also affect the ability of a worker to adequately see what he is doing. In Slide 179, you can see that examples B and D show poor placement of supplemental lighting. The other examples show good placement and specific applications of supplemental lighting. (See also Visual 34-8.) B.2. Estimation techniques useful in spot-checking the adequacy of illumination include the following: (1) Can you see fine details at the working surface? In corners? (2) Are there shadows that affect seeing detail work or affect scribing? (3) Is there direct glare from unshielded bulbs or windows? (4) Is there reflected glare from machine surfaces or glossy surfaces? Slide 180 shows a cable manufacturing process. This is a good example of general illumination with supplementary lighting provided at work stations where fine detail work is done.

NOTES	INSTRUCTION
Slide 181	Here in Slide 181 is an example of poor lighting in a shop area. Shadows are noticeable on work surfaces and in corners.
Slide 182	The laminar flow hood shown here in Slide 182 presents a good application of supplemental lighting of the diffused type.
<u>Heat stress</u>	C. Heat stress can adversely affect a worker's job performance and health. Human beings are normally in thermal equilibrium with their environment, though they may be stressed to maintain this equilibrium. A person may alter his environment to reduce the temperature stress. If the stress is severe, body temperature will be raised or lowered to combat the outside temperature, and adverse effects will occur.
Temperature variations of the human body	C.1. Physiologically, man is able to maintain a deep body temperature of 99°F (mouth temperature 98.6°F). His rate of heat production (metabolism) is balanced with his heat lost to the environment via sweating and evaporative cooling.
Body adaptation to the thermal environment	Acclimatization to the thermal environment is a significant factor. In temperature environments above the skin temperature, the radiant and convective heat load, plus metabolic heat, must be eliminated by evaporative cooling. When the body surface becomes fully wetted, the upper evaporative cooling limit is reached and the body must heat up. When body temperature reaches 105°F in otherwise healthy individuals, critical (sometimes fatal) effects can occur.
Visual 34-9	Visual 34-9 shows corrected effective temperatures, converting from dry to wet bulb.
Slide 183 (Visual 34-10)	The effects of heat stress on man are shown next. The effects can be psychological, psychophysiological, and physiological. Note the effects of moisture in the air and the effects of increasing age.

NOTES	INSTRUCTION																								
Slide 184 (Visual 34-11) Federal standards for heat stress ACGIH recommended standards	Now trace the specifically physiological effects of heat stress. C.2. Federal standards are proposed for the control of heat stress, but have not as yet been promulgated. The ACGIH tentative standards are as follows: <table><tr><td></td><td colspan="3">Work Load (Temperatures are in degrees centigrade)</td></tr><tr><td>Work - Rest Regimen</td><td>Light</td><td>Moderate</td><td>Heavy</td></tr><tr><td>Continuous work</td><td>30.0</td><td>26.7</td><td>25.0</td></tr><tr><td>75% work - 25% rest</td><td>30.6</td><td>28.0</td><td>25.9</td></tr><tr><td>50% work - 50% rest</td><td>31.4</td><td>29.4</td><td>27.9</td></tr><tr><td>25% work - 75% rest</td><td>32.2</td><td>31.1</td><td>30.0</td></tr></table>		Work Load (Temperatures are in degrees centigrade)			Work - Rest Regimen	Light	Moderate	Heavy	Continuous work	30.0	26.7	25.0	75% work - 25% rest	30.6	28.0	25.9	50% work - 50% rest	31.4	29.4	27.9	25% work - 75% rest	32.2	31.1	30.0
	Work Load (Temperatures are in degrees centigrade)																								
Work - Rest Regimen	Light	Moderate	Heavy																						
Continuous work	30.0	26.7	25.0																						
75% work - 25% rest	30.6	28.0	25.9																						
50% work - 50% rest	31.4	29.4	27.9																						
25% work - 75% rest	32.2	31.1	30.0																						
Flexibility of ACGIH standards	Higher heat exposures than shown above are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers should not be permitted to continue their work when their deep body temperature exceeds 38.0°C.																								
Engineering controls to reduce heat stress Isolation Ventilation (local exhaust) Shielding Ventilation (dilution) Air conditioning	C.3. The following engineering controls may be useful in reducing the heat load on workers: (1) isolation of heat sources. (2) local exhaust ventilation. (3) shielding (reflective, absorptive, water-cooled, etc.) (4) general dilution ventilation (with and without air conditioning). (5) air conditioning																								

MODULE Physical Hazards		NO. 34
NOTES		INSTRUCTION
Protective equipment		(6) man-cooling suits, other protective equipment, salt tablets.
Slide 185 Local exhaust ventilation		Slide 185 shows local exhaust ventilation in a salt bath area. Metal heat-treating salt baths have temperatures in excess of 1500°F. These radiant heat sources must have local exhaust to remove some of the generated heat.
Slide 186 Air conditioning		Slide 186 shows a room air conditioning unit. The industrial hygienist is testing the cool air from a local air conditioning unit used in a rubber hot press room.
Slide 187 Protective devices		Aluminized asbestos protective clothing is pictured in Slide 187. In this hot drop-hammer forging area, the unit on the right is an oven at 1200°F that heats steel. Aluminized asbestos coats and gloves are worn to minimize the radiant heat-load when handling parts and when the oven is open.
Estimating heat stress hazards		C.4. For environments where thermal stress is suspected, the following techniques may be useful for hazard estimation: a. Feeling How uncomfortable do you feel? Do you feel little or no cooling despite profuse sweating? Is there any cooling from air movement? Do you have a headache? b. Temperature and moisture Check wall thermometers. What is the dry bulb temperature? How "muggy" or humid does it feel? c. Worker signs Are workers sweating profusely? Do they appear listless? Are they permitted rest periods from work, heat, or both?

NOTES	INSTRUCTION
<u>Radiant energy</u> Infrared Light Ultraviolet X-radiation Radioactive materials: alpha, beta, gamma radiation Microwaves Lasers and masers Electromagnetic spectrum Slide 188 (Visual 34-12) Types of radiant energy Slide 189 (Visual 34-13)	D. Radiant energy is used in industry for many purposes. Infrared radiation is used for heating and drying. Where heated surfaces are present, the radiant heat load to a worker may be appreciable. Visible radiation (light) can also result in a significant heat load. Ultraviolet light is used in photographic and printing processes and may also be generated by arcs, welding, germicidal lamps, and so on. X-radiation is commonly used for inspecting welds and internal defects and in microscopy. Radioactive materials are used as gamma sources and for alpha and beta radiation. Radioactive materials are commonly used as tracers in testing procedures. The use of most radioactive materials is licensed and monitored by state agencies or by the U.S. Atomic Energy Commission. Microwaves are used in communications transmission. Lasers and masers are high-intensity coherent light sources (infrared, visible, ultraviolet), and masers are coherent microwave sources. They are used for alignment, surveying, cutting, melting, and bonding. D.1. The electromagnetic spectrum includes radiation of all wave lengths from extremely long radio waves to extremely short X-rays and the gamma rays from radioactive materials. Slide 188 (Visual 34-12) illustrates the relationship of elements in the electromagnetic spectrum. Examples of types of energy are charted here in Slide 189 (Visual 34-13). These are examples of effects, uses, control practices, and signs to look for when surveying for microwaves, ultraviolet, X-rays, and lasers.

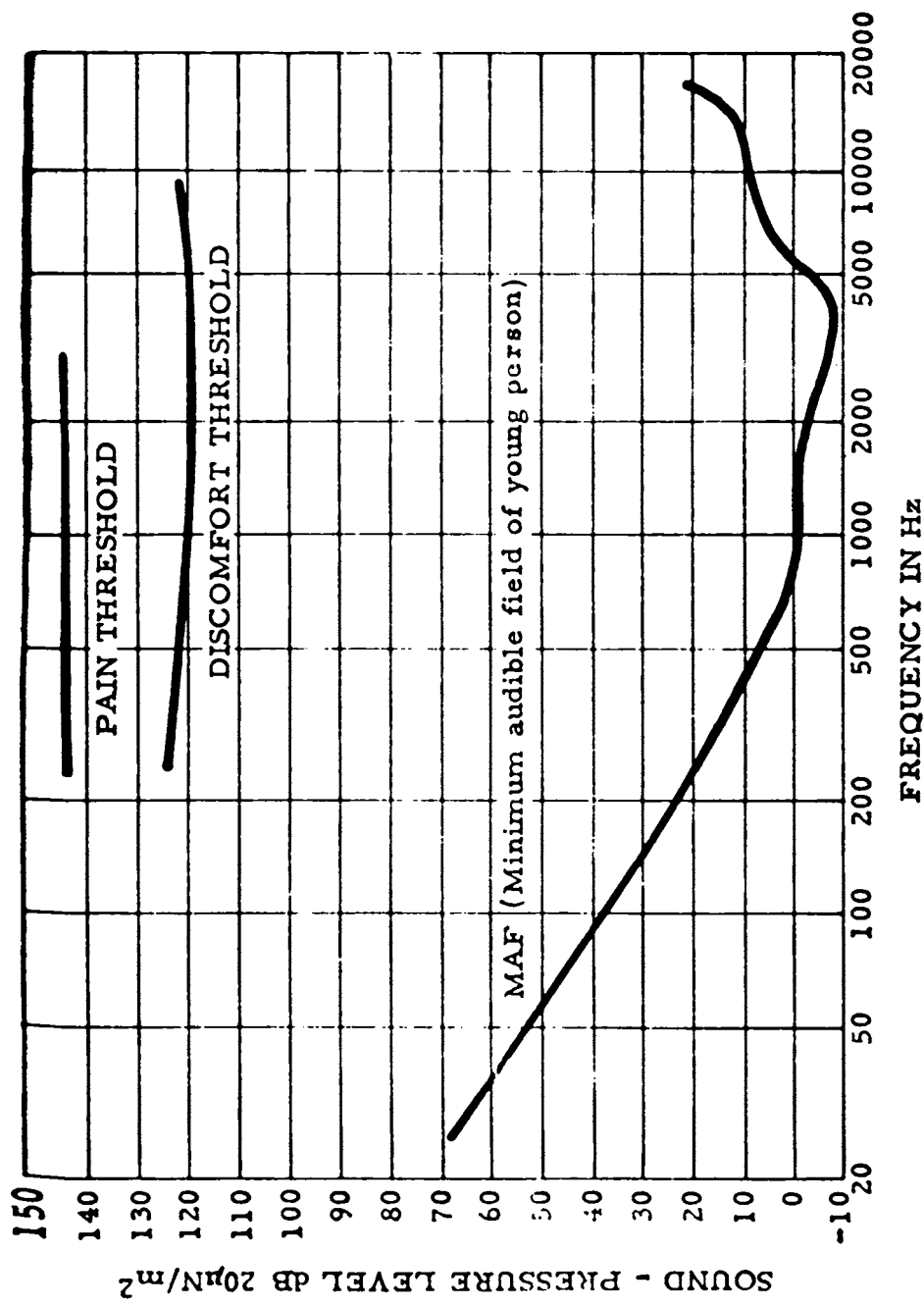
MODULE Physical Hazards		NO. 34
NOTES	INSTRUCTION	
Hazards of microwaves	D.2. Microwaves are short radio waves that have application in the television and radar fields.	
Slide 190 (Visual 34-14)	Some common uses of microwave energy of various wave lengths are shown here in Slide 190 and Visual 34-14.	
Slide 191	In Slide 191, you can see microwave antennas being used for communication purposes. Note the security fence that restricts close access to the microwave beam. Fences should be installed at distances from the source or beam that will prevent unsafe exposures.	
Ultraviolet hazards	D.3. Ultraviolet radiation comprises the wave lengths with associated dry thermal, germicidal, and ozone-producing properties. It is of major importance in industrial hygiene.	
Slide 192 (Visual 34-15)	Slide 192 (Visual 34-15) illustrates the ultraviolet action spectrum. Wave lengths that are visible cause sunburn.	
Hazards of infrared	D.4. Infrared radiation with wave lengths longer than those of microwaves is principally a source of heat, an industrial hygiene consideration when it comes to heat stress hazards.	
Hazards of X-rays	D.5. X-rays, the shortest wave length radiation considered here, has wide application in industry for the location of imperfections in metal structures.	
	X-radiation (a stream of photons) is extremely penetrating and has strong physiological effects, making it a major industrial hygiene concern.	

NOTES	INSTRUCTION
Slide 193 X-ray vault	Slide 193 shows the inside view of an X-ray vault. An industrial X-ray machine is in the foreground. The back wall has a door opening switch (that acts as a "SCRAM" button), a back-up door opening crank, a warning bell, and a light. "SCRAM" is a term used to describe a safety device which will deactivate the X-ray unit in the event a person is inside the vault when the unit is turned on.
Slide 194 X-ray vault interlock	Slide 194 shows an X-ray vault interlock. The interlock at the top right is activated by the fully closed vault door. The X-ray controls are wired so X-rays cannot be taken until all interlocks are activated.
Control of radiant energy hazards	D.6. Industrial hygienists must know the types of radiant energy, how and where they are used, and the controls to establish.
Dosimetry Slide 195	Methods of applying radiation dosimetry are shown in Slide 195. A film badge, a "Chirper", and an ionization measuring dosimeter are pictured. A "Chirper" makes bird-like chirping sounds when exposed to ionizing radiation.
Warning signs Slide 196	A typical laser warning sign and three types of laser goggles are depicted in Slide 196. The following controls are generally applicable to radiant energy.
Fixed energy source	(a) The energy source should be fixed so that energy is not accidentally directed outside the intended channel. X-ray or laser energy accidentally directed into an area where people are could produce tragic effects.
Equipment operation	(b) The equipment should not be in operation except when in use by qualified personnel.

MODULE Physical Hazards NO. 34	
NOTES	INSTRUCTION
Trained, qualified technicians	(c) Only trained and qualified technicians who know the potential hazards and proper control measures should operate the equipment.
Restricted areas	(d) Barriers, warning placards, and devices must be placed all around the equipment area and energy path.
Shielding	(e) Shielding should be provided around all radiant energy sources and paths. Reflective surfaces should be minimized for ultraviolet and laser operations.
Safety procedures	(f) A set of procedures should be developed and tested for safe operation of each type of radiant energy device.

NOTES	INSTRUCTION
<u>Summary of Key Points</u>	<u>SUMMARY OF KEY POINTS</u> A. <u>Noise</u> is unwanted sound. <u>Sound</u> is the effect of cyclic variations in air pressure. <u>Loudness</u> results from large air pressure variations. <u>Pitch</u> of sound is determined by frequency of air pressure cycles (measured in cycles per second, or <u>hertz</u>). Sound <u>intensity</u> is measured in terms of its strength (<u>sound pressure level</u>) relative to a reference sound pressure level. The ratio of these two levels is stated in terms of <u>decibels</u> , the relative intensity of sound. B. Noise is classified as either continuous (steady-state) or periodic (impact). C. OSHA permissible noise exposures are based on sound level measures using the "A" weighting scale (dBA). D. Excessive noise can induce physical stress, degrees of hearing loss, and total deafness. E. Engineering noise controls are the most effective type of abatement. F. Personal protective devices should be used to reduce unavoidable noise exposures. G. Hearing conservation programs should be established in noisy industries. H. Good illumination means greater efficiency, productivity, worker morale, and overall workplace cleanliness. I. Both the quality and the quantity of light should be considered when determining illumination needs. Older workers need more light.

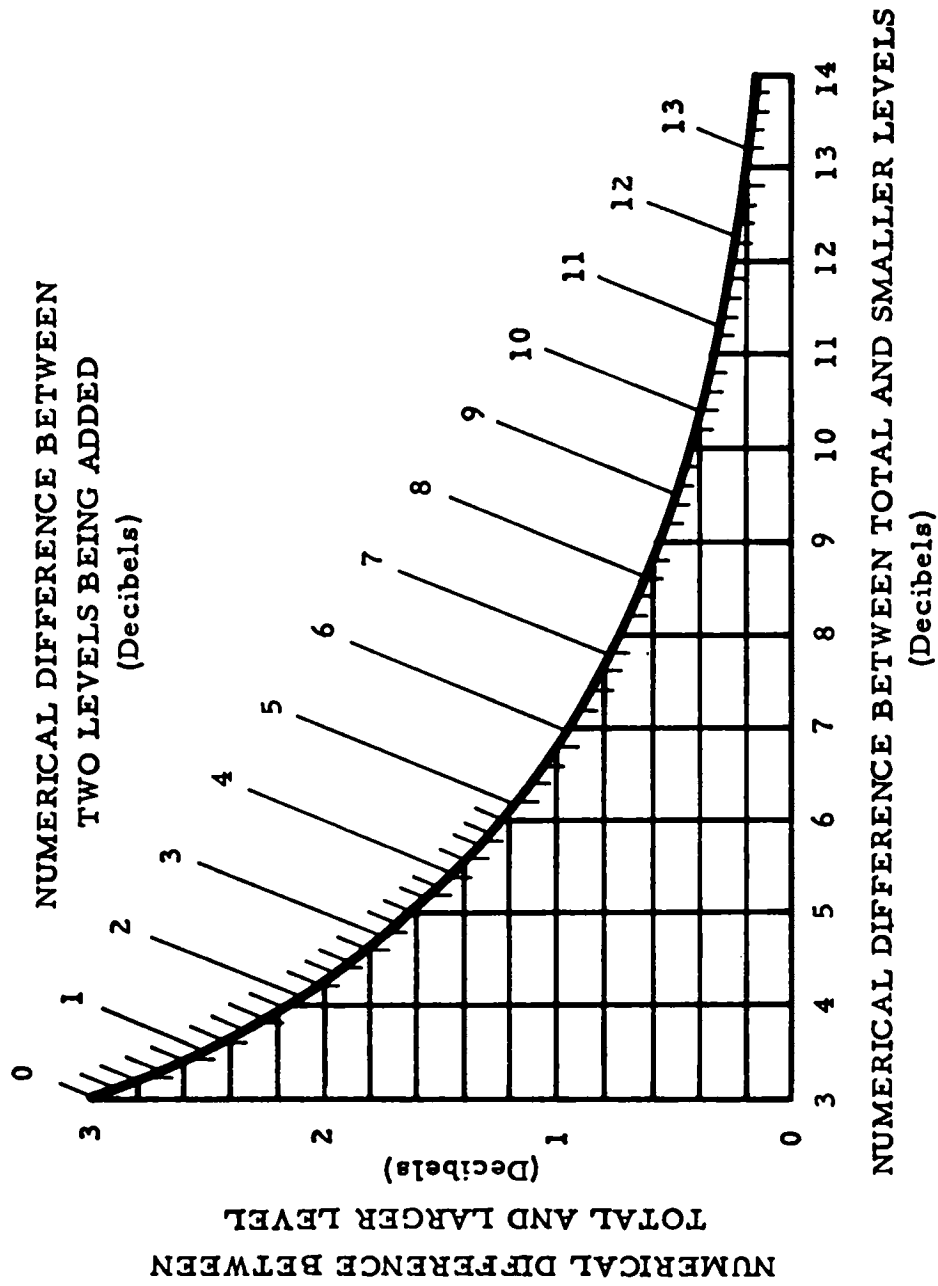
NOTES	INSTRUCTION
	J. Heat stress is best reduced by engineering controls—ventilation, isolation, shielding, and air conditioning. Personal protective equipment should be used where heat exposures are unavoidable. K. Radiant energy is of two main types—ionizing and non-ionizing. L. Non-ionizing radiation produces heat stress hazards. Ionizing radiation produces hazards in terms of both heat stress and radiation exposure. Ionizing radiation is by far the more dangerous. M. Controls for radiant energy hazards must include: (1) fixing of the energy source; (2) operation of equipment by trained technicians; (3) strict control of access to the radiant energy area; (4) use of warning devices; (5) placement of shielding around energy sources and the path of radiation beams; (6) strictly controlled operating procedures; (7) continuous monitoring of radiation levels in the workplace; (8) an on-going medical surveillance program.



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THRESHOLDS OF HEARING AND TOLERANCE

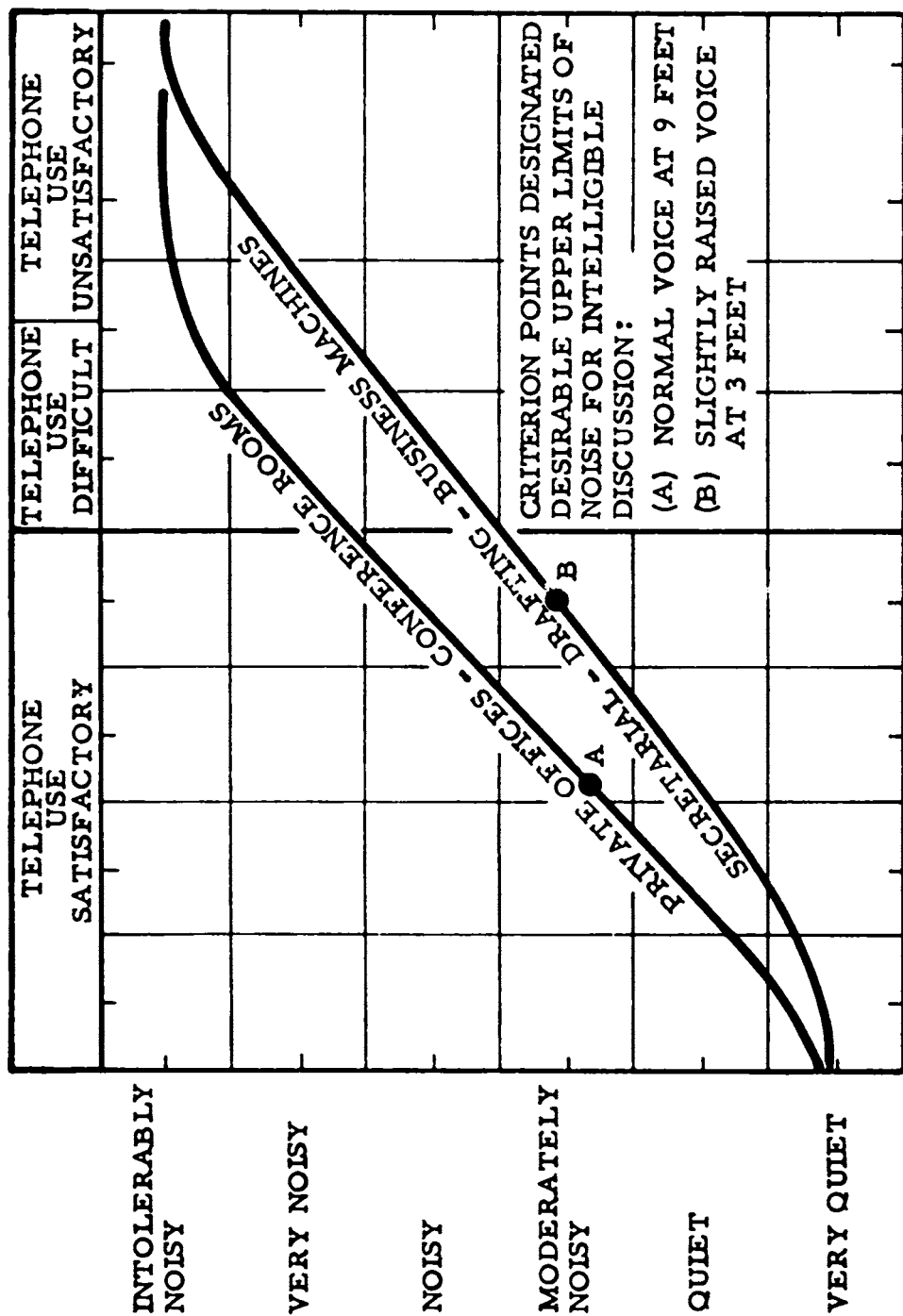
Visual 34-1



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CHART FOR COMBINING OR SUBTRACTING DECIBELS

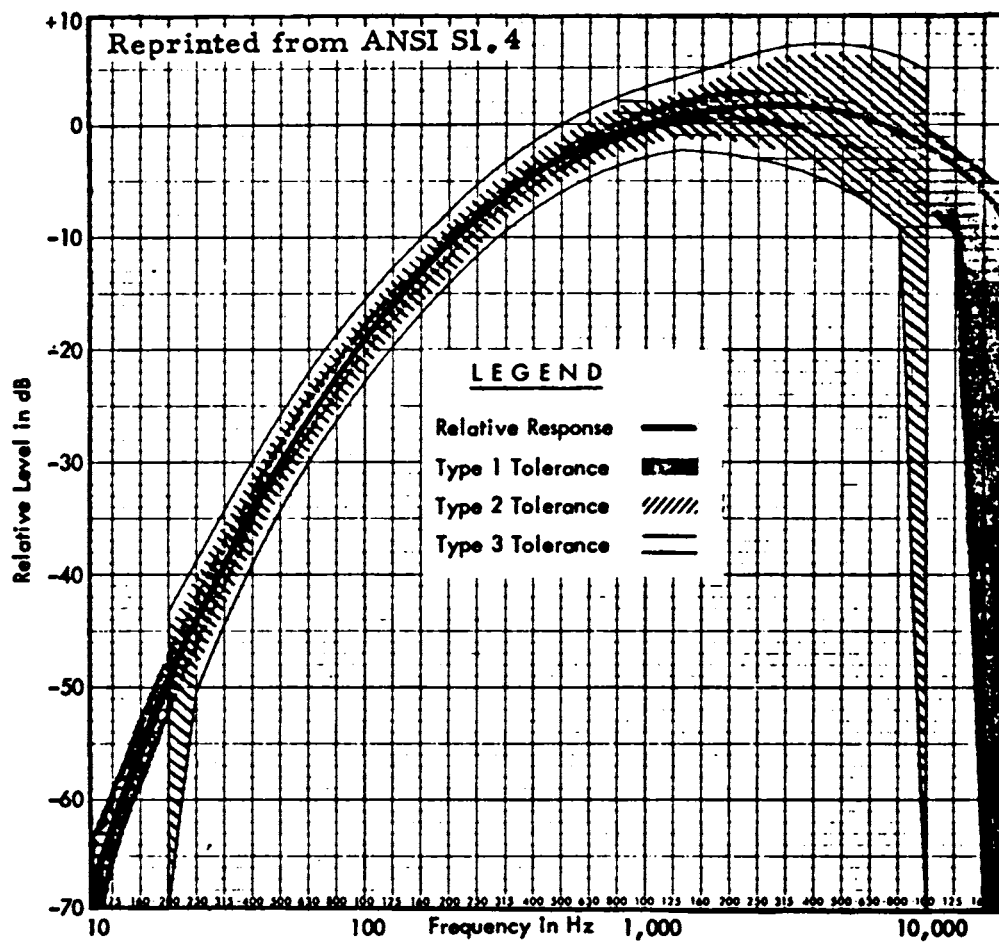
Visual 34-2



AVERAGE OF SOUND LEVELS IN BANDS AT 500, 1000, 2000Hz (SIL) DECIBELS RE20 μ N/m²
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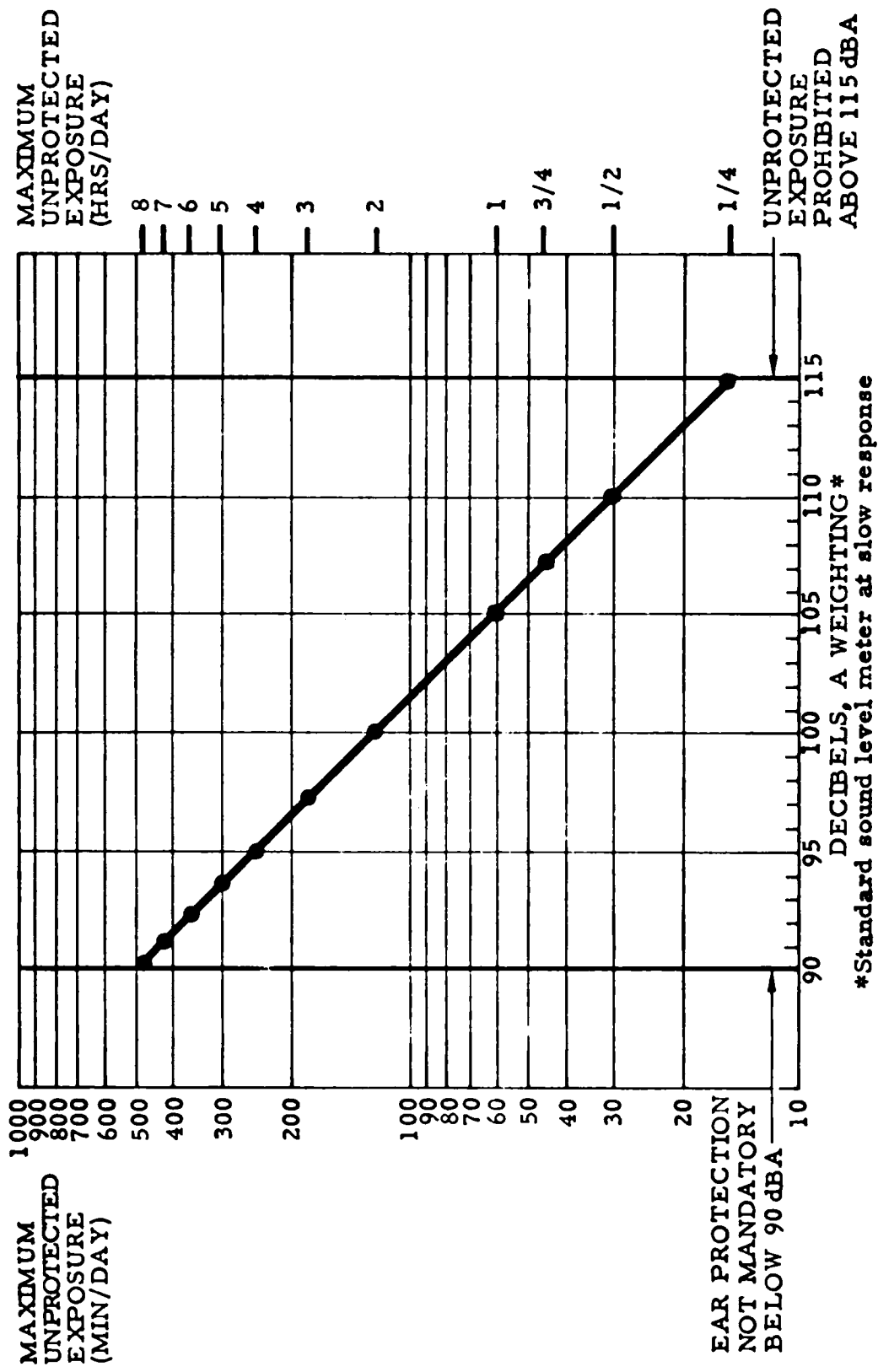
RATING CHART FOR OFFICE NOISES

Visual 34-3



SOUND WEIGHTING AND TOLERANCES - "A" SCALE

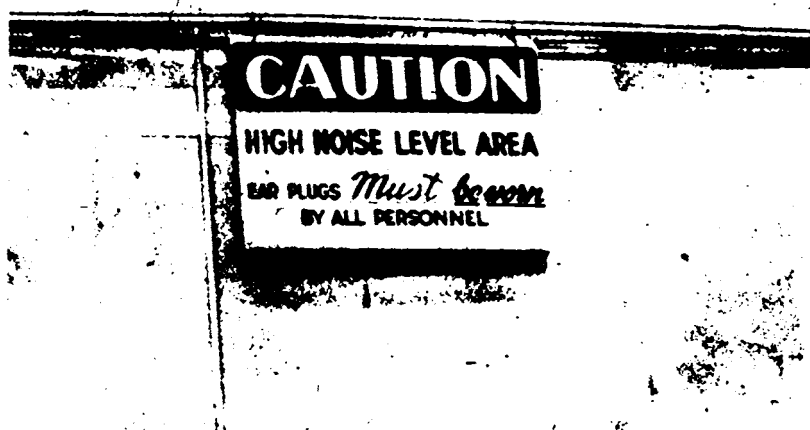
Visual 34-4



(FROM 29 CFR -PART 1910-95)

PERMISSIBLE UNPROTECTED NOISE EXPOSURES

Visual 34-5



HIGH NOISE LEVEL WARNING SIGN

Visual 34-6

Table 1—Levels of Illumination Currently Recommended

Area	Footcandle on Task*	Area	Footcandle on Task*	Area	Footcandle on Task*
Airplane manufacturing		Book binding (cont.)		Control station (interior) (cont.)	
Stock parts		Cutting, punching, stitching — 70		Auxiliary, battery room, boiler or feed pump, tanks, compressors, gauge area — 20	
Production — 100		Embossing and inspection — 200		Boiler platforms — 10	
Inspection — 200		Bevereries		Burner platforms — 20	
Parts manufacturing		Brew house — 30		Cable room, calculator or pump bay — 10	
Drilling, riveting, screw fastening — 70		Breeding and leg washing — 30		Coal conveyor, crusher, loader, scale area, pulverizer, fan area, transfer tower — 10	
Spray booths — 100		Filling (bottles cans, kegs) — 50		Condensers, dewaterer floor, evaporator floor, boiler floor — 10	
Sheet aluminum layout and template work, shaping and smoothing of small parts for fuselage, wing sections, cowling, etc. — 100		Building (Construction)		Control rooms	
Welding		General construction — 10		Vertical face of switchboards	
General illumination — 50		Excavation work — 2		Simple or section of duplex facing operator —	
Precision manual arc welding — 1000		Building exterior		Type A—Large centralized control room 66 inches above floor — 0.1	
Subassembly		Entrances		Coal unloading	
Loading gear, fuselage, wing sections, cowling and other large units — 100		Active (pedestrian and or non-vehicle) — 5		Truck (loading or unloading zone) — 5	
Final assembly		Inactive (normally locked in from) — 1		Large storage area — 0.5	
Placing of wings — 100		Examination of canned samples — 200		Car dumper — 0.5	
Motor — 50		Container handling — 200		Tipple — 5	
Hand — 100		Can uncrabbers — 70		Coal storage area — 0.1	
Scales and thermometers — 50		Labeling and cartoning — 30		Conveyors — 2	
Wiping room — 30		Central station (interior)			
Book binding		Air-conditioning equipment, air preheater and fan floor, ash sluicing — 10			
Folding, assembling, pasting, etc. — 70					

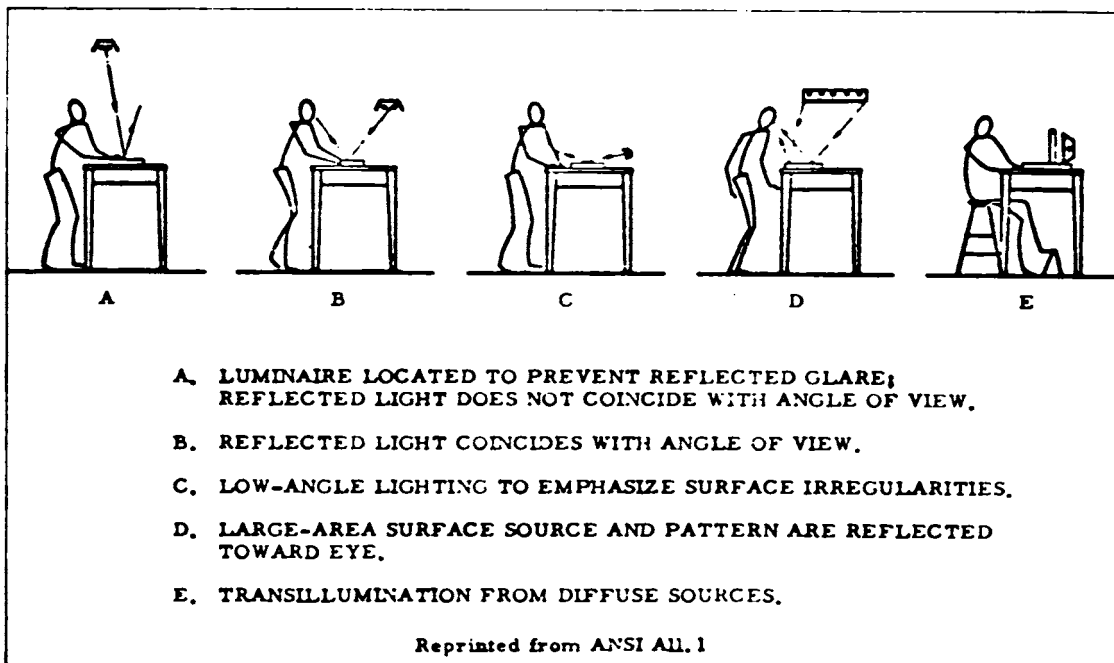
* Minimum on the task at any time. For other notes see end of table.

(Table continued on next page)

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LEVELS OF ILLUMINATION CURRENTLY RECOMMENDED

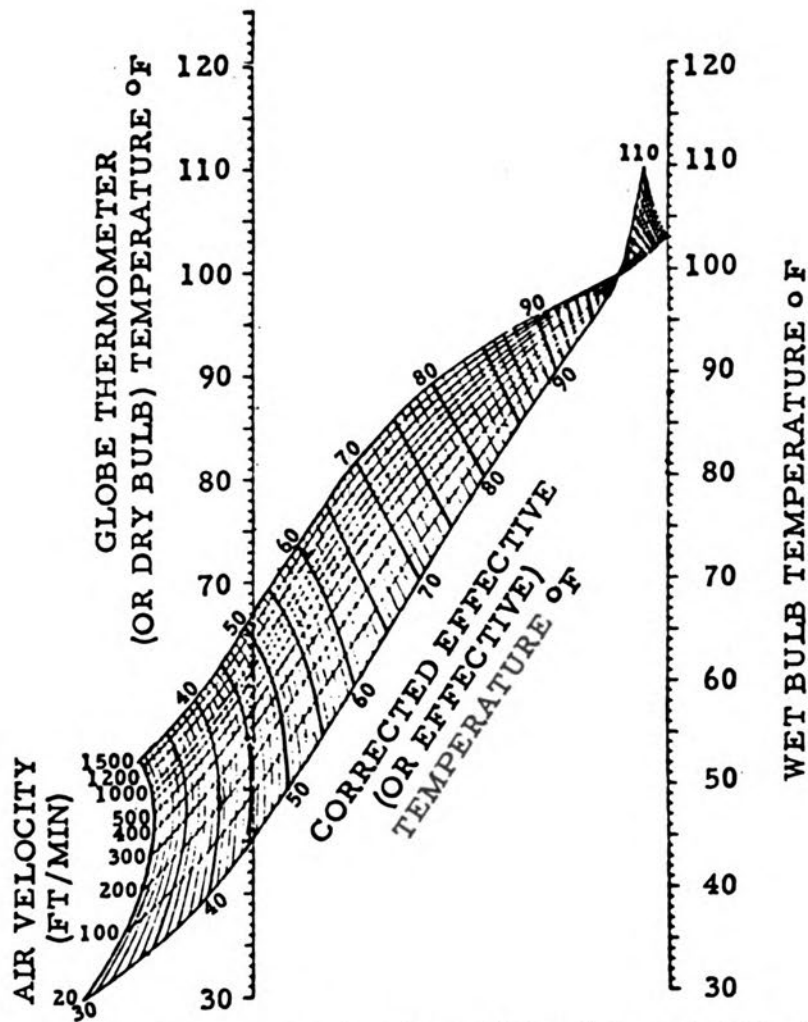
Visual 34-7



Reprinted from ANSI A11.1

PLACEMENT OF SUPPLEMENTAL LUMINAIRES

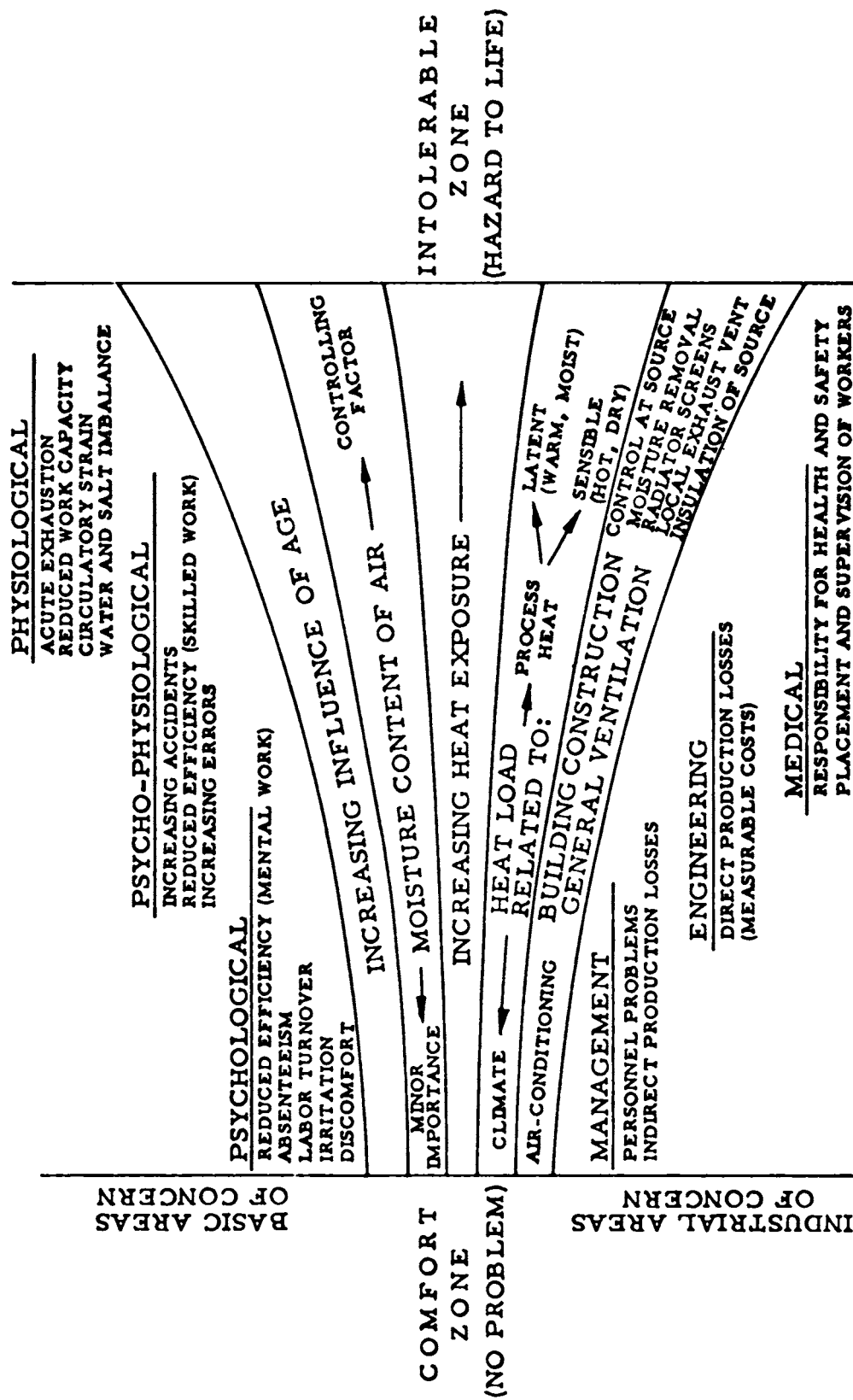
Visual 34-8



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NORMAL SCALE OF CORRECTED EFFECTIVE TEMPERATURE

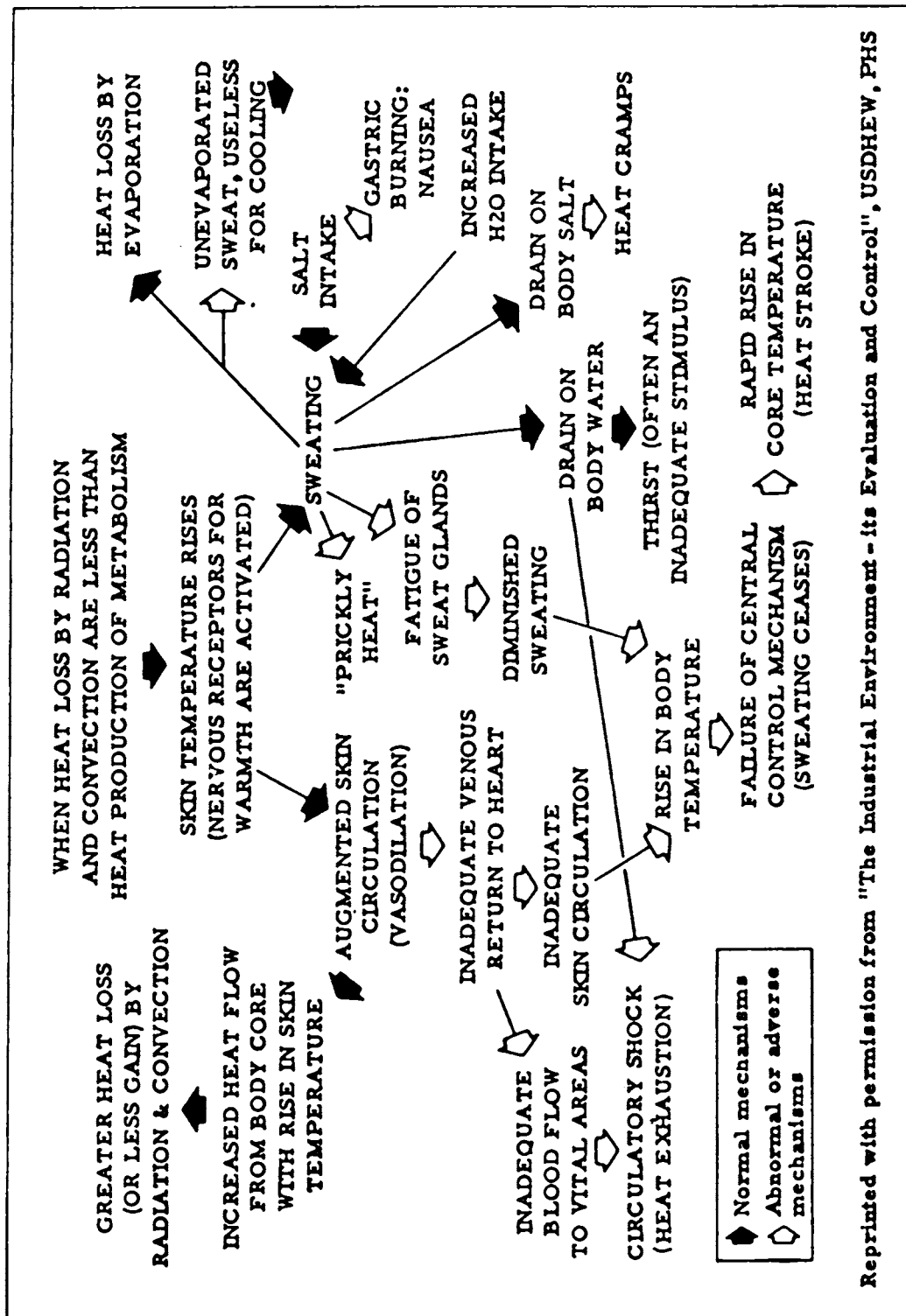
Visual 34-9



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EFFECTS OF HEAT ON MAN

Visual 34-10

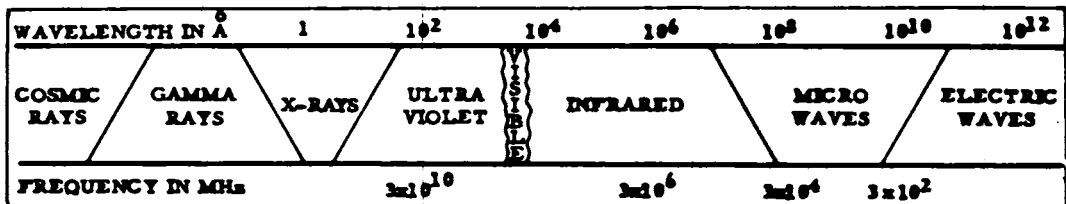


PHYSIOLOGICAL HEAT EFFECTS

Energy Type	Effects	Industrial Applications	Control Practices	Signs
Microwaves	1. Heat energy absorbed and causes damage in fat, bone, muscle, eyes 2. Changes in electrical charge of tissue molecules 3. Studies indicate changes in antigenic activity and production of cataracts in animals 4. Possible heart pacemaker effects	1. Microwave ovens 2. Broadcasting 3. Radar 4. Diathermy	1. Distance 2. Wire mesh shield 3. Dummy loads 4. Interlocks 5. Area placarding 6. Protective suits (not practical)	Look for lack of control practices
Ultraviolet	1. Photochemical skin reactions—possibly skin cancers 2. Radiation below 2950Å can cause eye damage (decreases rapidly from 2950–3600Å)	1. Arc, especially shielded arc and plasma arc welding 2. Germicidal lamps 3. Photography/reproduction machines 4. Sun lamps 5. Black light	1. Shielding 2. Non-reflective walls, ceilings 3. Distance 4. Enclosure 5. Eye/skin protection	Look for lack of controls; nearby chlorinated hydrocarbon use; ozone
X-ray	1. Damaging to cells and tissues (cumulative) 2. Potentially carcinogenic 3. Lifespan shortening 4. Genetic effects	1. Electronic tubes 2. Electron beam welders 3. X-radiography equipment 4. X-ray diffraction equipment 5. Electron microscopes	1. Shielding 2. Distance 3. Exposure time 4. Interlocks 5. Personnel monitoring, dosimetry 6. Placarding and warning lights 7. "Scram" buttons	Look for lack of controls and auxiliary hazards such as handling of lead shielding (ingestion)
Lasers & Masers (Coherent energy)	1. Damage to the retina 2. Superficial tissue damage due to heat 3. Does not conform to inverse square law	1. Alignment laser 2. Cutting and welding 3. Communications 4. Medical applications 5. Military uses	1. Isolation or enclosure of beam 2. Non-reflective walls, ceilings 3. Visible or audible alarms, positioned to draw attention away from beam 4. Good general illumination (pupil constriction) 5. Protective eye shields 6. Education	Look for lack of controls and auxiliary hazards such as toxic gases (ozone, CO, NO _x); cryogenics; x-ray from high voltage supporting equipment

EXAMPLES OF TYPES OF ENERGY

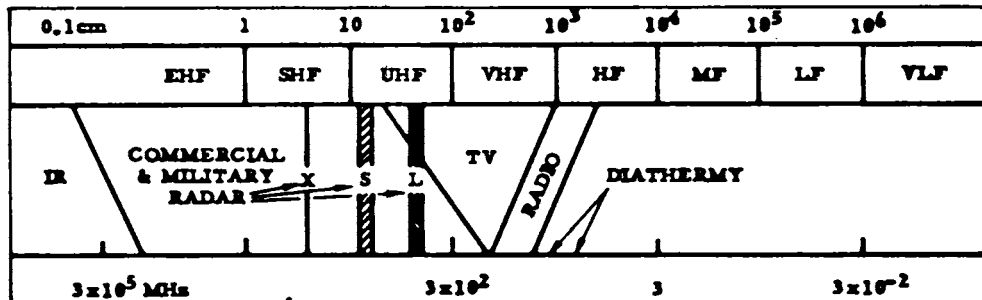
Visual 34-13



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ELECTROMAGNETIC SPECTRUM

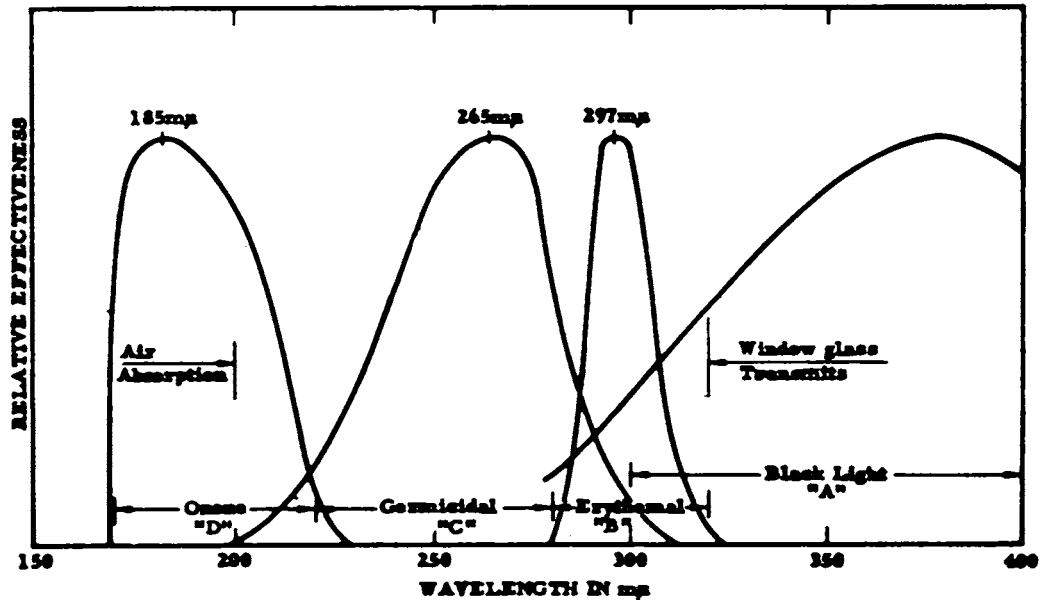
Visual 34-12



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MICROWAVES

Visual 34-14



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ULTRAVIOLET ACTION SPECTRUM

Visual 34-15



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Physical Hazards Workshop NO. 35 TIME: 50 minutes

Practice in making preliminary surveys of potential physical hazards.

Objectives. Enable the trainee to evaluate physical hazards through

Knowledge of typical conditions;
Recognition of hazardous conditions;
Application of survey techniques;
Recall of information from other sources.

Content. Case studies of the following industrial situations:

Heat stress
Noise
Ancillary Exposures
Cleanroom (Illumination)
Aircraft Parts Inspection Area (Illumination)
Automated Gas Cutting Shop (Illumination)
Industrial Radiography

Methods. Simulated observation and individual problem-solving

Materials. Chalkboard, chalk, and eraser
Slide Projector (35mm) and Screen or Suitable Wall
Slides 197 - 208 and 35-G
Visual 35-1

Special Terms. Physical operations above and related terms, including

Chirper	Film badge
Dosimetry	Footcandle
Drop forge	KV
Drop hammer	Millilamp

REFERENCES

Basic References

Refer to Module 34.

Other References

1. American Conference of Governmental Industrial Hygienists. Industrial Ventilation - A Manual of Recommended Practice. 12th Edition. Lansing, Michigan: Edward Brothers, Inc., 1972.
2. Carson, Gordon B. Production Handbook. 2nd Edition. New York: The Ronald Press Company, 1959.

NOTES	INSTRUCTION
Survey	SURVEY OF DROP FORGING The first survey in this workshop deals with drop forging. Drop forging is similar to all other types of forging processes: 1. Metal is heated to a very high temperature to reduce it to a plastic state. 2. Metal heated above the work-hardening range is formed by pressure or impact into a predetermined shape. Drop forging shapes the hot plastic metal by pounding it between dies with a drop hammer. The finished piece may require a sequence of several forging operations.
Slide 35-1 (Visual 35-1)	Drop Hammer
Visual 35-1	Look at Visual 35-1 in your manual. Here is a simplified sketch of a gravity machine used to pound metal into shape. Observe the (A) heavy weight that is raised and then dropped on the (B) metal. In our survey today, the drop hammer is operated by pressurized steam instead of gravity.
Directions	<u>Directions</u> You are asked to evaluate a drop forging operation for heat stress, noise, and ancillary exposures.
Work Plan	Work each of the three problems by yourself, as follows: 1. Read the problem situation to determine conditions. 2. Answer the evaluation questions.

NOTES	INSTRUCTION
Answer by recall Problem 35-A Situation Evaluation	<u>Directions (continued)</u> 3. Hold any questions for discussion later. Try to make your evaluations by recall rather than reference to the problem situation. You may not be able to do this with the first problem; you should be able to do it with the third problem. PROBLEM 35-A. HEAT STRESS <u>Situation</u> Assume that the workers are on the job all day, except for a 30-minute lunch break and two 10-minute rest periods. The oven temperatures are 1800°F and the forging temperatures are 1200 - 1400°F. There are no local exhaust controls on the hot processes. Regular work clothes are worn and asbestos gloves are used. <u>Evaluation</u> 1. Which one or more of the following do you recommend for potential heat stress exposure? a. No further action. b. Evaluate heat stress conditions, including a joint survey with an Industrial Physician. c. Immediate use of aluminized asbestos clothing as an interim control. d. Cease the operation until local exhaust controls are installed.

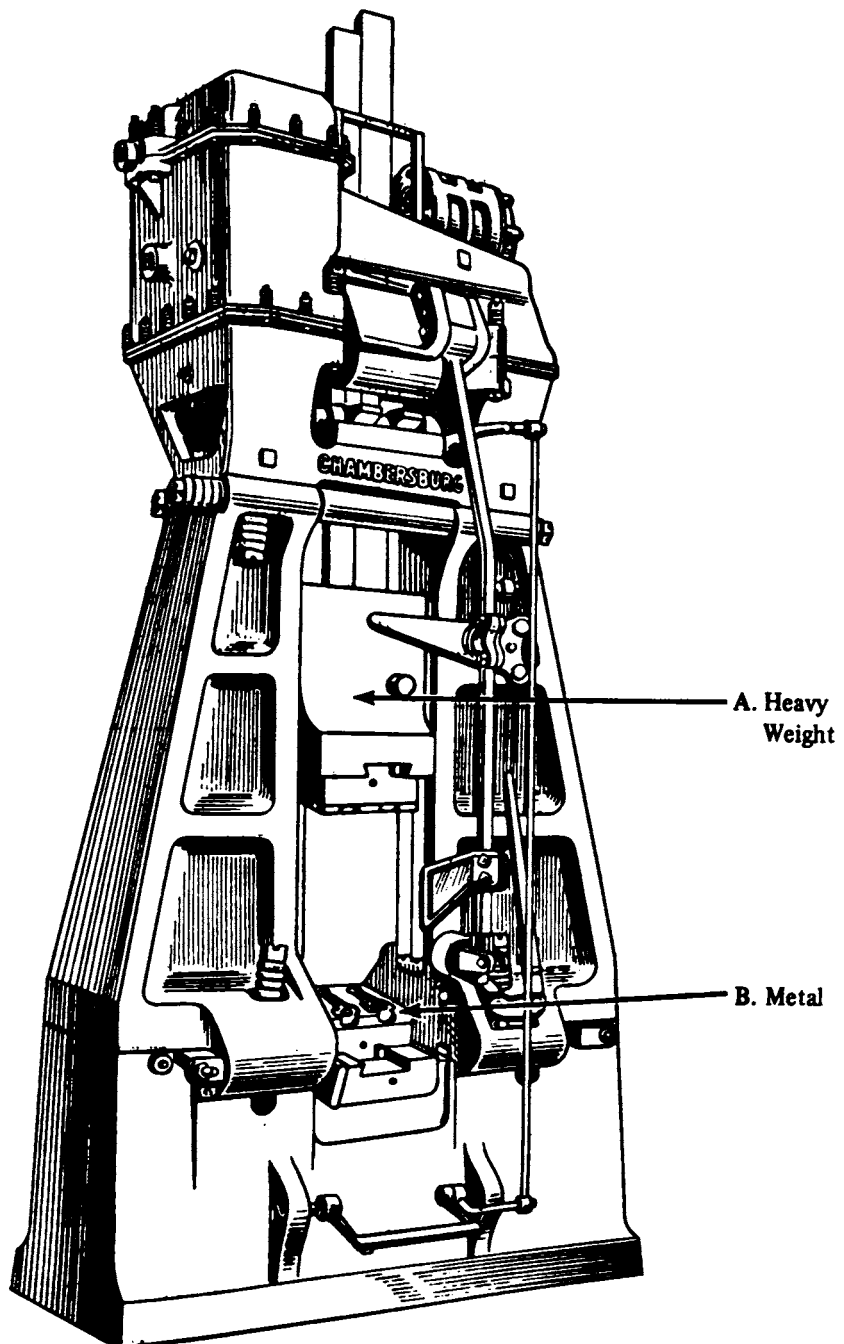
NOTES	INSTRUCTION
Problem 35-C	PROBLEM 35-C. ANCILLARY EXPOSURES
Situation	<u>Situation</u> Large gasoline-driven forklifts are used throughout the plant. Lead-based oils are used to lubricate some of the forgings. Although 50 footcandles was the recommended illumination, the forging areas are shadowy.
Evaluation	<u>Evaluation</u> - Which of the following would you include in the report of your preliminary survey? - Further study in the vicinity of the forges for lead fumes and aldehydes. - Further study throughout the plant to sample carbon monoxide and aldehydes. - Further study throughout the plant to sample carbon monoxide, lead fume, and aldehydes. - None of the above. - How do you feel about the illumination? - Shadows indicate that the illumination is not adequate. - Further action is not necessary. - Another industrial hygiene survey is recommended to make illumination measurements. - Suggestions for improvements can be included in the survey reports.

NOTES	INSTRUCTION
Survey Directions Problem 35-D Slide 197 Slide 198	SURVEY OF PLANT ILLUMINATION You are asked to survey three areas of an aircraft plant for hazardous conditions with respect to illumination. <u>Directions</u> Again, please work by yourself and follow the directions below. 1. Read the conditions for each problem. 2. Look at the slides. 3. Answer the questions, as indicated. PROBLEM 35-D. CLEANROOM • The recommended general illumination in the area is 100 footcandles. • Diffuse overhead fluorescent lighting is provided. Cleanroom - General Illumination Overhead diffused fluorescent lighting is provided. • For close inspection type work, 200 footcandles is recommended. • The inspection area is provided with supplementary illumination. Laminar Flow Hood - Supplementary Lighting The operator is counting dust contamination with a microscope at the laminar flow hood. Supplementary diffuse fluorescent lighting is provided at the hood. • No shadows or glare are noticeable.

NOTES	INSTRUCTION
Evaluation	<u>Evaluation</u> Do not look back to answer this question. Which of the following do you recommend? a. No further action. b. Evaluate the illumination levels. c. Provide additional lighting. d. Both b and c.
Note	<u>Note</u> The other two evaluations in this survey are similar to Problem 35-D. Practice your powers of observation. Cover the evaluation question while you concentrate on the information about the problem situation. Then cover this information while you answer the question.

NOTES	INSTRUCTION
Problem 35-F	PROBLEM 35-F. AUTOMATED GAS CUTTING SHOP • The recommended illumination in this area is 50 footcandles on the work. • The room appears very dimly lit. You cannot clearly see detail in corners of the room at the opposite side. Black shadows are evident throughout the room.
Slide 200	Gas Cutting - Illumination Gas cutting with shadows on the work.
Slide 201	Gas Cutting Shop - Illumination Note the dark shadows and lack of detail in the right-hand corner.
Evaluation	<u>Evaluation</u> Which of the following do you recommend? a. No further action. b. Evaluate the illumination levels. c. Provide additional lighting. d. Both b and c.

35 - 13



Source: Carson, 1959, p. 20-15.

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Visual 35-1



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Vibration NO. 36 TIME: 50 Minutes

Most industrial vibration exposure is long-term and chronic, making it a serious work hazard in terms of physical and psychological health.

Objectives. Enable the trainee to:

Understand the physical nature of vibration;
Recognize industrial vibration hazards;
Know the methods for controlling vibration exposures.

Content. Definition of vibration.
Characteristics of vibration.
Human physical and psychological reactions to vibration exposure.
Control of vibration exposure and hazards.

Methods. Lecture, Exercises, and Discussion

Materials. Chalkboard, chalk, and eraser
Visuals 36-1 and 36-2

<u>Special Terms.</u>	Acceleration	Harmonic motion
	Angular frequency	Oscillate
	Damping	Periodic motion
	Displacement amplitude	

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Pages 38-39.
2. Industrial Environment - Its Evaluation & Control. Chapter 26.

Other References

1. Stellman, Jeanne M.; Daum, Susan M. Work Is Dangerous to Your Health. New York: Pantheon Books, 1973. Chapter 4, pp. 106-120.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

Every machine that has moving parts vibrates. That statement also includes the human body. Your vocal cords vibrate when you speak or sing. Your teeth vibrate and hands shiver when you're too cold for comfort. Think about the objects in your own home that give off vibrations. Some are so taken for granted that you don't even notice them: the refrigerator, washing machine, furnace, air conditioner, electric clock, vacuum cleaner, mixer, and of course, the family car.

Nine times out of ten, we pay no attention to the vibrating objects around us because their motion does not disturb us. Some vibrations may even be comforting, as in the case of hand massagers and vibrating mattresses. But there comes a point when vibration gets to be unpleasant and irritating. The unpleasantness may be due to the length of time the vibration persists. Suppose you had one of those nice vibrating mattresses, but something went wrong and you couldn't turn it off. Eventually you would go sleep on the livingroom couch!

Vibration may be unpleasant because of its violence. How long could you stand operating a pneumatic drill or living right under the paths of jet planes that continually take off and land? Some people have trouble enduring the frequency of vibration, such as found in high-speed dental drills. In non-industrial situations, much of the vibration we encounter is in the form of noise. Although we may not feel the vibrations caused by heavy traffic going by, we still react to it through our sense of hearing. We cannot feel the vibration of the screaming siren or the pounding jackhammer, but the vibrations reach us in the form of noise and so cause irritation. Or if the vibration happens to be the quiet purr of a kitten, we may consider it a pleasant sound.

MODULE Vibration	NO. 36
NOTES	INSTRUCTION
	In many industrial occupations, however, workers come into bodily contact day after day with very intense or very forceful vibrations. They may have to stand on vibrating platforms, sit inside vibrating vehicles, work with vibrating power tools, or work on vibrating machinery. In virtually all of these cases, the vibrations are audible—the workers both feel and hear the vibrations. People cannot work under such conditions without their bodies and their minds being affected in some way. Noise, discomfort, injury, fatigue, emotional wear, mechanical wear, malfunction, and destructive failure are all normal manifestations of vibration that require the limiting of vibration to acceptable levels.

NOTES	INSTRUCTION
<u>Explanation-Lecture</u> Definition of vibration Characteristics of vibration Displacement amplitude Angular frequency Acceleration Harmonic motion Types of vibration Range of industrial mechanical vibrations Solid-borne and airborne vibrations	<u>EXPLANATION - LECTURE</u> A. When an object moves in an oscillating motion, it is said to vibrate. If, in its motion, it is displaced an appreciable distance from its equilibrium position, its <u>displacement amplitude</u> is said to be high. When the displaced motion is great enough, it can be measured with an ordinary ruler. The rate at which displacement occurs is the <u>angular frequency</u> of the vibration. When forces act upon the object to change the angular frequency, this change is called <u>acceleration</u>. A.1. Pure, harmonic (periodic) vibration occur when the same motion repeats itself at regular intervals. In such a case, the displacement, angular frequency, and acceleration are related in mathematical terms. Quite often, however, a vibration is made up of a complex combination of motions; or it may be completely random, such as an occasionally repeated bump or jerk; or it may be a steady, transient, continuous, or intermittent motion. A.2. Most industrial mechanical vibrations lie in a range of from 1-2 hertz (cycles per second) to 2,000 hertz. This corresponds to rotational speeds of 60 to 120,000 revolutions per minute. A.3. Solid-borne vibrations are those that are transmitted to adjacent solid members, sometimes for considerable distances. Airborne vibrations are those in which a vibrating surface is in contact with the air.

MODULE Vibration	NO. 36
NOTES	INSTRUCTION
Vibration and noise Effects of vibration on the human body Human response to various sorts of vibration Visual 36-1 Industrial exposures to vibration are usually chronic Consequences of extended exposure to industrial vibration	Transmission of vibration to the air may produce an audible sound, or noise. The vibration of violin strings, the cone of a loudspeaker, and even your own vocal cords are designed to produce audible sounds. B. If the human body or a segment thereof is subjected to vibration for extended periods by touching, sitting, or standing on a vibrating object, discomfort, fatigue, irritation, and physical injury can result. B.1. It is interesting to note the human response to different vibrations. A vibration with a displacement amplitude of 0.1 inch at a frequency of 2 Hz is considered to be unpleasant. It becomes intolerable if the frequency is raised to 4 Hz. As shown in Visual 36-1, a displacement of 0.001 inches, though only "perceptible" at 4 Hz, becomes very unpleasant to intolerable at 60 Hz. Frequencies above about 100 Hz are noticed primarily by feel or skin sensation. The transmission of these high-frequency vibrations is greatly affected by interposing layers of clothing, such as shoes and gloves, or any material which tends to dampen or absorb the vibration. B.2. Industrial exposures to vibration may be of extended duration. Some workers spend many months and years repeatedly using the same vibrating hand tool or working at a particular machine that transmits vibration to the worker. Such chronic types of exposure to vibration and their consequent response characteristics are ill-defined. It is recognized, however, that prolonged use of hand-held, high-speed (1,000-8,000 rpm) tools can cause peripheral vascular abnormalities. These can be recognized by numbness and tingling sensations in fingers, commonly called

MODULE Vibration		NO. 36
NOTES	INSTRUCTION	
Process substitution	C.1. Some vibrations are necessary to the proper functioning of certain machines. When such inherent vibrations become offending, it may be possible to change the process or procedure to one that does not require the vibratory tool.	
Performing tasks at lower rotational speeds	In this case, substitution is the best control measure. If the task can be done equally well using lower rotational speeds, the frequency of the source can be changed. This may eliminate or reduce the offending vibration.	
Overloading machines adds to vibration level	C.2. Occasionally a machine is undersized for its job. To get the job done, its capacity is raised, though efficiency may suffer, by increasing the speed.	
Select proper size machinery for the job	Fans and blowers are often ill-used in this way. Associated vibration problems would better be solved by proper selection and sizing of machinery.	
Vibration due to badly maintained attachments	C.3. Although a driving motor may be free of vibrations and well seated in its bearings and mountings, the attached machinery or tools may not be. If attachments are not balanced, or if they are allowed to become imbalanced through inadequate maintenance, vibrations may develop that offend or injure the worker, cause wear or damage to the well-tuned driving motor, and thus increase the amount and kinds of vibration.	
Isolation of the vibration	C.4. If the source of vibration cannot be eliminated by substitution, or if the vibration itself cannot be reduced in velocity, amplitude, acceleration, or jerk, then isolation of the vibration may be necessary. Reducing the response of radiating surfaces may also control the vibration.	
Reducing response of radiating surfaces	Isolation means confining the vibration to the source, where it may be inherent to the task, and reducing the transfer of the vibration to	

MODULE Vibration	NO. 36
NOTES	INSTRUCTION
Isolation mounts Changing the center of gravity of the vibrating mass Blocking transmission of vibration Interface clamping Use of deadeners Use of visco-elastic material Summary of control methods	structural members that tend to transmit or radiate the vibration. Where a machine transmits vibration through its mountings, properly designed isolation mounts may be very effective. It is important that these mountings be carefully designed for the particular machine according to its weight and frequency of vibration. If this is not done, amplification of the offending vibration may occur. It may also be beneficial to change the center of gravity of the vibrating mass by mounting it first on a heavy base, and then attaching isolation mounts to the base. Blocking the transmission of a vibration from one object to another can be done by interposing a layer of damping material that allows one object to move without imparting an appreciable amount of this motion to another object. This procedure is called interface damping. External coatings of mastic materials (deadeners) are sometimes used to dissipate the vibration energy or damp the vibration. Here the thickness and the elasticity of the damping material and the structural element are factors in the resulting vibration energy loss. Sandwiching a thin layer of visco-elastic material between panels has proved to be an even more effective damping method than using a thicker external coating. In summary, controls for vibration are a combination of common sense, simple solutions when possible, use of trial and error, and application of engineering and physical methods for measurement, analysis, and design of controls.

MODULE Vibration	NO. 36
NOTES	INSTRUCTION
<u>Summary of Key Points</u>	<u>SUMMARY OF KEY POINTS</u> A. When an object moves in an oscillating motion, it is said to vibrate. B. Most industrial mechanical vibrations lie in a range of from 1 to 2 Hz to 2,000 Hz. C. Pure harmonic motions occur when the same motion repeats itself at regular intervals. D. If the human body or a segment thereof is subjected to vibration for extended periods, discomfort, fatigue, irritation, and physical injury can result. E. People react differently to various amplitudes and frequencies of vibration. F. Long-term exposure to vibration leads to consequences that are as yet ill-defined. They range from a simple tingling sensation in the hands to grave dysfunction of body systems. G. Control of vibration is best accomplished by reducing the mechanical disturbance causing the vibration. H. Inherent vibrations can be reduced by substitution of non-vibratory processes or procedures, or lowering the rotational speeds of machinery. I. Proper selection of machinery will eliminate the necessity of forcing undersized machines to do more work by raising their speed. J. Isolation of vibration sources may be necessary when substitution is not possible. I. Vibration can be controlled by blocking the transmission of vibration from one object to another.

EXERCISES

1. A saw that rotates at 1000 rpm uses a blade that has six large cutting edges. What would you expect the predominant frequency of vibration to be for this saw blade while operating?

_____ a) 1000 Hz
_____ b) 6000 Hz
_____ c) 100 Hz
_____ d) 6 Hz

2. A study was done in a plant where workers were finishing aluminum engine castings using electrically cable-driven rotary cutting tools with speeds of 1100, 2800, and 6000 rpm. The size of the cutting burr depended upon the task. Forty percent of the 300 workers showed signs of "dead hand." Workers' hands became very sensitive to exposure to cold, and some lost the sensation of touch altogether. The average duration of work before the onset of symptoms was 23 months, but in some cases it was only 6 months. What should be done about this situation? (Check the correct statement(s).)

_____ a) The loss of sensation in the hands is related to the use of rotary cutting tools and exposure of the hands to vibrations.
_____ b) Use of the 6000 rpm units should be discontinued.
_____ c) The workers' hands should not be allowed to become chilled.
_____ d) Work on these jobs should not exceed 6 months.
_____ e) Mechanization of the cutting process or insulation of workers' hands should be initiated to reduce the exposures to a level that eliminates the onset of these symptoms.
_____ f) Larger, more powerful cutting tools should be substituted in order to get the job done faster and thus reduce exposure.

3. The subjective response of the human body to vibrating motions of various frequencies shows a comfort limit approximated by this relationship for the low (1-6 Hz) range:

$$\text{Vertical displacement amplitude} = \frac{2}{(\text{frequency})^3}$$

For a vibration of 6 Hz, what maximum vertical displacement amplitude would this approximation allow?

- _____ 1. 1 inch
- _____ 2. 0.1 inch
- _____ 3. 0.01 inch
- _____ 4. 6 inches
- _____ 5. 3 inches

NOTES

INSTRUCTION

DiscussionDISCUSSION

1. Be prepared to explain your answers to the Exercise questions.
2. Do you work in a plant, factory, or other location where workers are in contact with a great amount of vibration?

What types of machinery are involved? How many hours a day are workers exposed? Do you consider these vibration levels to be extraordinarily high? Do you happen to know exactly how high the vibration levels are?

What methods, if any, are in use at your workplace to reduce vibration exposure? Are any administrative controls in force? Do workers get "rest" periods away from the vibration area? Are tasks rotated?

Do you know if any worker has ever complained of "dead hand" or other adverse effects from vibrating tools or machinery? What were those complaints? What was done to alleviate the worker's problem?

3. Have you had any personal experience with dampening materials or vibration-reduction methods that proved to be especially good? What were those materials or methods and how were they used?

SUBJECTIVE RESPONSES TO VIBRATORY NOTION

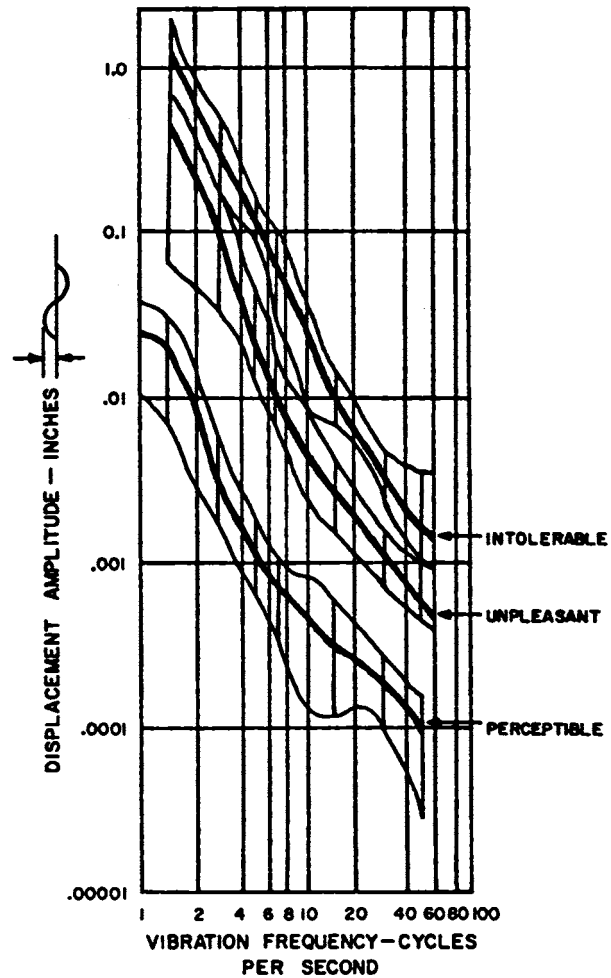


Chart is based on the averaged values of various investigators and is valid for exposures of up to a few minutes. The vertical arrows represent one standard deviation above and below the means.

Source: NIOSH, The Industrial Environment—Its Evaluation and Control, 1973, p. 336.

Visual 36-1

**EUROPEAN INDUSTRIES IN WHICH
CLINICAL EVIDENCE OF OVEREXPOSURE
OF WORKERS TO VIBRATION
HAS BEEN REPORTED**

Industry	Type of Vibration	Common Vibration Sources
Agriculture	Whole body	Tractor operation
Boiler Making	Segmental	Pneumatic tools
Construction	Whole body Segmental	Heavy equipment vehicles, pneumatic drills, jackham- mers, etc.
Diamond cutting	Segmental	Vibrating hand tools
Forestry	Whole body Segmental	Tractor operation chain saws
Foundries	Segmental	Vibrating cleavers
Furniture manufacture	Segmental	Pneumatic chisels
Iron and steel	Segmental	Vibrating hand tools
Lumber	Segmental	Chain saws
Machine tools	Segmental	Vibrating hand tools
Mining	Whole body Segmental	Vehicle operators rock drills
Riveting	Segmental	Hand tools
Rubber	Segmental	Pneumatic stripping tools
Sheet metal	Segmental	Stamping equipment
Shipyards	Segmental	Pneumatic hand tools
Stone dressing	Segmental	Pneumatic hand tools
Textile	Segmental	Sewing machines, looms
Transportation (operators and passengers)	Shole body	Vehicle operation

**Source: NIOSH, The Industrial Environment—Its Evalua-
tion and Control, 1973, p. 336.**



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Back on the Job NO. 37 TIME: 50 Minutes

Once back at work, how will you put what you have learned into effect and how will you be able to get further information?

Objectives. To enable the trainee to get information about:

- (1) how to put industrial hygiene principles and programs into practice; and
- (2) how and where to get materials on various aspects of industrial hygiene and professional help in solving problems on the job.

Content. Additional training
Professional organizations
Certification
Employment opportunities
Consultants
Analytical laboratory facilities
State agency assistance
Reference works for the industrial hygienist
Industrial hygiene equipment
OSHA

Methods. Lecture, Discussion, and Supplements

Materials. Chalkboard, chalk, and eraser
Publications listed in the Supplements section of this module

Special Terms. American Board of Industrial Hygiene (ABIH)
American Conference of Governmental Industrial Hygienists (ACGIH)
American Industrial Hygiene Association (AIHA)
American Occupational Medical Association

Note. This module is not covered in the final examination.

REFERENCES

Basic References

1. Fundamentals of Industrial Hygiene. Chapters 20 and 21.
2. Industrial Environment - Its Evaluation & Control. Chapters 48 and 49.
3. Industrial Toxicology. Volume II, Chapter 49.

NOTES	INSTRUCTION
<u>Introduction</u>	<u>INTRODUCTION</u> Here you are at the end of the course in Recognition of Occupational Health Hazards. All week you have been bombarded with information, much of it new to you, so it is understandable that you may have more questions--questions about how to put it all together and apply what you've learned when you get back on the job next week. This session is centered around you, your job, and any questions you may have about how to get things started back at work. The lecture material will give you some guidance about professional activities and where to obtain help and information once you leave this classroom. But while you are still here, take advantage of your instructor's wealth of experience to get last-minute questions answered. Your instructor will have brought copies of informational booklets and other materials to the classroom. Study these carefully, noting the kinds of industrial hygiene information they contain. The three basic readings listed in the Reference section of this module will give you a good overview of what is involved in putting an industrial hygiene program into practice. If possible, read these before class with an eye to how the ideas presented might apply to your own workplace circumstances. Be sure to ask any questions you may have about these readings.

NOTES	INSTRUCTION
<u>Explanation - Lecture</u> Additional training NIOSH courses OSHA courses Course announcements in the AIHA <u>Journal</u> Special course announcements from AIHA for members Academic training in industrial hygiene	<u>EXPLANATION-LECTURE</u> A. <u>Where can one obtain additional training?</u> 1. NIOSH offers a wide variety of training, ranging from general introductory courses to courses on specific subjects. You can obtain a copy of the current NIOSH <u>Course Announcement</u> by writing to: NIOSH Division of Training 550 Main Street Cincinnati, Ohio 45202 2. The OSHA agency in your state may offer specialized courses. 3. The American Industrial Hygiene Association <u>Journal</u> usually has announcements of courses being offered by universities and other agencies. The American Industrial Hygiene Association has contracts with OSHA to present training courses in various areas of the country. These course announcements are usually carried in the <u>Journal</u> three to six months in advance of their presentation. 4. Members of the American Industrial Hygiene Association usually receive special announcements of short-term training courses. B. <u>Where can one receive academic training in industrial hygiene?</u> Industrial hygiene is not taught as a major subject in any undergraduate curriculum, but a number of universities offer advanced degrees in industrial hygiene. Prerequisites generally include a B.S. in the physical or biological sciences plus any other requirements of the particular graduate school.

NOTES	INSTRUCTION
Universities offering advanced degrees in industrial hygiene	Here are some of the institutions that offer advanced degrees in industrial hygiene. This list is not complete, as other universities may have initiated industrial hygiene programs in recent years. Harvard University--School of Public Health Wayne State University University of California--Berkeley University of Cincinnati University of Michigan--School of Public Health University of North Carolina--School of Public Health University of Pittsburgh--School of Public Health University of Iowa--Institute of Agricultural Medicine University of Texas--Houston
Industrial hygiene professional organizations	C. <u>What are the professional organizations in industrial hygiene?</u>
American Industrial	The American Industrial Hygiene Association (AIHA) is the principle organization representing professional industrial hygienists. Classes of membership include: Student, Associate, and Member. For more information write to: Managing Director, AIHA, 66 South Miller Road, Akron, Ohio 44313. The Association publishes the <u>AIHA Journal</u> and sponsors an annual Industrial Hygiene Conference.
American Conference of Governmental Industrial Hygienists	Industrial hygiene personnel in government agencies and universities should become members of the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH is very active in the development of standards, procedures, analytical methods, and other matters of interest to industrial hygiene. For more information write to: Secretary-Treasurer, ACGIH, P.O. Box 1937, Cincinnati, Ohio 45201.

NOTES	INSTRUCTION
Certification of industrial hygienists States do not certify industrial hygienists Certification by the American Board of Industrial Hygiene Membership in the American Academy of Industrial Hygiene Definition of an industrial hygienist	D. <u>Can an industrial hygienist be registered or certified?</u> No state registers industrial hygienists. You can register in your basic profession, such as engineering, medicine, and so forth. The American Board of Industrial Hygiene (ABIH) certifies individuals as to their education, experience, and professional ability in the comprehensive practice of industrial hygiene or specialized aspects of the profession. ABIH also offers a classification of Industrial Hygienist in Training. Certification for professionals is based on education, experience, and a qualifying examination. Areas of specialization include: - Comprehensive Practice - Engineering Aspects - Chemical Aspects - Toxicological Aspects - Radiological Aspects - Air Pollution Aspects Once you are certified by the American Board of Industrial Hygiene, you also become a member of the American Academy of Industrial Hygiene. The ABIH does not have a permanent secretary. The Managing Director of AIHA can give you the name and address of the ABIH Secretary presently in office. The American Board of Industrial Hygiene is jointly sponsored by AIHA and ACGIH. E. <u>What is an industrial hygienist?</u> The following is the definition used by AIHA: An Industrial Hygienist is a person having a college or university degree or degrees in engineering, chemistry, physics, medicine, or related biological sciences who, by virtue of special studies and training, has acquired competence in

NOTES	INSTRUCTION
Employment opportunities in industrial hygiene	industrial hygiene. Such special studies and training must have been sufficient in all of the cognate sciences to insure mastery of the following abilities: (1) recognizing the relevant environmental factors and their effect on man and his well being; (2) evaluating, on the basis of experience and with the aid of quantitative measurements and techniques, the magnitude of environmental stresses in terms of their ability to impair man's health and well being; and (3) prescribing methods to eliminate, control, or reduce such stresses when necessary to alleviate their effects.
	F. <u>What are the employment opportunities in industrial hygiene?</u> Because of nationwide interest in the Occupational Safety and Health Act, employment opportunities at this time are excellent and are likely to remain so for a number of years. As measured by membership in AIHA, the profession has grown from a relatively small number of individuals in 1939 to over 1500 members in 1974, with 137 industrial associate members.
AIHA placement service	Employment opportunities exist in federal, state, and local government agencies, private industry, and consulting firms. There are also a limited number of positions for industrial hygienists in certain international organizations, such as the World Health Organization and the International Labor Office.
Civil Service Commission for federal employment	AIHA has a placement service, and job advertisements can frequently be found in the <u>ACGIH Journal</u>. For employment in federal agencies, one should apply through the U.S. Civil Service Commission. Grade levels to which appointments are made depend on the education and experience of applicants.

NOTES	INSTRUCTION
Salary range for industrial hygienists How to contact consultants for special plant problems AIHA list of consultants American Occupational Medical Association list of medical consultants How to arrange for analytical laboratory facilities AIHA list of certified laboratories	Jobs can be had ranging from grade GS-7 to GS-15, although the higher grade levels are usually filled by promotions. G. <u>What salary level can be expected?</u> Entrance salaries in both government agencies and private industry range from \$10,000 to \$14,000 per year, depending upon training and experience. With few exceptions, peak earnings in federal agencies would be in the range of \$24,000 (based on the 1974 salary schedule). Salaries in private industry are slightly higher than in government. In most state agencies, salary levels are competitive with those of the federal government and private industry at the entrance level, but salaries for higher-level positions in state agencies are often significantly below the equivalent federal salaries. H. <u>Are consultants available to assist in special plant problems?</u> There are management consulting firms and individual consultants of various kinds in almost all parts of the country. The managing director of AIHA can provide you with a list of consultants identified by their areas of specialization. This list includes some medical consultants. The American Occupational Medical Association (150 North Wacker Drive, Chicago, Illinois 60606) can provide a more extensive list of medical consultants. I. <u>Are analytical laboratory facilities available?</u> There are commercial laboratories certified by AIHA for industrial hygiene laboratory services. A list of certified laboratories can be obtained from the managing director of AIHA.

NOTES	INSTRUCTION
State agency assistance	J. <u>Can industrial hygiene assistance be obtained from a state agency?</u> Many states provide industrial hygiene assistance. The extent of this service varies from state to state. Some states provide a consultation service which is outside the inspection role of OSHA, except for imminent hazards. Other states have industrial hygiene agencies which have no relationship to OSHA and therefore can provide more services. The state agency for industrial hygiene is usually located in the state health or labor departments. A call to the person in charge will identify the available services.
Industrial hygiene texts and reference works	K. <u>Is there a list of suggested texts and journals for a minimal industrial hygiene library?</u> NIOSH regularly publishes a bibliography entitled <u>Current Publications</u>. These should be inspected by all industrial hygienists for relevant and essential material. The three basic texts for this course, plus a selection of the books and journals listed in the course Bibliography, would comprise a good basic library for any industrial hygienist.
NIOSH Current Publications list	
Basic texts for this course	
Check the Bibliography for this course	
Approved industrial hygiene equipment	L. <u>Is there a list of approved or certified equipment for industrial hygiene purposes?</u> The National Institute for Occupational Safety and Health certifies personal protective equipment and certain industrial hazard measuring instruments. Use of NIOSH certified products is required when they are available. <u>NIOSH Certified</u>
NIOSH certified personal protective equipment	

NOTES	INSTRUCTION
Information on OSHA regulations and standards Federal Register BNA Reporter Get on the mailing lists of these organizations	<u>Personal Protective Equipment, February 1974</u> (HEW Publication No. (NIOSH) 74-112), and a supplement dated May 1974, includes lists of coal mine dust personal sampler units, gas detector tube units, and respiratory protective devices certified by NIOSH. Future certifications of other safety and industrial hygiene products will be listed in regular supplements to this publication. The publication is obtained by writing to NIOSH, Morgantown, West Virginia 26505. M. <u>How can I keep abreast of OSHA regulations and standards?</u> All official actions relating to OSHA are published in the <u>Federal Register</u>, which is available either in single copies or by an annual subscription from the Government Printing Office, Washington, D.C. Another source of information, which includes official actions, interpretations, and news items, is the <u>BNA Reporter</u>, published by the Bureau of National Affairs, 1231 25th Street, N.W., Washington, D. C. In general, it would be wise for you to get your name on the following organizational mailing lists, in order to be kept posted on current industrial hygiene developments: NIOSH OSHA ACGIH (membership list) AIHA (membership list) Bureau of National Affairs (There is a fee charged for BNA mailings.) Your state and local industrial hygiene agencies Your company may wish to join the Industrial Health Foundation, Inc. (5231 Centre Avenue, Pittsburgh, PA. 15232) and receive their publications.

NOTES	INSTRUCTION
Approved industrial hygiene instruments There is no special list of instruments Seek advice from a consultant before buying equipment Check the book entitled <u>Air Sampling Instruments</u> Industrial hygiene professional meetings Annual Industrial Hygiene Conference Refresher courses offered Employment information service Displays of equipment Certification exams	N. <u>Is there a list of industrial hygiene instruments that I should have?</u> No. The instruments required depend upon the nature of the problems in a particular plant, the ability of the personnel to operate and interpret the results, and the availability of laboratory services. Before investing large sums in equipment, ask a consultant to advise you on the kinds of instruments available for your particular problems, and the technical and personnel requirements for their operation. <u>Air Sampling Instruments</u>, a text published by ACGIH, can serve as a guide if you must select your own instruments. O. <u>Is there an annual professional meeting of industrial hygienists?</u> AIHA and ACGIH sponsor the annual Industrial Hygiene Conference. This meeting usually occurs in the spring. The 1974 meeting in Miami had about 3,000 registrants. One does not have to be a member of either organization to attend. The Conference lasts five days, during which time several hundred papers are given on subjects relating to industrial hygiene. Two days prior to the Conference, AIHA conducts refresher courses in a variety of technical subjects. The Conference also sets up an employment information center, and manufacturers display all kinds of industrial hygiene equipment. During the course of the meeting, the American Board of Industrial Hygiene conducts examinations for certification.

NOTES	INSTRUCTION
	<u>DISCUSSION</u> Once you are back on the job, it's up to you to put into practice the hazard control measures discussed throughout this course. In general, controls are of three types: engineering, administrative, and medical. Think over the situation at your workplace and ask any questions you might have about how to institute, maintain, and enforce hazard control measures. Listen carefully to the questions asked by other trainees. They might apply to your situation, or you may be able to offer advice from your own experience.

NOTES

INSTRUCTION

SupplementsSUPPLEMENTS

The instructor may have copies of the following publications available for you to take home. If this is not possible, then copies will be available in the classroom for you to look at.

1. American Industrial Hygiene Association, Membership Book (for the current year).
2. NIOSH, Current Publications (most recent issue).
3. NIOSH, Certified Personal Protective Equipment (with current supplements).
4. NIOSH, Course Announcement, Division of Training, (most recent issue).
5. NIOSH, The Hazard Evaluation Program of the National Institute for Occupational Safety and Health (be sure to note the information given in the Introduction).
6. Industrial Medicine and Surgery, Vol. 41, No. 8 (August, 1972).

Your instructor may make available other materials of interest besides those listed.



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE:

Review 5

NO. 38 TIME: 50 minutes

Classroom opportunity to review the last day of instruction and related modules.

Objectives.

Enable the trainee to achieve the terminal objectives of the course through practice in identifying hazards and applying proper concepts and terminology to the recognition, evaluation, and control of factors that affect occupational disease.

Content.

Modules 33 through 36, plus 18 through 21, 25, and 26

Methods.

Self-Check Exercises and Discussion

Materials.

Only the course manual is required.

Special Terms.

See the Modules in review.

REFERENCES

See Modules 33 through 36, plus 18 through 21, 25, and 26.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

This is the last review before the final exam. It covers the fifth morning of instruction and related modules from the third and fourth day of instruction.

The exercises are similar to those in previous reviews. However, the focus is on discussion in class rather than self-study.

The instructor may suggest that you begin this review before the scheduled class period.

DirectionsDIRECTIONS

Follow the specific directions for each part and question, as usual.

The instructor will give you additional guidelines.

NOTES

A. Module Summaries and Applications

Read the summary of key points in each review module.

Select one concept for class discussion.

Write below a list of specific questions about the selected concept.
Be prepared to present these questions to the instructor or another trainee as if you were a reporter in a press conference.

B. Special Terms

Go through the review modules looking for abbreviations. Include elements of formulas, such as the H in the heat stress equation.

List below the abbreviations you find and what they stand for.

Be prepared to ask and answer questions about them in class discussion.

C. Self-Test

Answer each of the questions, as directed.

Check your work against the correct answers on the last page.

Be prepared for class discussion on any of the questions.

1. A standard sound level meter, set on "A" weighting,
 - a. measures all frequencies and combines their effect.
 - b. measures frequencies in the 500 - 10,000 Hertz range.
 - c. measures sound level in decibels.
 - d. attenuates frequencies above and below a speech range.
2. Two sound level sources of 20 dBA and 25 dBA will combine to give a total level of approximately
 - a. 45.0 dBA.
 - b. 28.0 dBA.
 - c. 26.2 dBA.
 - d. 31.2 dBA.
3. With a noise level of 100 dBA, the permissible unprotected noise exposure per day is
 - a. 1/2 hour.
 - b. 1 hour.
 - c. 2 hours.
 - d. 3 hours, 20 minutes.

4. On an aircraft flight line, jet engines are warmed up. It is impossible to be heard at arm's length, even when shouting. The noise is a very high-pitched whine. You are wearing fitted ear plugs, and the noise in your ears still feels intense.

Which of the following protective devices would you recommend to flight-line mechanics who must be exposed to this noise level daily?

- a. Fitted ear plugs
- b. Ear muffs
- c. Helmets
- d. a and b in combination
- e. a and c in combination

5. Match the dBA figure with the noise level.

a. Discomfort threshold	_____	(a) 115 dBA
b. Unprotected exposure is prohibited above this level.	_____	(b) >90 dBA
c. Normal voice at 3 ft. can be heard.	_____	(c) <60 dBA
d. Shout at arms length to be heard	_____	(d) 120 dBA
e. Ear protection or time level is required above this level.	_____	(e) 90 dBA

6. Good illumination requires

- a. high levels of light so you can see in corners.
- b. high levels of light so you can see fine details in all kinds of work.
- c. sufficient light for performing the work without eye strain.
- d. glare-free light without shadows that affect seeing the work.
- e. supplementary lighting that is properly placed for the task requiring it.

7. Indicate the correct statement(s) regarding illumination.
- a. Reflected light should coincide with the angle of view to highlight surface irregularities.
 - b. ANSI Standard A11.1 requires certain minimum lighting levels.
 - c. Fine, detailed inspection-type work may require the use of supplementary illumination.
 - d. Quantity of illumination on the work task is measured in terms of footcandles.
8. Which of the following are likely effects of an increased climatic temperature of 92° F in an office area that is not air conditioned.
- a. Acute heat exhaustion of employees
 - b. Irritability
 - c. Reduced mental efficiency
 - d. Failure of body heat control mechanisms
9. Which of the following affect body reaction to heat?
- a. Acclimatization
 - b. Age
 - c. Relative humidity
 - d. Air movement
10. Which of the following are normal physiological responses to increased heat exposures?
- a. Cooling by evaporation of sweat
 - b. Reduced blood flow to the heart
 - c. Rise in skin temperature
 - d. Rise in body core temperature

11. Which of the following influence heat loss by the body?
- a. High humidity
 - b. Low humidity
 - c. Metabolic rate
 - d. Temperatures above 98.6° F.
 - e. Work
12. Which of the following should you consider when estimating heat stress conditions?
- a. Air conditioned rest areas for employees
 - b. Your degree of comfort
 - c. Amount of physical exertion the job requires
 - d. Availability of salt tablets
 - e. Aggravating factors, such as noise and fume.

Input for 13 and 14

A microwave cooking oven is located in a food service area of the plant you are surveying. It is provided with integral interlocks (to prevent operation with the door open) and seals (to prevent microwave radiation leakage). A visual inspection of the seals shows food accumulation and grease.

13. What immediate corrective action should you take?
- a. Install wire mesh shielding in the area.
 - b. Prohibit oven operation until the seals are cleaned.
 - c. Check the oven for microwave leakage.
 - d. Provide protective suits for personnel wishing to use the oven.

14. Following correction of the above problem, what permanent controls do you recommend for this area?
- a. Implement a routine maintenance program for microwave ovens.
 - b. Install wire mesh shielding around all microwave ovens.
 - c. Placard entries to area to warn employees wearing heart pacemakers.
 - d. Eliminate the use of microwave ovens.

Input for 15 and 16

A plant photographic organization uses a high intensity lighting system which produces ultraviolet radiation. The room walls and ceiling are painted white. The operator stands adjacent to the task and looks away when the lights are on. He is wearing a short-sleeved shirt.

Possible Control Measures

a. Protective skin clothing	e. Provide a non-reflective barrier for the operator to work behind.
b. Protective skin creams	f. Cease this work.
c. Protective goggles	g. Enclose the operation with remote controls outside the UV area.
d. Repaint walls and ceiling for a non-reflective surface.	

15. Which of the above do you recommend as interim controls?

16. Which do you recommend as permanent controls?

17. Which of the following may be sources of X-radiation?

- a. Metal-shielded arc welding machines
- b. High voltage laser support equipment
- c. Some microscopes
- d. Electronic tubes

18. Indicate the correct statement(s) regarding radiant energy.
- a. Microwaves, ultraviolet, X-radiation, and lasers can all be controlled by distance, since all conform to the inverse square law.
 - b. Audible or visual alarms should be placed near the laser beam source to warn personnel of its location.
 - c. Microwaves, ultraviolet, X-radiation and lasers are all capable of causing skin, tissue, or cell damage.
 - d. Audible or visual alarms should be placed so that attention is directed away from the laser beam source.
19. An operator of a laser is wearing a wrist watch and ring. Which of the following statements are correct?
- a. The watch and ring may cause more severe tissue damage if the laser beam strikes them, due to a heating effect.
 - b. The watch and ring may be damaged if the laser beam strikes them.
 - c. The watch and ring may act as reflectors of the laser beam.
 - d. The watch and ring should be removed.
20. Indicate the correct statement(s) regarding laser control measures?
- a. Laser beams should be isolated with barriers or enclosed.
 - b. Areas in which lasers are used should be dimly lit to minimize potential eye exposure.
 - c. Areas in which lasers are used should be brightly lit to minimize potential eye exposure.
 - d. Laser operators should be trained and qualified prior to any actual laser operation

Answers to Self-Test

1. b, d
2. c
3. c
4. e
5. d, a, c, e, e
6. c, d, e
7. c, d
8. b, c
9. a, b, c, d
10. a, c
11. a, b
12. a, b, c, d
13. b, c
14. a, c
15. a, b, c, e
16. d, e, g
17. b, c, d
18. c, d
19. c, d
20. a, c, d



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: Examination NO. 39 TIME: 50 minutes

Measures of progress since Module 1.

Objectives. Enable the trainee to show how well the instruction meets the terminal objectives of the course.

Content. Part A. Fundamentals
Part B. Preliminary Survey

Methods. Variety of questions to be answered with books closed.

Materials. Slide Projector (35mm) and Screen or Suitable Wall
Slides 209 - 205 (Part B.)
Visual 39-1 (Part B.)
Stopwatch (Instructor)

Special Terms. No new terms are used.

REFERENCES

This is a closed-book exam.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

The final examination for the course is very similar to the test you took in Module 1.

As we said way back then, the purpose of the two tests is to show what you have learned in between, as a result of the course.

In other words, we want to know if the course really does what it is supposed to do.

The instructor will distribute each part of the exam separately. The first part is based on the fundamentals of industrial hygiene. The second part simulates a preliminary survey.

You will receive the necessary directions as you need them.



NIOSH Training Course

Recognition of Occupational Health Hazards

MODULE: **Wrap-Up** **NO. 40** **TIME: 50 minutes**

Formal and informal evaluation of the course.

Objectives. **Enable the trainee to critique the course from his or her own point of view and make both general and specific suggestions for improvement.**

Content. **Modules 1 through 39**

Methods. **Individual written critiques and group discussion**

Materials. **Course Manual**
Evaluation Envelope for each trainee (Instructor)

Special Terms. **No new terms are used.**

REFERENCES

The bibliography in Appendix B lists all the references used in the course.

You might want to use this page for notes about additional references that are recommended by the instructor.

NOTES

INSTRUCTION

IntroductionINTRODUCTION

This is the final module of the course.

We will wrap-up whatever unfinished business there might be and give you a chance to ask any further questions.

The main purpose of the module, however, is to evaluate the course and course materials as individuals and as a group.

DirectionsDIRECTIONS

The following pages contain evaluation forms for the preliminaries and appendices, each day of instruction, and the course as a whole.

Please take time to complete these carefully. We can't improve the course without your help.

When you finish, put your evaluations in the envelope your instructor will distribute. Seal the envelope and return it to him.

The rest of the period will be devoted to group discussion.

The instructor will give you further directions.

Name _____ Number _____

Preliminaries and Appendices

Please give your frank opinion of the following parts of the course.
Indicate YES for satisfactory, NO for unsatisfactory, ? for not sure.
Comment as freely as you wish.

	<u>Yes</u>	<u>No</u>	<u>?</u>
<u>Course Administration</u>			
Announcement	_____	_____	_____
Application Procedures	_____	_____	_____
Costs	_____	_____	_____
Materials Provided	_____	_____	_____
Facilities Provided	_____	_____	_____
<u>Course Manual</u>			
Course Agenda	_____	_____	_____
General Course Description	_____	_____	_____
General Course Directions	_____	_____	_____
Bibliography (Appendix)	_____	_____	_____
Glossary (Appendix)	_____	_____	_____
<u>Other Course Materials</u>			
Sampler (Registration Piece)	_____	_____	_____
Bi-Lingual Glossary	_____	_____	_____
Supplementary Course Program	_____	_____	_____

Comments. Continue on the other side.

Name _____ Number _____

Day 1 Critique

A. Course modules for the first day of instruction are listed below.

1. Orientation and Pretest	5. Pathology of Occupational Diseases
2. Intro. to Industrial Hygiene	6. Industrial Hygiene Surveys
3. Biomodes of Entry	7. Survey Procedures
4. Toxicity of Chemical Agents	8. Review 1

B. Please rank the above modules from high to low, based on considerations that are important to you.

<u>Choice</u>	<u>Module</u>	<u>Choice</u>	<u>Module</u>
1	_____	5	_____
2	_____	6	_____
3	_____	7	_____
4	_____	8	_____

C. Please rate the group of modules on the following elements. Use these grades:
A = Excellent B = Good C = Fair D = Poor E = Terrible

<u>Element</u>	<u>Score</u>	<u>Element</u>	<u>Score</u>
Overview	_____	References	_____
Objectives	_____	Introduction	_____
Content (Topics)	_____	Directions	_____
Methods	_____	Explanation-Lecture	_____
Materials	_____	Summary of Key Points	_____
Special Terms	_____	Discussion	_____
Format	_____	Exercises & Problems	_____
Length	_____	Slides	_____
Organization	_____	Visuals	_____
Instructor(s)	_____	Supplements	_____

D. What did you like best about this group of modules?

E. What did you like least about this group of modules?

F. Comments. Continue on the other side.

Name _____ Number _____

Day 2 Critique

A. Course modules for the second day of instruction are listed below.

1. Epidemiologic Factors	5. Principles of Prevention
2. Toxicity Evaluations	6. Chemical Hazards
3. Standards Development & Application	7. Chemical Hazards Workshop
4. Pneumoconiosis	8. Review 2

B. Please rank the above modules from high to low, based on considerations that are important to you.

<u>Choice</u>	<u>Module</u>	<u>Choice</u>	<u>Module</u>
1	_____	5	_____
2	_____	6	_____
3	_____	7	_____
4	_____	8	_____

C. Please rate the group of modules on the following elements. Use these grades:
A = Excellent B = Good C = Fair D = Poor E = Terrible

<u>Element</u>	<u>Score</u>	<u>Element</u>	<u>Score</u>
Overview	_____	References	_____
Objectives	_____	Introduction	_____
Content (Topics)	_____	Directions	_____
Methods	_____	Explanation-Lecture	_____
Materials	_____	Summary of Key Points	_____
Special Terms	_____	Discussion	_____
Format	_____	Exercises & Problems	_____
Length	_____	Slides	_____
Organization	_____	Visuals	_____
Instructor(s)	_____	Supplements	_____

D. What did you like best about this group of modules?

E. What did you like least about this group of modules?

F. Comments. Continue on the other side.

Name _____ Number _____

Day 3 Critique

A. Course modules for the third day of instruction are listed below.

1. Occupational Skin Diseases	5. Noise Workshop
2. Physical Agents--	6. Chemical Treatment
Electromagnetic Spectrum	7. Chemical Treatment Workshop
3. Radiation	8. Review 3
4. Noise	

B. Please rank the above modules from high to low, based on considerations that are important to you.

<u>Choice</u>	<u>Module</u>	<u>Choice</u>	<u>Module</u>
1	_____	5	_____
2	_____	6	_____
3	_____	7	_____
4	_____	8	_____

C. Please rate the group of modules on the following elements. Use these grades:
A = Excellent B = Good C = Fair D = Poor E = Terrible

<u>Element</u>	<u>Score</u>	<u>Element</u>	<u>Score</u>
Overview	_____	References	_____
Objectives	_____	Introduction	_____
Content (Topics)	_____	Directions	_____
Methods	_____	Explanation-Lecture	_____
Materials	_____	Summary of Key Points	_____
Special Terms	_____	Discussion	_____
Format	_____	Exercises & Problems	_____
Length	_____	Slides	_____
Organization	_____	Visuals	_____
Instructor(s)	_____	Supplements	_____

D. What did you like best about this group of modules?

E. What did you like least about this group of modules?

F. Comments. Continue on the other side.

Name _____ Number _____

Day 4 Critique

A. Course modules for the fourth day of instruction are listed below.

1. Illumination	5. Monitoring
2. Heat Stress	6. Welding, Metal Processing & Controls
3. Occupational Cancer	7. Welding & Metal Workshop
4. Human Factors (Ergonomics)	8. Review 4

B. Please rank the above modules from high to low, based on considerations that are important to you.

<u>Choice</u>	<u>Module</u>	<u>Choice</u>	<u>Module</u>
1	_____	5	_____
2	_____	6	_____
3	_____	7	_____
4	_____	8	_____

C. Please rate the group of modules on the following elements. Use these grades:
A = Excellent B = Good C = Fair D = Poor E = Terrible

<u>Element</u>	<u>Score</u>	<u>Element</u>	<u>Score</u>
Overview	_____	References	_____
Objectives	_____	Introduction	_____
Content (Topics)	_____	Directions	_____
Methods	_____	Explanation-Lecture	_____
Materials	_____	Summary of Key Points	_____
Special Terms	_____	Discussion	_____
Format	_____	Exercises & Problems	_____
Length	_____	Slides	_____
Organization	_____	Visuals	_____
Instructor(s)	_____	Supplements	_____

D. What did you like best about this group of modules?

E. What did you like least about this group of modules?

F. Comments. Continue on the other side.

Name _____ Number _____

Day 5 Critique

A. Course modules for the fifth day of instruction are listed below.

1. Instrumentation	5. Back on the Job
2. Physical Hazards	6. Review 5
3. Physical Hazards Workshop	7. Examination
4. Vibration	8. Wrap-Up (and Course Evaluation)

B. Please rank the above modules from high to low, based on considerations that are important to you.

<u>Choice</u>	<u>Module</u>	<u>Choice</u>	<u>Module</u>
1	_____	5	_____
2	_____	6	_____
3	_____	7	_____
4	_____	8	_____

C. Please rate the group of modules on the following elements. Use these grades:
A = Excellent B = Good C = Fair D = Poor E = Terrible

<u>Element</u>	<u>Score</u>	<u>Element</u>	<u>Score</u>
Overview	_____	References	_____
Objectives	_____	Introduction	_____
Content (Topics)	_____	Directions	_____
Methods	_____	Explanation-Lecture	_____
Materials	_____	Summary of Key Points	_____
Special Terms	_____	Discussion	_____
Format	_____	Exercises & Problems	_____
Length	_____	Slides	_____
Organization	_____	Visuals	_____
Instructor(s)	_____	Supplements	_____

D. What did you like best about this group of modules?

E. What did you like least about this group of modules?

F. Comments. Continue on the other side.

Name _____ Number _____

Course Critique

Please answer the questions below. Continue on the other side.

1. There are five reviews in the course. (Modules 8, 16, 24, 32, 38)

Which did you like best? _____ Least _____?

2. There are five workshops in the course. (Modules 15, 21, 23, 31, 35)

Which did you like best? _____ Least _____?

3. There are 27 lecture-type modules in the course. (All but the above and Modules 1, 39, and 40)

Which did you like best? _____ Least _____?

4. What do you believe are the strengths of this course?

5. What do you believe are the weaknesses of this course?

6. What would you like to have added or expanded in the course?

7. What would you like to have eliminated or reduced in the course?

APPENDICES

APPENDIX A

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 1. Orientation and Pretest</u>	
1-1	ABC Metal Fabricating Company (Not in Student Manual)
<u>Module 2. Introduction to Industrial Hygiene</u>	
2-1	The Man-Machine System
2-2	Occupational Diseases: Cause and Effect
2-3	Findings Resulting from Precursory and Diagnostic Tests for Chemical Agents
<u>Module 3. Biomodes of Entry</u>	
3-1	Organs of the Respiratory System
3-2	The Relationship of the Dead Space, Lung Ventilation, Blood Circulation and Body Tissue
3-3	Diagram of Gas and Particulate Exchange Between Alveoli and Capillary Blood Vessels
3-4	Biologic Transport of Chemical Agents
3-5	Respiratory System Worksheet
<u>Module 4. Toxicity of Chemical Agents</u>	
4-1	Organs and Biologic Systems and Examples of Chemical Agents Affecting Them
4-2	Toxicity Data for Selected Chemical Agents
4-3	Biologic Actions from Chemical Agents

VISUALS

<u>Number</u>	<u>Title</u>
	<u>Module 6. Industrial Hygiene Surveys</u>
6-1	Preliminary Industrial Hygiene Survey Plant Layout
6-2	Preliminary Industrial Hygiene Survey
6-3	Study Plan and Recommendations
6-4	Exposure Profile: Batch-Type Operation
6-5	Exposure Profile: Continuous Operation
	<u>Module 7. Survey Procedures</u>
7-1	Typical Preliminary Industrial Hygiene Survey Data Sheet
7-2	XYZ Metal Fabricating Company
7-3	Hazard Estimation Decision Matrix
7-4	Decision Matrix for Inhalation Exposures
7-5	Evaluation Matrix Worksheet

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 9. Epidemiologic Factors</u>	
9-1	Epidemiologic Factors of Occupational Diseases
9-2	Relationship of Coal Pneumoconiosis to Dust Concentration
9-3	Prevalence of Pneumoconiosis According to Age and Years of Employment
9-4	Dose-Response Curve
9-5	Zone of Biologic Reactions Due to Chemical Agents
9-6	Comparison of Hazards and Tensions in the Manufacture of Automobile Batteries and the Operation of a Blast Furnace
9-7	Spectrum of Hazards Faced by Many Workers
<u>Module 10. Toxicity Evaluations</u>	
10-1	Time-Weighted Average and the Excursion Factor
10-2	Relationship of Ceiling Value to TLV
10-3	Examples of Time-Weighted Exposures
10-4	Excursion Factors
10-5	Maximum Allowable Concentrations for Selected Substances
10-6	TLVs for Mixtures

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 12. Pneumoconiosis</u>	
12-1	Classification of Pneumoconiosis
12-2	Deposition of Dust in Lung Tissue by Particle Size
12-3	Relationship of Coal Pneumoconiosis to Dust Concentration
12-4	Specification for Size Selective Performance of First Stage Separators Compared with Pulmonary Deposition Curve
<u>Module 13. Principles of Prevention</u>	
13-1	Trends in Chronic and Communicable Diseases as Causes of Death, Along With Average Length of Life
13-2	Disease and the Effects of Stress, and Chemical, Physical, and Infectious Agents
<u>Module 14. Chemical Hazards</u>	
14-1	Solvents in Common Use
14-2	Solvent Processes
14-3	Cartridge Respirator
14-4	Canister Respirator
14-5	TLVs and Odor Thresholds of Common Solvents

VISUALS

<u>Number</u>	<u>Title</u>
	<u>Module 15. Chemical Hazards Workshop</u>
15-1	Cleanroom
	<u>Module 17. Occupational Skin Diseases</u>
17-1	Protective Mechanisms of the Skin
	<u>Module 18. Physical Agents - Electromagnetic Spectrum</u>
18-1	The Electromagnetic Spectrum
18-2	Effects Produced by Different Portions of the Electromagnetic Spectrum
	<u>Module 19. Radiation</u>
19-1	Attenuation Coefficients
19-2	Beta Particle Range Energy Curve
19-3	Alpha Particle Energy Range Curve
19-4	Data for Neutron Sources
19-5	Data for Gamma-Ray Sources
19-6	Simplified Diagram of Metabolic Pathways of Radionuclides in the Body
19-7	Practical Quality Factors
19-8	NCRP Dose-Limiting Recommendations: Maximum Permissible Dose Equivalent for Occupational Exposure

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 20. Noise</u>	
20-1	Relationship Between A-Weighted Sound-Pressure Level in Decibels (dB) and Sound Pressure in N/m^2
20-2	Permissible Noise Exposure
20-3	ONHS Hearing Level Distribution Grouped by Age and dBA
<u>Module 21. Noise Workshop</u>	
21-1	Sound Source Producing Sound Intensity in Watts Per Unit Area
21-2	Octave Band Analysis
21-3	Numerical Difference Between Two Levels Being Added (Decibels)
21-4	Permissible Noise Exposure
<u>Module 22. Chemical Treatment</u>	
22-1	Some Industrial Chemicals in Common Use
22-2	Examples of Industrial Chemical Usage
22-3	Push-Pull Hood
22-4	Hazard Estimation Checklist
22-5	TLVs and Odor Thresholds of Some Common Industrial Chemicals and By-Products
22-6	Push-Pull Ventilation Data

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 23. Chemical Treatment Workshop</u>	
23-1	Polyurethane Foam Shop
23-2	Chemical Milling Area
23-3	Examples of Industrial Chemical Usage
<u>Module 25. Illumination</u>	
25-1	Examples of Recommended Levels of Illumination
25-2	Minimum Levels of Illumination Recommended for Typical Tasks
25-3	Recommended Maximum Luminance Ratios
<u>Module 26. Heat Stress</u>	
26-1	Heat Loss by Convection
26-2	Heat Gain by Convection
26-3	Heat Loss by Evaporation
26-4	Heat Gain by Radiant Heat
<u>Module 28. Ergonomics</u>	
28-1	Typical Human Errors in Equipment Operation and Their Possible Causal Factors

VISUALS

<u>Number</u>	<u>Title</u>
<u>Module 30. Welding, Metal Processing, and Control and Controls</u>	
30-1	Examples of Electrode and Weld Rod Filler Materials (AWS)
30-2	Examples of Fluxes Used in Metal Processes
30-3	Welding Contaminants-Examples of Metal Oxide Fume
30-4	Welding Contaminants-Examples of Gases
30-5	Controls for Welding, Cutting and Fume Producing Heat Application for Selected Metals
30-6	Welding Respirators
<u>Module 31. Welding and Metal Workshop</u>	
31-1	Estimating Velocities-Hood
31-2	Estimating Velocities-Duct (Composite)
31-3	ABC Metal Works Layout
<u>Module 33. Instrumentation</u>	
33-1	Sampling Instruments
33-2	Midget Impinger and Accessories
33-3	Elements of a Filter Sampling System
33-4	Respirable Dust Sampler
33-5	Sampling Head Electrode Cross Section Barnes and Penny Precipitator Sampler
33-6	Squeeze-bulb Colorimetric Sampler
33-7	Sampling Pump

VISUALS

<u>Number</u>	<u>Title</u>
	<u>Module 34. Physical Hazards</u>
34-1	Thresholds of Hearing and Tolerance
34-2	Chart for Combining or Subtracting Decibels
34-3	Rating Chart for Office Noises
34-4	Sound Weighting and Tolerances
34-5	Permissible Unprotected Noise Exposures
34-6	High Noise Level Warning Sign
34-7	Levels of Illumination Currently Recommended
34-8	Placement of Supplemental Luminaries
34-9	Normal Scale of Corrected Effective Temperature
34-10	Effects of Heat on Man
34-11	Physiological Heat Effects
34-12	Electromagnetic Spectrum
34-13	Examples of Types of Energy
34-14	Microwaves
34-15	Ultraviolet Action Spectrum

VISUALS

<u>Number</u>	<u>Title</u>
	<u>Module 35. Physical Hazards Workshop</u>
35-1	Drop Hammer
35-G	Problem 35-G Evaluation (Not in Student Manual)
	<u>Module 36. Vibration</u>
36-1	Subjective Responses to Vibratory Motion
36-2	European Industries in Which Clinical Evidence of Overexposure of Workers to Vibration Has Been Reported
	<u>Module 39. Examination</u>
39-1	XYZ Metal Fabricating Company (Not in Student Manual)

SLIDES

Module 1. Orientation and Pretest

209a	ABC Metal Fabricating Company
210	Forklifts Operating Inside Building
211	Air Compressor and Air Conditioning Equipment
212	Plant Area Office
213	Sheet Metal Cutter
214	Grinders in Operation
215	Dust Accumulation at Base of Grinder
216	Open Area MIG Welding
217	Industrial X-ray Vault
218	Vault Interlock Taped Closed
219	Vapor Degreaser - Cover Open
220	Removing Parts from Degreaser
221	Ventilation Smoke Tube Test
222	Alkaline Tank - Parts Removal - Mist
223	Acid Tank without Exhaust Ventilation
224	Plating Tank
225	Inspection Area - Operator at Work

SLIDES

Module 5. Pathology of Occupational Diseases

NIOSH No. 20	Frostbite
27	Chest X-ray of Pneumoconiosis
33	Asbestosis
33a(5)	Normal Lung
36	Lung Section of Miner with Pneumoconiosis
39	Lung Changes Caused by Organic Dust
43	Anthrax Acquired Through Contact with Infected Hair or Hides
44	Erysipeloid
48	Exposure to Radiation
50	Radiation Injury of the Hand
54	Left: Actinic Conjunctivitis Right: Cataract of the Eye
56	Vibration Disease
64	Lead Poisoning
67	Beryllium Poisoning
69	Handwriting Sample of Worker with Mercury Poisoning
70	Effects of Exposure to Vanadium
74	Scrotal Cancer Due to a Coal Tar Product

NOTE: All but Slide 33a(5) are selected from NIOSH filmstrip #672 on Occupational Diseases.

SLIDES

Module 7. Survey Procedures

- 1 Typical Industrial Hygiene Survey Data Sheet
- 2 Smoke Tube Demonstration
- 3 Industrial Hygienist Using Tape Recorder
- 4 XYZ Metal Fabricating Company
- 5 Chemical Drums
- 6 Plasma Spray
- 7 Air Arc Cutting
- 8 Alodine Dip Tank
- 9 Spray Painting
- 10 X-ray Room
- 11 Alodine Tank with Push-Pull Ventilation
- 12 Salt Bath
- 13 Personal Protective Equipment
- 14 Lack of Protective Equipment
- 15 Eye Protection--Lasers
- 16 Vapor Degreaser
- 17 Automated Cutting
- 18 Well Lit Area
- 19 Microwave Antenna
- 20 Dermatitis on Hands
- 21 Caustic Tank with Poor Ventilation
- 22 Welding with Diffusion Ventilation
- 23 Evaluation Matrix
- 24 Evaluation Matrix with Data

SLIDES

Module 14, Chemical Hazards

82	Chemical Process Tanks
83	Solvents in Common Use
84	Solvent Processes
85	Vapor Degreaser
86	Vapor Degreaser Warning Sign
87	Ultrasonic Cleaning Tank
88	Hand Degreasing with Trichloroethylene
89	Spray Painting in Booth
90	Solvent Processes
91	Small Spray Booth
92	Alkaline Dip Tank
93	Flow Coat Area
94	Ventilation Interlock
95	Vapor Degreaser Sensing Probes
96	Vapor Degreaser Controls
97	Large Paint Spray Room
98	Air Supply for Large Paint Room
99	Multiple Exhaust Stacks
100	Chemical Respirators
101	Welding Respirators
102	Smoke Tube Test
103	Dermatitis on Hands
104	TLVs and Odor Thresholds of Common Solvents

SLIDES

Module 15. Chemical Hazards Workshop

105	Small Degreaser
106	Operator Performing Degreasing
107	Removing Part from Degreaser
108	Cleanroom
109	Ultrasonic Tanks
110	Trichloroethylene Spray Bin
111	Trichloroethylene Spray Bin
112	Laminar Flow Hood
113	Placing Parts in Dip Tank
114	Rinsing Parts with Freon® 113
115	Chemically Milled Parts
116	Flow Coat Area
117	Start Flow Coating
118	Continue Flow Coating
119	Chemical Barrels

SLIDES

Module 22. Chemical Treatment

120	Some Industrial Chemicals in Common Use
121	Examples of Industrial Chemical Usage
122	Alodine Process Line
123	Nitric Acid Pickle
124	Plating Tanks - Enclosed
125	Plating Tanks - Open
126	Ammonia Process Reproduction Machine
127	Ammonia Process Reproduction Machine
128	Removal of Urethane Foam
129	Warning Label, Epoxy Resin
130	Handling Epoxy Resin
131	Application of Epoxy Resin
132	Spray Application of Paranitrophenol Fungicide
133	Anodic Seal Tank with Push-Pull Ventilation
134	Velocity Estimation - Smoke Tube
135	Tank with Steam Visible
136	Agitated Nitric Acid Tank
137	Lowering Parts into Alkaline Dip Tank
138	Corrosion on Hydrofluoric Tank
139	Protective Equipment when Spraying Paranitrophenol
140	Protective Equipment - Nitric Acid Handling
141	Dermatitis on Hands

NOTE: The following review slides are optional.

85	Vapor Degreaser
89	Spray Painting in Booth
91	Small Spray Booth
92	Alkaline Dip Tank
93	Flow Coat Area
94	Ventilation Interlock
95	Vapor Degreaser Sensing Probes

SLIDES

Module 23. Chemical Treatment Workshop

142	Polyurethane Foam Shop
143	Operator Removing Polyurethane Foam
144	Polyurethane Foam Drums
145	Foam Shop - Overhead Plenum
146	Weighing Hood - Smoke Tube Test
147	Small Paint Spray Booth - Smoke Tube Test
148	Foam Mold Hood - Smoke Tube Test
149	Foam Storage Cabinet
150	Foam Curing Oven
151	Fungicide Spray Room - Warning Sign
152	Supply Air - Velocity Test
153	Hood Exhaust Velocity Test
154	Thermostat
155	Spraying Paranitrophenol Fungicide
156	Spraying Paranitrophenol Fungicide
157	Fungicide Spray Room - Door Ajar
158	Small Paint Spray Booth
159	Chemically Milled Part
160	Chemical Milling Area
161	Lowering Parts into Alkaline Tanks
162	Steam and Mist Over Tank
163	Agitated Alkaline Tank
164	Acid Tank - Corrosion
165	Acid Tank and Duct - Corrosion
166	Lowering Parts into Alkaline Tank
167	Respiratory Irritation - Alkaline Tank
168	Smoke Tube Test - Push Side
169	Smoke Tube Test - Pull Side

SLIDES

Module 30. Welding, Metal Processing, and Controls

25	Metal Arc Welding
26	Gas Welding Torch
27	Spot, Seam, and Projection Welding
28	Pouring Lead
29	TIG Welding of Aluminum
30	Fume from Metal Coatings
31	Electrode and Weld Rod Filler Materials
32	Spool of Solder
33	Fluxes Used in Metal Processes
34	Examples of Metal Oxide Fume
35	Welding Contaminants - Examples of Gases
36	Manual Air-Arc Cutting
37	Plasma Spray
38	Controls for Fume Producing Operations
39	Vent Plenum - Welding Shop
40	Trichloroethylene Vapor Degreaser
41	MIG Welding - Barriers
42	Welder's Hood
43	Eye Protection Placard
44	Lead Pouring - Protective Equipment
45	Hood and Ear Muffs
46	Welding Respirators

NOTE: The following slides included in the set are not used in this module:

47	Shielded Metal Arc Welding
48	MIG Welding Gun
49	Solder Dip Bath
50	Automated Gas Cutting
51	Manual Air Arc Cutting
52	Plasma Spray

SLIDES

Module 31. Welding and Metal Workshop

- 53 MSA Ventilation Smoke Tubes
- 54 Smoke Tube at Face of Hood
- 55 Estimating Velocities
- 56 TIG Welding with Freely Hanging Hood
- 57 Velocity over 100 fpm
- 58 Velocity About 100 fpm
- 59 Velocity Under 100 fpm
- 60 Estimating Velocities - Duct (composite)
- 61 ABC Metal Works Layout
- 62 Long View - Gas Cutter
- 63 Close View - Gas Cutter
- 64 Gas Cut Parts
- 65 Cutting - Eye Protection
- 66 Cutting - Sparks
- 67 TIG Welding
- 68 Smoke Tube Test
- 69 TIG Welding Ventilation Problem
- 70 Semi-Automatic MIG Welding
- 71 Air Arc Cutting - Personnel Exposed
- 72 Air Arc Cutting
- 73 Outside of Gas Cutting Shed
- 74 Inside Gas Cutting Shed
- 75 Gas Cutting
- 76 Plasma Spray Room
- 77 Plasma Arc Hood
- 78 Plasma Arc Spray Gun
- 79 Glove Box
- 80 Plasma Spraying
- 81 Operator With Hood and Ear Muffs

SLIDES

Module 34. Physical Hazards

170	Thresholds of Hearing and Tolerance
171	Chart for Combining or Subtracting Decibels
172	Rating Chart for Office Noises
173	Metal Cutter
174	Sound Weighting and Tolerances
175	Permissible Unprotected Noise Exposures
176	Hearing Protection Devices
177	Well Luminated Area
178	Levels of Illumination Currently Recommended
179	Placement of Supplemental Luminaries
180	Cable Manufacturing - Good Lighting
181	Shop Area - Poor Lighting
182	Laminar Flow Hood - Supplementary Lighting
183	Effects of Heat on Man
184	Physiological Heat Effects
185	Salt Bath - Local Exhaust Ventilation
186	Room Air Conditioning Unit
187	Aluminized Asbestos Protective Clothing
188	Electromagnetic Spectrum
189	Examples of Types of Energy
190	Microwaves
191	Microwave Antennas
192	Ultraviolet Action Spectrum
193	X-ray Vault - Inside View
194	X-ray Vault - Interlock
195	Radiation Dosimetry
196	Laser Warning Sign and Goggles

SLIDES

Module 35. Physical Hazards Workshop

197	Clean Room - General Illumination
198	Laminar Flow Hood - Supplementary Lighting
199	Inspection Area - General Illumination
200	Gas Cutting - Illumination
201	Gas Cutting Shop - Illumination
202	Industrial X-ray Machine
203	X-ray Vault - Outer View
204	Radiation Dosimetry
205	Vault Safety Features
206	Vault Interlock - Upper
207	Vault Interlock - Lower
208	X-ray Vault - Outer View
35-G	Problem 35-G Evaluation

SLIDES

Module 39. Examination

209	XYZ Metal Fabricating Company
210	Forklifts Operating Inside Building
211	Air Compressor and Air Conditioning Equipment
212	Plant Area Office
213	Sheet Metal Cutter
214	Grinders in Operation
215	Dust Accumulation at Base of Grinder
216	Open Area MIG Welding
217	Industrial X-ray Vault
218	Vault Interlock Taped Closed
219	Vapor Degreaser - Cover Open
220	Removing Parts from Degreaser
221	Ventilation Smoke Tube Test
222	Alkaline Tank - Parts Removal - Mist
223	Acid Dip Tank without Exhaust Ventilation
224	Plating Tank
225	Inspection Area - Operator at Work

FILMS AND TAPES

The following modules include optional presentations on film or tape:

Module 5. Filmstrip/Tape

Module 17. Slide/Tape

Module 21. Film/Sound

Module 31. Film Clip

Module 34. Film/Sound

For details and addresses for ordering these audio-visual materials, see the modules listed above.

APPENDIX B

Recognition of Occupational Health Hazards

BIBLIOGRAPHY

Basic Reference Works

- American Conference of Governmental Industrial Hygienists. TLVs[®]. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1973. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1973.
- National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Hot Environments. Washington, D.C. U.S. Government Printing Office, 1972.
- National Institute for Occupational Safety and Health. The Industrial Environment--It's Evaluation and Control. Washington, D.C.: U.S. Government Printing Office, 1973.
- National Safety Council. Fundamentals for Industrial Hygiene. Chicago: National Safety Council, 1971.
- Occupational Safety and Health Act of 1970. Public Law 91-596, 91st Congress, S. 2193, December, 1970.
- Occupational Safety and Health Standards, Title 29, Code of Federal Regulations, Part 1910. In Federal Register, 39(125), June 27, 1974.
- Patty, Frank A.: ed. Industrial Hygiene and Toxicology. (2 Vols.) 2nd rev. ed. New York: Interscience Publishers, Inc., 1958.

Additional Reference Works

- American Conference of Governmental Industrial Hygienists. Air Sampling Instruments Manual. 4th ed. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1972.
- American Conference of Governmental Industrial Hygienists. Industrial Ventilation--A Manual of Recommended Practice. 12th ed. Lansing, Michigan: Edward Brothers, Inc., 1972.
- American Industrial Hygiene Association. Industrial Noise Manual. 2nd ed. Detroit, Michigan: American Industrial Hygiene Association, 1966.
- American National Red Cross. Standard First Aid and Personal Safety. Garden City, New York: Doubleday & Company, Inc., 1973..

- Birmingham, Donald J.; and Key, Marcus M. "Occupational Dermatoses." In Occupational Diseases: A Guide to Their Recognition. Public Health Service Publication No. 1097. Washington, D.C.: U.S. Government Printing Office, 1964.
- Brandt, A. D. Industrial Health Engineering. New York: John Wiley & Sons, 1947.
- Browning, Ethyl. Toxicity of Industrial Metals. London: Butterworths, 1961.
- Carson, Gordon B. Production Handbook. 2nd ed. New York: The Ronald Press Company, 1959.
- Davies, T. A. The Practice of Industrial Medicine. 2nd ed. London: Churchill, Ltd., 1957.
- Dorland's Illustrated Medical Dictionary. 24th ed. Philadelphia: W. B. Saunders Company, 1965.
- Doyle, H. N. "A Model for Evaluating Coal Mine Dust Standards." Journal of Occupational Medicine, 12(9):370.
- Drinker, P.; and Hatch, T. Industrial Dust - Hygienic Significance, Measurement, and Control. New York: McGraw-Hill Book Company.
- Eleccion, Marce. "Laser Hazards." Spectrum, 10(8):32-38, August 1973.
- Fairhall, L. T. Industrial Toxicology. Baltimore, Maryland: Williams and Wilkins Company, 1960.
- Federal Radiation Council. Guidance for the Control of Radiation Hazards in Uranium Mining. Staff Report No. 8, Revised. Washington, D.C.: Federal Radiation Council, 1967.
- Fleming, A. J.; D'Alonzo, C.A.; and Zapp, J.A. Modern Industrial Medicine. Philadelphia: Lea & Ferber, 1960.
- Flinn, R. H.; Brinton, H. P.; Doyle, H. N. Silicosis in the Metal Mining Industry: A Revaluation -- 1958-1961. Public Health Publication No. 1076. Washington, D.C.: U.S. Government Printing Office, 1963.
- Gafafer, W.M.; ed. Occupational Diseases: A Guide to Their Recognition. Public Health Service Bulletin 1097. Washington, D.C.: U.S. Government Printing Office, 1964.
- Gleason; et al. Clinical Toxicology of Commercial Products. Baltimore: Williams and Watkins Co., 1963.
- Hamilton, A.; and Hardy, H. L. Industrial Toxicology. New York: Paul B. Hoeber, Inc., 1949. Acton, Massachusetts: Publishing Sciences Group, 1974 (3rd Edition).

- Henderson, Yandell; Haggard, Howard W. Noxious Gases and the Principles of Respiration Influencing Their Action. 2nd ed. New York: Reinhold Publishing Company, 1943.
- Holaday, D. A.; et al. Control of Radon and Daughters in Uranium Mines and Calculations of Biologic Effects. Public Health Service Publication No. 494. Washington, D.C.: U.S. Government Printing Office, 1957.
- Hueper, W.C. Occupational Tumors and Allied Diseases. Springfield, Illinois: Charles C. Thomas, 1942.
- Illuminating Engineering Society. IES Lighting Handbook. 5th ed. New York: Illuminating Engineering Society, 1972.
- International Commission on Radiological Protection. Recommendations of the ICRP, Report of Committee IV on the Evaluation of Radiation Doses to Body Tissues from Internal Contamination Due to Occupational Exposure. ICRP Publication 10. Long Island City, N.Y.: Pergamon Press, 1968.
- Lainhart, W.S.; et al. Pneumoconiosis in Appalachian Bituminous Coal Miners. Public Health Service Publication No. 2000. Washington, D.C.: U.S. Government Printing Office.
- Lighting Survey Committee of the IES. "How to Make a Lighting Survey." Illumination Engineering 57:87, 1963.
- Lloyd, J.W. "Long-Term Mortality Study of Steelworkers--Respiratory Cancer in Coke Plant Workers." Journal of Occupational Medicine, 13:53-68, 1971.
- Lundin, F. E.; et al. "Mortality of Uranium Miners in Relation to Radiation Exposure, Hard-Rock Mining and Cigarette Smoking - 1950 through September 1967." In Health Physics (Vol. 16), New York: Pergamon Press, 1969.
- Lundin, Frank E.; et al. Radon Daughter Exposure and Respiratory Cancer: Quantitative and Temporal Aspects. Report from the Epidemiological Study of United States Uranium Miners, NIOSH-NIES Joint Monograph No. 1, 1971.
- Manufacturing Chemists Association. Chemical Safety Data Sheets (Series), Washington, D.C.: Manufacturing Chemists Association, Inc., (various dates).
- McCormick, E. J. Human Factors Engineering. New York: McGraw-Hill Book Company, 1970.
- MacMahon, Brian; Pugh, Thomas F.; Ipsen, J. Epidemiologic Methods. Boston: Little, Brown and Co., 1960.

- National Bureau of Standards. Handbook 69: Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and Water for Occupational Exposure. NCRP Report No. 22. Washington, D.C.: U.S. Government Printing Office, 1959.
- National Council on Radiation Protection and Measurements. Basic Radiation Protection Criteria. NCRP Report No. 39. Washington, D.C.: National Council on Radiation Protection and Measurements, 1971.
- National Fire Protection Association. Fire Protection Guide on Hazardous Materials. 4th ed. Boston: National Fire Protection Association, 1972.
- National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Asbestos. Washington, D.C.: U.S. Government Printing Office, 1972.
- National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Carbon Monoxide. Washington, D.C.: U.S. Government Printing Office, 1972.
- National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Exposure to Inorganic Mercury. Washington, D.C.: U.S. Government Printing Office, 1973.
- National Institute for Occupational Safety and Health. Occupational Exposure to Noise. Publication HSM 73-11001. Washington, D.C.: U.S. Government Printing Office, 1972.
- National Institute for Occupational Safety and Health. Occupational Noise and Hearing, 1968-1972. HEW Publication No. (NIOSH) 74-116. Washington, D.C.: U.S. Government Printing Office, 1974.
- Sax, N. I. Dangerous Properties of Industrial Materials. 3rd ed. New York: Reinhold Publishing Corp., 1968.
- Schwartz, L.; Tulipan, L.; and Birmingham, D.J. Occupational Diseases of the Skin. 3rd ed. Philadelphia: Lea and Ferber, 1957.
- Selikoff, I.J.; Hammon, E.C.; and Churg, J. Mortality Experience of Asbestos Insulation Workers. Republic of South Africa: Department of Mines, International Conference on Pneumoconiosis, 1969.
- Shimkin, M.B. Science and Cancer. Public Health Service Pub. No. 1161. Washington, D.C.: U.S. Government Printing Office, 1969.
- Singleton, W. T. Introduction to Ergonomics. Geneva: World Health Organization, 1972.
- Stellman, Jeanne M.; and Daum, Susan M. Work Is Dangerous to Your Health. New York: Pantheon Books, 1973.

Stokinger, H.E. "Mode of Action of Toxic Substances." In Occupational Diseases: A Guide to Their Recognition. Public Health Service Publication No. 1097. Washington, D.C.: U.S. Government Printing Office, 1964.

U.S. Department of Health, Education, and Welfare. Toxic Substances: Annual List, 1971. Publication DHEW-HSM 72-10260. Washington, D.C.: U.S. Government Printing Office, 1971.

U.S. Public Health Service. Radiological Health Handbook. Washington D.C.: U.S. Government Printing Office, 1970.

Van Oettingen, W.F. Poisonings: A Guide to Clinical Diagnosis and Treatment. 2nd ed. Philadelphia: W.B. Saunders Co., 1958.

Williams, R.T. Detoxication Mechanisms: The Metabolism and Detoxication of Drugs, Toxic Substances and Other Organic Compounds. 2nd ed. London: Chapman & Hall, 1959.

APPENDIX C

Recognition of Occupational Health Hazards

GLOSSARY

ABIH	American Board of Industrial Hygiene.
Absorb	To take up or receive by chemical or molecular action.
Acceleration	Any gradual speeding up of a process.
Acclimatization	In terms of hot environments, a series of physiological and psychological adjustments that occur in an individual during his first week of exposure so that thereafter he is capable of working in a hot environment without excessive strain.
ACGIH	American Conference of Governmental Industrial Hygienists.
ACIL	American Council of Independent Laboratories.
Acoustic, acoustical	Containing, producing, arising from, actuated by, related to, or associated with sound. "Acoustic" designates something that has the properties, dimensions, or physical characteristics associated with sound waves; "acoustical" does not explicitly designate such properties, dimensions, or physical characteristics.
ACS	American Chemical Society.
Actinic	Pertaining to rays of light beyond the violet end of the spectrum that produce chemical effects.
Actinic conjunctivitis	Inflammation of the lining that covers the inner surface of the eyelid and the exposed surface of the eyeball; the condition is caused by radiation exposure.
Adsorption	Condensation of gases, liquids, or dissolved substances on the surfaces of solids.
Aerosol	Dispersion of solid or liquid particles of microscopic size in a gaseous medium.
AIChE	American Institute of Chemical Engineers.
AIHA	American Industrial Hygiene Association.
AIME	American Institute of Mining, Metallurgical, and Petroleum Engineers.

Air velocity test	Method of measuring in feet per minute the speed of air moving into or out of ventilation and exhaust systems. (See also <u>Smoke tube test</u> .)
Aliquot	Of, pertaining to, or designating an exact divisor or factor of a quantity, especially of an integer; contained exactly or an exact number of times.
Alkyl sodium sulfonates	Class of compounds used as biodegradable detergents and anionic surfactants; also called sodium alkane sulfonates. They are derived from sodium salts of sulfated high fatty alcohols; are a white powder or fluid; have a melting point of 180-190 degrees; and are used as detergents, wetting agents, fungicides, and insecticides. (See also <u>Anionic detergent and Surfactant</u> .)
Alpha particle	Helium nucleus consisting of two protons and two neutrons with a double positive charge.
Alveoli	Tiny air sacs in the lungs where the gaseous exchange of oxygen/carbon dioxide takes place.
AMA	American Medical Association.
Ambient	Surrounding, encircling, pertaining to the environment.
Amine odor	Strong fishy odor given off by amine compounds; can be used to detect concentrations of amine contaminants.
Angstrom (Å)	Unit of length equal to one hundred-millionth (10^{-8}) of a centimeter, used especially to specify radiation wavelengths. (See also <u>Nanometer</u> .)
Angular frequency	Rate at which displacement of a vibrating object occurs as compared with its equilibrium position.
Anionic detergent	Any of a class of synthetic compounds whose anions are alkali salts, as soap, or whose ions are ammonium salts. (See also <u>Alkyl sodium sulfonates</u> .)
ANS	American Nuclear Society, Inc.
ANSI	American National Standards Institute (formerly titled USA Standards Institute, American Standards Association.)

Anthrax	Infectious, usually fatal disease of warm-blooded animals, especially of cattle and sheep, caused by <u>Bacillus anthracis</u> . It is transmissible to man, capable of affecting various organs, and especially characterized by malignant ulcers.
Anthropometry	Study and technique of human body measurement for use in anthropological classification and comparison.
APHA	American Public Health Association, Inc.
Aqueous	Relating to or resembling water.
Argon	Colorless, odorless, inert gaseous element constituting approximately one percent of the earth's atmosphere from which it is commercially obtained by fractionation for use in electric lamps, fluorescent tubes, radio vacuum tubes, and as an inert gas shield in arc welding. Atomic number 18, atomic weight 39.94.
Aromatic amine	Cyclic organic compound having a chemical structure similar to benzene but with an amine radical (N, NH, or NH ₂) attached to a carbon atom in the ring structure.
ASA	Acoustical Society of America.
Asbestosis	Pneumoconiosis caused by breathing asbestos dust.
Asphyxiation, chemical	Toxic reaction wherein chemicals reaching the bloodstream react in such a way as to deprive the body of oxygen.
Asphyxiation, simple	Coating or blockage of passageways in the lungs so that oxygen cannot reach the alveoli or be absorbed into the bloodstream.
ASSE	American Society of Safety Engineers.
Attenuation	Process by which a beam of radiation is reduced in intensity when passing through matter. It is the combination of absorption and scattering processes.
Audible sound	Sound containing frequency components lying between 15 and 15,000 cps.
Auditory	Of or pertaining to the sense, the organs, or the experience of hearing.

Baffle	Any structure used to impede, regulate, or alter flow direction, as of a gas, sound, or liquid.
Bagassosis	Pneumoconiosis caused by breathing moldy bagasse, the residue of sugar cane.
Band pressure level	For a specified frequency band, the sound pressure level for the sound contained within a restricted band; a reference pressure must be specified. (See also <u>Sound pressure level</u> .)
Bandwidth	Interval of transmitted sound waves between the low and high cutoff frequencies.
Barrier, radiation	Absorbing material (such as lead, concrete, or earth) used to attenuate or block radiation and reduce radiation hazards.
Basophilic stippling	Stippled or dotted pattern that shows up when a tissue is stained with basic dyes.
Batch operation	Industrial operation in which the end product is produced only at completion of a definite technical and time cycle.
BCSP	Board of Certified Safety Professionals of the Americas, Inc.
Beta particle	Charged particle emitted from the nucleus of an atom and having a mass and charge equal in magnitude to those of an electron.
Bioassay	Evaluation of a drug by comparison of its effect with that of a standard on a test organism.
Biologic effect	Any change in an organ or biologic system.
Biologic monitoring	Program in which frequent clinical tests are made on a worker to determine if biologic changes attributable to environmental factors are occurring.
Biologic reference point	Reaction of groups or individuals to a situation or a substance.
Biologic system	System of organs or organisms that comprise the physiology of humans and other animals.
Biomechanics	Study of the mechanics of biological organisms, the functioning of structural elements of the body, and the effects of external and internal forces on various parts of the body.

Biomode	Process whereby substances enter the human body and affect its life processes.
Bis-chloromethyl ether	2,2'-dichloroethyl ether; intermediate product in the manufacture of certain plastics. Colorless, stable liquid causing acute local and systemic reactions when inhaled, ingested, or absorbed through the skin. The vapor is an irritant to the mucous membranes of the eyes and nose, it affects the kidneys and liver in varying degrees and is a mild narcotic.
Brazing	Soldering two pieces of metal together using a hard solder with a high melting point.
Bronchi	Large air passages in the lungs that connect with the trachea.
Bronchiole	Subdivision of the bronchi leading to the alveolar sacs.
BTU (British Thermal Unit)	Amount of heat required to raise the temperature of one pound of water one degree F.
Burton's lead-line	Series of purplish to black dots appearing on the edge of the gums where gums and teeth meet.
BZ	Breathing zone.
C	Ceiling value. (See also <u>Ceiling limit</u> .)
Calibrate	To check, adjust, or systematically standardize the graduations of a quantitative measuring instrument.
Cancer	Any malignant tumor, made up chiefly of cells in abnormal forms and arrangements. Cancer is one of the three leading causes of death in industrialized societies.
Candle	Unit of luminous intensity. One candle produces 4 π lumens. (See also <u>Lumen</u> .)
Candlepower	Luminous intensity of light sources.
Carcinogen	Any cancer-producing substance.
Casting knock out	Process of removing a mold, which usually has a high silica content, from a casting.
Cataract	Thickening and opacity of the lens or capsule of the eye, causing partial or total blindness.

CCFP	Closed cup flash point.
Ceiling limit Ceiling value	Control of exposure to fast-acting substances by placing a limit on their concentration. Such substances are marked with a "C" in the TLV table. The concentration of these substances cannot at any time in the work cycle (except for a 15-minute period) exceed the TLV. (See also <u>Threshold limit value.</u>)
Chemical agent	Dust, gas, vapor, or fume that acts on or reacts with the human physiologic system.
Chemical hazard	Exposure to any chemical which, in acute concentrations, has a toxic effect.
Chirper	Radiation monitoring device that emits a chirping sound when in the presence of high-energy radiation.
Chloracne	Skin eruption caused by exposure to chlorine and chlorine compounds.
Chromatograph	Instrument for separating gases and determining their concentration.
Chronic effect	Disease symptom or process of long duration, usually frequent in occurrence, and almost always debilitating.
Chronic symptom	Symptom that persists over a long period.
Cilia	Tiny hair-like appendages in the bronchi and other respiratory passages that help remove dust trapped on moist respiratory tissue surfaces.
Classical symptom	Symptom that is characteristic of a disease.
Clinical pattern	Observable symptoms and effects of a disease.
Co-carcinogen	Environmental agent that acts with another agent to cause cancer.
Colic	Acute pain in the abdomen caused by spasm, obstruction, or distention of the stomach or intestines.
Collagen	Fibrous constituent of bone, cartilage, and connective tissue.
Conduction	Heat loss or gain by the human body due to a temperature differential between the body and the surrounding atmosphere.

Consensus standard	Any generally accepted standard of environmental quality established through input from a number of experts and professional groups knowledgeable about matters pertaining to the subject of the standard.
Contaminant	Any harmful, irritating, or nuisance material foreign to the normal atmosphere or other medium.
Continuous operation	Industrial operation where the final product is produced at or near a continuous rate.
Convection	Motion resulting in a fluid from the difference in density and the action of gravity; heat loss or gain by the body to the surrounding atmosphere.
Core temperature	Temperature of the body cavity, usually measured in the rectum.
Cornified	Converted into horny tissue.
cps	Cycles per second. (See also <u>Hertz</u> .)
Criteria	Standard upon which a judgment or decision may be based.
Criteria document	Publication of NIOSH criteria-related research upon which standards can be based. Documents contain essential parts of a standard, including environmental limits, sampling requirements, labeling, monitoring requirements, medical examinations, compliance methods, protective equipment, recordkeeping requirements, and other recommendations to OSHA for establishment of a standard.
Critical dosage	Dosage great enough to initiate a toxic or pathologic reaction within the human body.
CSHO	Compliance Safety and Health Officer, OSHA.
C-T	Concentration-time; two factors upon which dosage is based. (See also <u>Dose</u> .)
Curie	That quantity of a radioactive nuclide disintegrating at a rate of 3.7×10^{10} atoms per second. Several fractions of the curie are in common use: millicurie (mc), microcurie (μ c) and picocurie (pc).

Cyanosis	Loss of light touch and inability to flex fingers tightly; condition caused by use of highly vibratory tools.
Cycle	Time interval in which a characteristic, especially a regularly repeated event or sequence of events, occurs.
Cytology	Scientific study of cells, their structure and function.
Cytopathologist	Pathologist who specializes in the study of cells.
Damping	Muffling or reducing the transference of vibration from one object to another.
dB	Decibel. (See also <u>Decibel scale</u> .)
dBA	Decibel measurement on the "A" weighting network. (See also <u>Sound level</u> .)
Decay, radioactive	Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or electromagnetic radiation.
Decibel scale	Logarithmic scale used to express relative difference in power, usually between acoustic or electric signals, equal to ten times the common logarithm of the ratio of the two levels.
Defensive biologic mechanism	Mechanism developed by the body to fight disease.
Degradation	Reduction of the complexity of a chemical compound.
Dermatosis	Any skin disease.
Desorption	Removal of a substance from the surface at which it is absorbed.
Detoxication	Removal of poisons or their effects from the human system.
Direct reading instruments	Instrument that gives a direct reading on a dial without the need for further computations or laboratory processing.
Displacement amplitude	Amount by which a vibrating object is displaced from its equilibrium position.

DNA	Deoxyribonucleic acid; a type of nucleic acid found exclusively in the chromosomes of a cell. DNA carries the genetic heredity codes.
Dose	Concentration of a contaminant multiplied by the duration of human exposure.
Dose, cumulative	Total dose resulting from repeated exposures.
Dose-effect study	Laboratory experiment in which animals are given varying doses of known or potentially harmful substances over varying periods of time, and the physical effects are measured in order to set exposure limits for these substances in the occupational environment.
Dose, permissible	Amount of radiation which may be received by an individual within a specified period with expectation of no significantly harmful result.
Dose-response curve	Graphic representation relating biologic response to concentration of contaminant and time of exposure. By multiplying these factors, dose is determined.
Dosimeter	Instrument used to detect and measure an accumulated dose of radiation. It is usually a pencil-sized chamber with a built-in self-reading meter, used for personnel monitoring.
Dosimetry	Accurate measurement of doses.
Drop forge	To forge between dies by a drop hammer or drop press. (See also <u>Drop hammer</u> .)
Drop hammer	Machine used to forge or stamp metal, consisting of an anvil or base aligned with a hammer that is forced down upon the molten metal; also called "drop press."
Dry bulb temperature	The temperature of a gas measured by an accurate thermometer after correction for radiant heat.
Dust	General term applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases. Derivation from larger masses through the application of physical force is usually implied.
Dyne	Centimeter-gram-second unit of force, equal to the force required to impart an acceleration of one centimeter per second per second to a mass of one gram.

Effective temperature (ET)	Empirically determined index of the degree of warmth perceived on exposure to different combinations of temperature, relative humidity, and air movement; can be corrected for radiant heat.
Electromagnetic radiation	The propagation of varying electric and magnetic fields through space, moving at the speed of light and exhibiting the characteristics of wave motion.
Electromagnetic spectrum	Radiation of all wavelengths from extremely long radio waves to extremely short X-rays and gamma rays.
Electron volt (ev)	Unit of energy equal to the energy acquired by an electron falling through a potential difference of one volt, approximately 1.602×10^{-19} joule. (See also <u>Joule</u> .)
$E_{\max}$	Maximum body heat loss from evaporation.
Emphysema	Lung condition with dilation of the air sacs following atrophy of the septa and resulting in labored breathing and increased susceptibility to infection.
Empirical reference	Any value or reference relying on experience or observation alone, often without regard for system and theory.
Encephalopathy	Disease of the brain.
Environmental monitoring	Program in which samples of air contaminants or energy measurements are taken and which establishes the level of worker exposure to such agents.
Environmental quality standard	Any standard specifying lower limits of contaminants, chemical or physical agents, and/or resulting stresses to the human body in order to maintain a particular, healthful and safe environment in which to work.
Enzyme	Delicate chemical substance, mostly protein, that enter into and bring about chemical reactions in living organisms.
Epidemiology	Study of disease as it spreads and involves large numbers of people; the study of disease patterns in large populations.
Epilation	Removal of hair by the roots.

Epithelioma	Epithelial cancer; a malignant tumor consisting mainly of epithelial cells (those which cover or act as a lining for organs or other tissues).
Equilibrium state	In the man-machine system, a point reached in which the effects of the man-machine process are in a balanced state with management, labor, and government, with the public accepting some risk as a price for creating, developing, and producing a product.
Ergonomics	Study of the interactions between man and all factors in his environment, including physiological and psychological environmental stresses.
Erysipeloid skin	Dermatitis caused by bacterial infection, usually contracted by workers handling fish and fish products.
Erythema	Redness of the skin produced by congestion of the capillaries; condition results from a variety of causes.
Etiology	Study of the causes of disease.
Evaporative effect	Heat loss by the body due to evaporation of sweat.
Excursion factor	Maximum extent to which a TLV can be exceeded.
Exposure limit value	General term designating any standard or measurement restricting human exposure to harmful or toxic agents.
Exposure profile	Graphic presentation of data on exposure of workers to contaminants in industry.
Extrinsic factor	Factor over which man has some control; any factor that is external or not inherent to a particular situation or condition.
Fibrous	Made up of fibers or fiber-like tissue.
Film badge	Pack of photographic film for approximate measurement of radiation exposure. Used for personnel monitoring purposes, the badge may contain two or three films of differing sensitivity and a filter that shields part of the film from certain types of radiation.
Fission, nuclear	Nuclear transformation characterized by the splitting of an atomic nucleus into at least two other atomic nuclei and the concomitant release of a relatively large amount of energy.

Flux	Liquid or solid which, when heated, exercises a cleaning and protective action upon surfaces to which it is applied; used in soldering.
Fog	General term applied to visible aerosols in which the dispersed phase is liquid; formation by condensation is implied.
Footcandle	Illumination of a surface one foot distant from a light source of one candle, equal to one lumen per square foot. (See also <u>Lumen</u> .)
Footlambert	Unit of luminance or photometric brightness represented by a source or surface emitting or reflecting one lumen per square foot. (See also <u>Lumen</u> .)
Freeboard	Distance between the ground and the underside of an object.
Frequency	Number of times a specified phenomenon occurs within a specified interval.
Frequency of sound	Number of peak sound pressure points occurring per second. (See also <u>Hertz</u> .)
Fritted glass	Porous, partly fused glass.
Frostbite	Relatively minor destruction of tissue due to exposure to cold.
Full work cycle	Amount of time required to complete a task or process; may be less or more than an eight-hour shift.
Fume	Solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances and often accompanied by a chemical reaction, such as oxidation.
Galvanizing	Coating iron or steel with rust-resistant zinc by spraying, immersion, or electrolytic deposition.
Gamma ray	Short wavelength, electromagnetic radiation of nuclear origin; wavelengths range from about 10^{-8} to 10^{-11} cm.
Gangrene	Serious destruction of tissue caused by excessive exposure to cold or any untreated infection.

Gas	Any material in the gaseous state at 25°C. and 760mm Hg.
Gaseous exchange	In the alveoli, the absorption of oxygen and concomitant removal of waste gases.
Gene	Functional hereditary unit that occupies a fixed location on a chromosome, has a specific influence on the appearance of an organism, and is capable of mutation.
Gingival margin	Edge of the gums where they meet the teeth.
Glottis	Space between the vocal cords.
Gross or massive industrial environment	Large production area with multiple chemical and physical hazards.
Half-life	Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life. (See also <u>Decay, radio-active.</u>)
Half-value layer	Thickness of any particular material necessary to reduce the intensity of an X-ray or gamma ray beam to one-half its original value.
Hardness	Relative specification of the penetrating power of X-rays; the shorter the wave length the harder the radiation.
Harmonic motion	Motion that occurs when the same movement repeats itself at regular intervals and the displacement, angular frequency, and acceleration are all related mathematically.
Hazard evaluation	Evaluation based on data concerning concentration of a contaminant and duration of exposure.
Health physics	Profession devoted to the protection of man and his environment from unwarranted radiation exposure.
Heat exposure, intermittent	Exposure to hot environmental conditions that continues no longer than 15 minutes without an interrupting interval spent in a cooler environment.
Hematopoietic	Having to do with the formation of blood cells.
Hertz (Hz)	Unit of frequency equal to one cycle per second. (See also <u>Frequency of sound.</u>)

Histologic	Having to do with the minute structure of animal and plant tissues as discernible through a microscope.
Histopathology	Study of tissue changes that affect a part of the body or accompany a disease.
Homolog	One of a series of compounds, each of which is formed from the one before it by the addition of a constant element; any chemical structurally similar to another chemical.
Hot environment	Any combination of air temperature, humidity, radiation, and wind speed that exceeds a wet bulb globe temperature of 79°F.
Human engineering	Industrial management of labor; the technology of efficient use of machines by human beings.
Hypersusceptibility	Greater than normal sensitivity to certain substances.
IHF	Industrial Hygiene Foundation of America, Inc.
Illumination level	Quantity of light falling on a surface as measured in footcandles. (See also <u>Footcandle</u> .)
IMA	Industrial Medical Association, Inc.
Impervious	Incapable of being passed through or penetrated.
Impinge	To impact, hit, strike, collide, or push against.
Impingement	Method of measuring air contaminants in which particulates are collected by their collision against some other material; also refers to the way in which particulate matter collects inside the respiratory tract.
Industrial hygiene survey	Systematic analysis of a workplace to detect and evaluate health hazards and recommend methods for their control.
Industrial hygienist	Professional hygienist primarily concerned with the control of environmental health hazards that arise out of or during the course of employment.
Inert dusts	Dust that does not chemically react with other substances.
Infrared radiation	Wavelengths of the electromagnetic spectrum that are longer than those of visible light and shorter than radio waves; infrared wavelengths measure 10^{-4} cm to 10^{-1} cm.

Ingestion	Introduction of substances into the digestive system.
Inspired air	Air drawn in during the breathing process.
Instantaneous sampling	Sampling done at one particular time either by a direct reading instrument or by trapping a definite volume of air for analysis.
Insufflation	Procedure for introducing substances directly into the lungs.
Integrated sample	Sample of workroom air taken over a long time period, such as an 8-hour shift or full work cycle.
Intensity	Measure of effectiveness of a force field given by the force per unit test element; the energy transferred by a wave per unit time across a unit area perpendicular to the direction of propagation.
Intensity level	Measurement of sound intensity in decibels; 10 times the logarithm to the base 10 of the ratio of the intensity of a sound to the reference intensity. The reference intensity must be stated explicitly. (See also <u>Decibel</u> .)
Intensity of light	Indication of how much light a source gives off in a given direction.
Intensity of sound	(See <u>Intensity level</u> .)
Interval sampling	Technique in which samples are taken for a definite time period each hour or for an entire work shift.
Intravenous	Into or inside a vein.
Intrinsic factors	Factor over which man has no control; factor which is internal or inherent to a particular situation or condition.
Inverse square law	Physical law which states that propagation of energy through space is inversely proportional to the square of the distance it must travel; an object three feet away from an energy source receives one-ninth the energy of an object one foot away.
Ion	Atomic particle, atom, or chemical radical bearing an electrical charge, either negative or positive.
ISEA	Industrial Safety Equipment Association, Inc.

Joule	In the International System of measurements, the unit of energy equal to the work done when a current of one ampere is passed through a resistance of one ohm for one second; a unit of energy equal to the work done when the point of application of a force of one newton is displaced one meter in the direction of the force. (See also <u>Newton</u> .)
Keloid	New growth or tumor of the skin, consisting of whitish ridges, nodules, and plates of dense tissue.
Keratin	Protein that is the principal constituent of epidermis, hair, nails, horny tissue, and tooth enamel.
Keratosis	Any horny growth, such as a wart; any disease attended by horny growths.
Kilocalorie	Amount of heat required to raise the temperature of 1,000 grams one degree C.
Kinetic energy	Energy due to motion.
KV	Kilovolt.
Lamp	Any man-made light source.
Laser	Any of several devices that convert incident electromagnetic radiation of mixed frequencies to one or more discrete frequencies of highly amplified and coherent visible radiation.
Lesion	Injury, damage, or abnormal change in a tissue or organ, especially one that impairs the function of the part involved or, even if it causes no impairment of function, expresses a symptom or sign of disease.
Lethal concentration (LC)	LC ₅₀ indicates atmospheric concentration of a substance at which half of a group of test animals die after a specified exposure time. LC ₀ indicates atmospheric concentration at which no deaths occur.
Lethal dose (LD)	LD ₅₀ indicates a dose that kills half of a group of test animals. LD ₀ indicates a dose at which no deaths occur.
LEL	Lower explosive limit.
Level	Logarithm of the ratio of one quantity to a reference quantity of the same kind. The base of the logarithm, the reference quantity, and the kind of level must be specified.

Lichenification	Thickening of the skin with exaggeration of its normal markings.
Lipid	Water-soluble fat.
Loudness	Intensive attribute of an auditory sensation in terms of which sounds may be ordered on a scale extending from soft to loud. Loudness depends primarily upon the sound pressure of the stimulus, but it also depends upon the frequency and wave form of the stimulus.
Lumen	In the International System of measurements, the unit of luminous flux equal to the luminous flux emitted in a solid angle of one steradian by a uniform point source having an intensity of one candle. (See also <u>Candle</u> , <u>Steradian</u> .)
Luminance	Amount of light emitted or reflected from a certain area of a surface. (See also <u>Footlambert</u> .)
Luminaire	An entire light assembly.
Lung cavitation	Formation and sudden collapse of low-pressure bubbles within the lungs.
Lymph	Pale, coagulable fluid that consists of a liquid portion resembling blood plasma and containing white blood cells.
MAF	Minimum audible field.
Man-machine system	Interaction of human and technological factors in generating products or services.
Maser	(See <u>Laser</u> .)
Maskant	Metal etch-resistant paint.
MCA	Manufacturing Chemists Association.
Mesothelioma	Rare form of cancer occurring in the pleural lining of the chest cavity.
Metabolic heat	Body heat that results from the metabolic process.
Metabolic process	Process by which the body converts food energy into heat energy.
Metabolic rate	Rate at which the body converts food energy into heat energy.

Metabolism	Chemical changes in living cells by which energy is provided and new body material is produced to repair loss through waste.
Metabolite	Any product generated by metabolic action.
Methyl alcohol	Organic compound important in chemical synthesis; also used in denaturing alcohol and as a solvent; is highly toxic.
MeV	One million electron volts or 10^6 electron volts.
mg/m ³	Air sampling measurement in milligrams (of contaminant) per cubic meter (of air).
Microbar	Unit of sound pressure equal to one dyne per square centimeter or 0.1 newton per square meter.
Microwave	Any electromagnetic radiation having a wavelength in the approximate range of from one millimeter to one meter; the region of the electromagnetic spectrum between infrared and short wave-radio lengths.
MIG	Metal inert gas; a type of welding.
Milliamp	One-thousandth of an amp.
Mist	General term applied to dispersion of liquid particles, many large enough to be individually visible to the naked eye.
Monitoring	Periodic or continuous determination of the amount of contamination present in an occupied region; used as a safety measure for purposes of health protection.
Morbidity rate	Illness or disease rate.
Morpholine	Tetrahydro-1, 4-oxazine; diethylenimine oxide. A colorless, hygroscopic oil irritating to skin, eyes, and mucous membranes. It has produced kidney damage in experimental animals and is often used as an additive in food for human consumption.
Mortality rate	Death rate.
mppcf	Million particles per cubic foot (of air).
MRE instrument	Air sampling instrument developed by the British Mines Research Establishment.
mu	Millimicrons.
NACOSH	National Advisory Committee on Occupational Safety and Health.

Nanometer (nm)	Unit of measurement for radiation wave lengths. One nanometer (nm) equals 10^{-6} millimeters on 10 Angstrom units. (See also <u>Angstrom</u> .)
Narrow band	Band of transmitted waves with height of critical or cutoff frequencies of the filter being zero or infinite.
Neoprene	Oil-resistant, synthetic rubber made by polymerization of chloroprene. Exposure to its vapor causes lung irritation and asphyxia. It is a central nervous system depressant causing severe degenerative changes in vital organs.
Neutron	Electrically neutral, subatomic particle having a mass 1,839 times that of an electron. It is stable when bound in an atomic nucleus and has a mean lifetime of about 16.6 minutes as a free particle. Neutrons and protons combine to form nearly the entire mass of atomic nuclei and in numbers characteristic of each nuclear species.
Newton	In the meter-kilogram-second system, the unit of force required to accelerate a mass of one kilogram one meter per second per second; equal to 100,000 dynes. (See also <u>Dyne</u> .)
NFPA	National Fire Protection Association.
NIOSH (National Institute for Occupational Safety and Health)	Institute established by the Occupational Safety and Health Act under the aegis of the Department of Health, Education, and Welfare with responsibility to conduct research and training in occupational safety and health, develop criteria, publish lists of toxic substances, and make inspections.
Nitrobenzene	Oil of mirbane; nitrobenzol; bright yellow crystals or yellow oily liquid causing cyanosis due to formation of methemoglobin. It is an explosion hazard when exposed to heat or flame, and it may be absorbed into the body from skin contact.
N-methylmorphine	Codeine; high acute and chronic systemic poison; narcotic; dangerous fire hazard when exposed to heat or flame.
Noise	Sound of any sort, especially unwanted sound.
Noise level	For airborne sound, unless specified to the contrary; noise level is the weighted sound pressure level; the weighting must be indicated. (See also <u>Sound pressure level</u> .)

Noxious	Harmful to health.
NSC	National Safety Council.
Occupational cancer	Cancer caused by exposure to chemical or physical agents in the work environment.
Occupational disease	Disease associated with a work environment, usually caused by a specific agent.
Octave	Interval between two sounds having a basic frequency ratio of two. (See also <u>Frequency of sound</u> .)
Oscillate	To move back and forth in a steady, uninterrupted rhythm; to vary between alternate extremes, usually within a definable period.
OSHA	Occupational Safety and Health Administration, U.S. Department of Labor.
OSHRC	Occupational Safety and Health Review Commission.
Oxidation	Enzymatic procedure whereby a chemical substance is changed by removing one or more electrons from an atom, ion, or molecule.

Papilloma	Cancerous tumor in tissues covering or lining organs or other tissues. The cancerous cells cover finger-like body processes, or ridges; includes warts and cutaneous horns.
Paralysis	Inability to move.
Parameter	Limit of consideration in a study or investigation.
Partial pressure	Pressure of a gas in a mixture equal to the pressure which it would exert if it occupied the same volume alone at the same temperature; known also as Dalton's Law of Partial Pressure.
Particulate	Particle of solid or liquid matter.
Pathologic action	Body action that is altered or caused by disease or other abnormal conditions.
Pathologic effect	Anatomic and physiologic deviation from normal that constitutes or characterizes a particular disease.
Periodic motion	Any motion that is repeated at regular intervals. (See also <u>Oscillate</u> .)
Permissible concentration	Official term that replaces "Threshold limit value".
Personal sampler	Air sampling instrument developed in the U.S. for estimating exposure of individual workers to air contaminants.
Phagocyte	Body cell whose function it is to engulf foreign material and consume waste matter.
Pharynx	Part of the alimentary canal between the cavity of the mouth and the esophagus.
Phenol	Carbolic acid, phenic acid, phenylic acid; a white crystalline mass that turns pink or red if not perfectly pure; has a burning taste and distinctive odor. Is a dangerous acute and chronic local and systemic poison. The main effect is on the central nervous system. Absorption from spilling phenols on the skin may be very rapid, and death results from collapse within 30 minutes to several hours.
Photon	Bundle or quantum of radiation. (See also <u>Quantum</u> .)
Physical hazard	Hazard raising mainly from exposure to the electromagnetic spectrum, nuclear radiation, vibration, or sound pressure waves--all energy sources.

Planck's constant	Constant of proportionality relating the quantum of energy that can be possessed by radiation to the frequency of that radiation; value is approximately 6.625×10^{-27} erg/sec. (See also <u>Quantum</u> .)
Plasma spray	Method of putting a coating of metal on an object by using a gun propelled by a gas; prior to such metallizing, surfaces must be abraded.
Plenum	Pressure-equalizing chamber.
Pleura	Delicate, watery membrane lining the thorax.
Plumbism	Chronic lead poisoning.
Pneumoconiosis	Any disease of the lungs caused by habitual inhalation of irritant particles.
Pneumoconiosis hazard	Alteration of lung tissue caused by the continued inhalation of dust and other particles.
p-Nitroaniline	l-Amino-4-Nitrobenzene; yellow crystals. Causes acute and chronic toxic effects when ingested, inhaled, or absorbed through the skin. Acute symptoms are headache, nausea, vomiting, weakness, and stupor.
p-Nitrophenol	Colorless to slightly yellow crystals; an acute and chronic poison when inhaled or ingested; has produced hyperthermia, methemoglobinemia, and acute depression in experimental studies.
Polycyclic hydrocarbon	Chemical compound containing a multiple number of benzene-type rings.
Polyester resin	Any of numerous synthetic resins, produced chiefly by reaction of dibasic acids with dihydric alcohols.
ppm	Air sampling measurement indicating parts (of contaminant) per million (parts of air).
Precancerous lesion	Lesion that may ultimately develop into cancer.
Precursor test	Test that indicates biologic change caused by a specific agent.
Preliminary evaluation	First step in an industrial hygiene survey, usually a visual inspection to identify possible hazards.
Primary irritant	Agent that causes a direct action on normal skin at the site of contact if permitted to act in sufficient intensity for a sufficient length of time.

Primary reaction	Main or principal reaction to a chemical or physical agent.
Priority List of Criteria Development	List developed by the National Institute for Occupational Safety and Health by which priority for development of exposure standards for particular substances can be determined.
Promulgated standard	Standard that has been enacted or otherwise made into law or regulation by authority.
psi	Pounds per square inch.
Pulmonary	Of or relating to the lungs.
Pulsed wave	Flash of radiation emission.
Push-pull ventilation	Method of exhausting fumes wherein the partial vacuum created by an exhaust fan is assisted by an additional fan that pushes fumes toward the exhaust hood.
Qualitative	Having to do with a characteristic element, attribute, kind, or degree of excellence which a thing possesses; a characteristic that constitutes the basic nature of a thing.
Quantitative	Referring to the property of anything which can be determined by measurement, the property being measurable in dimensions, amounts, etc.
Quantum	Invisible unit of energy equal for radiation of frequency ν to the product $h\nu$, where h is Planck's constant. (See also <u>Planck's constant</u> .)

Rad	Unit of absorbed dose which is 100 ergs per gram of any substance. The Rad is a measure of the energy from ionizing radiation per unit mass of irradiated material retained by matter at the place of interest.
Radiant heat	Heat loss or gain by the body due to long-wave radiation.
Radiation	Emission and propagation of energy through space or matter in the form of waves; energy itself that is propagated through space or through matter (when unqualified usually refers to electromagnetic radiation); by extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, such as cosmic radiation.
Radiation, external	Exposure to ionizing radiation when the radiation source is located outside the body and the radiation must then penetrate into the deeper tissues.
Radiation, internal	Exposure to ionizing radiation when the radiation source is within the body as a result of inhalation, ingestion, or absorption and deposition of radioactive elements in body tissues.
Radiation, ionizing	Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.
Radiation, scattered	Radiation which, in its passage through a substance, has been changed in direction.
Radioactivity	Process whereby certain nuclides undergo spontaneous disintegration in which energy is liberated, generally resulting in the formation of new nuclides. The process is accomplished by the emission of one or more particle types, such as alpha particles or gamma rays.
Radiopaque	Able to be detected by X-ray examination or other penetrating radiation.
Raynaud phenomenon	Spastic condition of the blood vessels caused by use of vibratory tools such as pneumatic drills.
Reaction vessel	Container in which toxic materials are generated.
Reactor	Apparatus in which nuclear fission may be sustained in a self-supporting chain reaction. It includes fissionable material (fuel), such as uranium or plutonium, moderating material, a reflector to conserve escaping neutrons, provision for heat removal, and measuring and control devices.

Recommended standard	Standard that has been recommended to authority for promulgation or enactment into law. (See also <u>Promulgated standard.</u>)
Reduction	Enzymatic procedure whereby a chemical substance is changed by adding one or more electrons to an atom, ion, or molecule.
Reflectance	Measure of the amount of light reflected from a surface; the ratio of the luminance to the illumination of a surface. (See also <u>Luminance.</u>)
Relative humidity	Ratio times 100 of the weight of water vapor contained in a unit volume of air and the weight it can contain at that temperature and pressure.
Resistance welding	Process whereby coalescence of metal is produced from heat generated by resistance of the work to electric current; filler metals and fluxes are not used.
Ring	Collection of atoms united in a continuous or closed chain or circle.
RNA	Ribonucleic acid; a type of nucleic acid found in the nuclei and cytoplasm of cells. RNA is involved in the synthesis of proteins.
Roentgen (r)	Unit of radiation exposure; an exposure dose of X-rays or gamma radiation such that a precise, specified amount of ionization will occur in a precise, specified weight of air.
Saccule, alveolar sac	Small space off the bronchiole and containing alveolar openings.
Sebaceous glands	Glands that secrete a greasy lubricating substance known as sebum.
SIL	Speech interference level.
Silicosis	Pneumoconiosis caused by breathing silica dust.
Smog	Smoke and fog; applied to extensive atmospheric contamination by aerosols arising from a combination of natural and man-made sources.
Smoke	Small, gas-borne particles created by incomplete combustion and consisting predominantly of carbon and other combustible materials.
Smoke tube ventilation test	Smoking the air in order to measure the velocity of air movement into and out of exhaust and ventilation systems.

Soldering	Using any of various fusible alloys, usually tin and lead, to join metallic parts when applied in the melted state to the solid metal.
Sone	Unit of loudness; a simple tone of a frequency of 1,000 cycles per second, 40 decibels above a listener's threshold, produces a loudness of one sone. The loudness of any sound that is judged by the listener to be X times that of the 1-sone tone is X sones.
Sound	Vibratory disturbance in the pressure and density of a gas or liquid, or in the elastic strain in a solid, with a frequency in the approximate range of between 20 and 20,000 cycles per second and capable of being detected by the human ear.
Sound analyzer	Device for measuring the band-pressure level or pressure-spectrum level of a sound as a function of frequency.
Sound level	Weighted sound pressure level obtained by the use of metering characteristics and the weighting A, B, or C. The weighting employed must always be stated. The reference pressure is 0.0002 microbar.
Sound level meter	Instrument for the measurement of noise and sound level; includes a microphone, amplifier, output meter, and frequency weighting networks.
Sound power	Total sound energy radiated by a source per unit time; normally expressed in watts. (See also <u>Sound power level</u> .)
Sound power level	In decibels, 10 times the logarithm to the base of the ratio of a given power to a reference power; the reference power must be indicated. (See also <u>Sound power</u> .)
Sound pressure	Root-mean-square value of the pressure changes above and below atmospheric pressure when used to measure steady-state noise; described in newtons per square meter, dynes per square centimeter, or microbars. (See also <u>Newton</u> , <u>Dyne</u> , <u>Microbar</u> .)
Sound pressure level	In decibels, 20 times the logarithm to the base 10 of the ratio of the pressure of one sound to a reference pressure; reference pressure must be stated.
Sound wave	Sound measured from the point of maximum pressure to the next point of maximum pressure; a series of such maximum pressure points occurring regularly and constituting a sound.

Standard	Any rule, principle, or measure established by authority.
Steradian	Unit of measure equal to the solid angle subtended at the center of a sphere by an area equal to the radius squared on the surface of the sphere. The total solid angle of a sphere is 4π steradians.
Stoddard solvent	Dry cleaning solvent possessing a flash point of 100°F. (40.6°C.) which evaporates without residue and consists of aliphatic, saturated materials and, in some formulations, 15 to 20 percent aromatics.
Stress	Any mentally or emotionally disquieting or disruptive influence; any inordinate disruption to regular physical functioning causing the body to work harder in order to maintain equilibrium.
Surfactant	Any surface-active agent.
Survey, radiological	Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under a specific set of conditions.
Synergism	Cooperative action of substances whose total effect is greater than the sum of their separate effects.
Synthesis	Enzymatic procedure whereby a new substance is produced through union of elements or simpler chemical compounds or by the degradation of a complex compound.
Systemic poisoning	Poisoning that attacks one or more bodily systems.
TCE vapor	(See <u>Trichloroethylene.</u>)
TDI	2,4-diisocyanotoluene; a clear, faintly yellow liquid causing acute and chronic local and systemic reaction when inhaled, ingested, or absorbed through the skin.
Temperature humidity index	Index based on the effective temperature scale using dry and wet bulb measurements; index equals $0.4(t_a + t_{wb}) + 15$. (See also <u>Effective temperature, Wet bulb temperature.</u>)
Therapeutic agents	Aid to healing.
THHP	Target Health Hazard Program, OSHA.
Thorax	Chest cavity between the neck and abdomen that contains the heart and lungs.

Threshold Limit Value (TLV)	Used by American Conference of Governmental Industrial Hygienists to designate degree of exposure to contaminants and expressed as parts of vapor or gas per million parts of air by volume at 25°C. and 760mm Hg pressure, or as approximate milligrams of particulate per cubic meter of air (mg/m ³). (See also <u>Permissible concentration</u> .)
Tidal movement	Volume of air inspired or expired during each respiratory cycle.
TIG	Tungsten inert gas; a welding process.
Time weighted average	Average exposure for an individual over a given working period, as determined by sampling at given times during the period.
Time-weighted exposure	Average over a given working period of a person's exposure, as determined by sampling at given times during the period.
TIP	Target Industry Program, OSHA.
TNT	Trinitrotoluene. (See also <u>Toluene</u> .)
Toluene	Hydrocarbon derived mainly from petroleum but also from coal. Source of TNT, lacquers, saccharin, and many other chemicals.
Tonus	Continuous contraction of muscle which aids in the return of blood to the heart.
Toxic agent	Substance potentially or actually poisonous to the human body.
Toxicologic effect	Harmful or poisonous effect of a chemical agent.
Toxicologist	Specialist in the science that deals with poisons and their effects.
Toxicology	Scientific study of poisons, their actions, their detection, and the treatment of conditions produced by them.
Toxic reaction	Alteration of a biologic system or organ due to the action of toxic agents.
Toxic Substances List	Annual compilation of known toxic substances prepared by the National Insititute for Occupational Safety and Health and containing about 25,000 names representing some 11,000 different chemical compounds.
Trachea	Tube leading from throat to lungs; the windpipe.

Transducer	Device capable of being actuated by waves from one or more transmission systems or media and of supplying related waves to one or more other transmission systems or media. The waves in either input or output may be of the same or different types such as electrical, mechanical, or acoustic.
Trichloroethylene	Stable, colorless, heavy, motile liquid with a chloroform-like odor; causes mild local and serious acute systemic reactions when ingested, inhaled, or absorbed through the skin. Inhalation of high concentrations causes narcosis and prolonged inhalation of moderate concentrations causes headache and drowsiness; used as an additive in food for human consumption.
Trichlorotrifluoroethane	Colorless gas having toxic hazard levels as yet unknown. It is a fire hazard when exposed to heat or flame and extremely dangerous in contact with acids or acid fumes.
Triethylamine	Colorless liquid causing acute and chronic local and systemic poisoning when inhaled, ingested or absorbed through the skin. Experimental animals have shown kidney and liver damage from exposures. Dangerous as a fire hazard when exposed to heat or flame, and highly dangerous in reaction with oxidizing materials.
UEL	Upper explosive limit.
UL	Underwriters' Laboratories, Inc.
Ultraviolet radiation	Wavelengths of the electromagnetic spectrum that are shorter than those of visible light and longer than X-rays; wavelengths measure 10^{-5} to 10^{-6} cm.
UV	Ultraviolet.
Vapor	Gaseous phase of a substance ordinarily liquid or solid at 25°C. and 760mm Hg.
Velocity of sound	Speed at which sound travels. Velocity depends on the medium through which sound passes; in air the value is 1,129 feet per second at an air temperature of 70°F.
Ventilation (pulmonary)	Process of supplying oxygen to the blood by inhaling air into the lungs.
VP	Vapor pressure.

Watts per square centimeter	Energy measurement for radiation stated in terms of watts per square centimeter of surface or joules per square centimeter. One watt is 10^7 ergs per second which is also one joule per second. Used in industrial hygiene standards for the visual range and radiations in the higher ranges. (See also <u>Joule</u> .)
Wavelength	In a periodic wave, the distance between two points of corresponding phase in consecutive cycles.
Wet bulb globe temperature (WBGT)	Combined measurements of dry bulb, natural wet bulb, and globe (radiant heat) temperatures.
Wet bulb temperature	Temperature at which water evaporating into the air can bring the air to saturation at the same temperature without gain or loss of heat.
Wide band	Transmitted waves with the height of critical or cutoff frequencies of the filter being zero or infinite.
Wrist drop	Inability to hold the wrist parallel with the forearm; the disability is caused by lead poisoning.
X-ray	Highly penetrating radiation similar to gamma rays. Unlike gamma rays, X-rays do not come from the nucleus of an atom but from the surrounding electrons and are produced by electron bombardment.
Xylene	Clear liquid having a molecular weight of 106.2 and formula $C_6H_4(CH_3)_2$. Cause mild toxic reactions in man, are dangerous when exposed to heat or flame, can react with oxidizing materials, and can cause explosions in vapor form when exposed to heat or flame.
Zero exposure	Exposure held to a negligible level.

APPENDIX D

Recognition of Occupational Health Hazards

FACILITIES

The basic requirements of the course are:

Well-lighted, well-ventilated room for 10 to 20 people

Conference tables and chairs

Chalkboard, chalk, and erasers

Slide projector (35mm)

Projection screen or suitable wall

The slide projector and screen are used in the following modules:

Day 1. Modules 1, 5, and 7

Day 2. Modules 14 and 15

Day 3. Modules 22 and 23

Day 4. Modules 30 and 31

Day 5. Modules 34, 35, and 39

Module 5 requires a filmstrip projector and a tape recorder if the instructor shows the entire filmstrip instead of selected frames mounted as slides. Module 17 also includes an optional tape.

Modules 21, 31, and 34 require a film projector with sound if the instructor shows the suggested films.

The following modules include optional demonstrations of equipment:

Module 21. Noise measuring instruments

Module 31. Ventilation smoke tubes

Module 33. Air sampling instruments

Recognition of Occupational Health Hazards

MATERIALS

Basic course materials are listed in the course description at the beginning of the Instructor and Student Manuals.

Trainees do not need any additional supplies, beyond note paper and pen or pencils for writing. Each class participant is expected to furnish his or her own writing materials.

Instructors need a stopwatch for the tests in Modules 1 and 39.

Additional publications from the Bibliography in Appendix B or from the instructor's own professional library are recommended for classroom reference. Specific suggestions are included in Module 37.

APPENDIX E

Recognition of Occupational Health Hazards

NIOSH INFORMATION FOR TRAINEES

Appendix E has been reserved for NIOSH additions to the course.

SUPPLEMENTARY COURSE PROGRAM

INTRODUCTION

Welcome to "Recognition of Occupational Health Hazards

This NIOSH course was developed for use through the recently established Regional Training Program (RTP) to train professionals and para-professionals who will become involved in the recognition, evaluation, and control of occupational health and safety hazards.

The RTP was established to multiply the efforts of NIOSH's Division of Training by contracting with a center for continuing education in each geographical region of the United States to conduct courses in that region. These centers will use as instructors technically competent professionals in the field of industrial hygiene. Leadership for the instructors of a single course or series of related courses will be provided by an outstanding industrial hygienist who is not only a technical expert, but also a specialist in training.

The course may also be presented by NIOSH personnel in the headquarters of the Division of Training in Cincinnati, Ohio, or in the field.

VISUALS

- 41 - 1 Schematic Illustration of the Interdisciplinary Character of Ergonomics
- 42 - 1 Standard Luminosity Curves: Relative Sensitivity to Radiant Flux as a Function of Wavelength
- 42 - 2 Luminance or Surface Brightness of Common Objects
- 42 - 3 Coefficients of Light Utilization
- 42 - 4 Efficiencies of Electric Lamps
- 42 - 5 Conversion Chart
- 43 - 1 Representation of Pure Harmonic (Sinusoidal) Vibration
- 43 - 2 Simplified Mechanical System Representing the Human Body Standing (or Sitting) on a Vertically Vibrating Platform
- 43 - 3 Vibration Exposure Criteria Curves
- 44 - 1 Guide to Instrument Selection for Some Chemical Agents
- 44 - 2 Instrument Terminology

MODULE 41. MORE ABOUT ERGONOMICS

ERGONOMICS

What is Ergonomics?

Ergonomics is concerned with the design of work. Its ultimate objective is to achieve optimal adjustment between man and his work environment which will enhance worker health, efficiency, and well being. Fitting a job or job component to man's anatomical or physiological characteristics and needs may be considered in general terms as the biology of work. Fitting a job or job component to man's psychological, social, or behavioral characteristics and needs may be considered generally as the psychology of work. There are no clear divisions within the field of ergonomics, since all of the variables in the man/machine/environment system are interrelated and, to some extent, interdependent. Similarly, the scientific and technical disciplines that are involved in ergonomics cannot be rigidly separated in their application to the solution of ergonomic problems.

The Biology of Work

The biology of work is the study of a task in relation to the anatomical and physiological aspects of man. Ergonomic problems dealing with provisions of energy are concerned with the biological and physiological capacity for work. Ergonomic problems dealing with the application of forces are concerned largely with human anatomical characteristics (biomechanics). Problems of body fit and posture are concerned with the size and structure of the body (anthropometry). Problems of climate or the thermal environment deal mainly with human physiology. Problems concerned with environmental stresses (exposure to noise, vibration, heat, illumination, ionizing radiation, and toxic materials) incorporate knowledge from the physical sciences, as well as environmental physiology and psychology.

The Psychology of Work

The psychology of work deals primarily with the behavior of workers, human motivational factors, incentives, and interactions between people. Included in this category is "skill psychology", dealing with information processing and decision making, and "occupational psychology", dealing with training, effort, and individual differences. These disciplines are used in designing controls; designing displays; designing man/machine information systems; designing temporal, social, and economic conditions of work; and studying work proficiency factors, such as age, fatigue, vigilance, and accidents. This interdisciplinary character of ergonomics is illustrated in Visual 41-1 as depicted by Dukes-Dobos (1).

Singleton (2) has defined the basic principles of ergonomics for use in teaching a scientific approach to, and application of, this subject. Although it is a complex subject, Singleton has presented ergonomics in a systematic perspective, delineating the biology of work and the psychology of work. The reader is

referred to the general principles and the particular cases with illustrations that are included in this reference.

The Provision of Energy

Energy expended by man must be supplied to him as food. The maximum energy expended by a human operator is about 2 horsepower. For day-long work, the approximate energy expenditure is 0.2 hp. The human body is from 10-30% efficient, depending upon how the body is used to perform the work. A high proportion of the energy intake is necessarily used in normal body functioning and maintenance, exclusive of work. The useful work done by human muscles, as compared with mechanical power, is many thousands of times more costly. It is possible to measure physical effort and to express work rate in terms of a number. In this way, totally different jobs can be compared with each other and with standards of acceptable work loads. However, the interpretation of results requires the consideration of many variables.

The Application of Forces

When the body expends energy in performing work, the efficient use of body weight and body motion in concert with (not opposing) the direction of the force will allow the muscular effort to most efficiently convert the expended energy into useful work. For maximum economy of effort, the muscles and joints should assume a posture that allows body weight to exert the required force. For maximum energy availability, the joints that involve large muscle masses moving over the largest possible distance should be used. For maximum precision, joints and movements that affect and oppose muscle groups should be used. Large, steady forces depend on body stability rather than on maximum muscle contractions.

Problems of Body Size and Posture

A designer must refer to the dimensions of those people that will occupy the space or use the equipment that he intends to design. A design is usually made to correspond with the body size of 90% of the population. Sex, ethnic, social, geographical, and even occupational differences exist with respect to body size, and these may change with time. Position and mobility of the body within the workspace are important considerations when designing equipment and layouts of work areas. Restriction of movement usually increases fatigue. In addition, there is often a conflict between optimum positions for manipulation and vision.

The Effects of Climate or Thermal Environment

A rise or fall in the core temperature of the body cannot be tolerated. If thermal conditions are within the limits of man's tolerance, he may become acclimatized after about a week of work in heat. Any measure of heat stress

must take into account the ambient air temperature, radiant temperature, air velocity, humidity, and the intensity of the work to be performed. Little is known about the effects of continuous heat stress over long periods of time. Cold stress can be produced by low temperatures and high wind speed. Protection from wind or air motion will reduce cold stress as will protective clothing to insulate body heat.

Limitations of Sense Organs

A worker must control his activities on the basis of information he receives from his surroundings. He receives such information through a highly versatile array of sensory mechanisms, all of which have limitations. For each sensory mechanism there are two related problems relating to environmental design: (1) to determine under what conditions the sensory mechanism operates best as an information channel; and (2) under what conditions it becomes a source of strain. Speech communication may be impaired not only by excessive noise levels but also by other factors that make lip reading or gesture interpretation difficult. Vision is the dominant sense in man. The amount of light required for the same level of visual effectiveness doubles for an individual about every 13 years. Eye adaptation to the dark takes many minutes, so that sudden changes of illumination can be dangerous. Colors change and eventually disappear as the level of illumination decreases. Dangerous levels of high intensity noise and light are man-made. Man has no intuitive instincts for avoiding these dangers. He must be trained to do so.

Design of Controls

A control is a link between an operator and a machine that allows the operator to change the state of the mechanism. There are pressure controls, where a force is exerted; and displacement controls, where movement is accomplished. Before a control can be used, it must first be identified and then selected. Control design must be based upon an understanding of what the operator is trying to control as well as how he can control it. Control design involves functional anatomy--matching the controls to the musculature of the operator; and dynamics--matching the control system to the motor skills and timing limitations of the operator.

Design of Displays

A display is an information source relevant to the task. It may be directly sensed by the operator; it may be sensed by a device giving an information display; it may contain information that does not change with time; or it may reflect changes of a variable with time. For maximum worker attention, the auditory channel should be used. For maximum speed (minimum attention) the kinesthetic channel should be used. Display design must be based on a clear definition of the task and on an understanding of the way a particular kind of operator performs it.

Man/Machine Information Exchange

Man is slow, subject to error, relatively weak, yet highly versatile. A machine is fast, accurate, powerful, and quite inflexible. These two mismatched units must be combined in some successful way. This is done through an information exchange, such as a display or control. In simple systems, man can adapt to most design weaknesses. In more complex systems, the designer should not assume that a skilled operator will compensate for deficiencies in design. Man/machine design involves functional anatomy, dynamics, encoding, and psychophysics.

Temporal, Social, and Economic Conditions of Work

The best length for a working day depends on many factors. An optimal length has not yet been determined, although the workday length is remarkably similar among different countries and industries. Human activity is cyclic. Rest periods are needed in every job, primarily to relieve monotony rather than to ease the intensity of the work.

Man is a social being, reacting with many other individuals within and outside of his working group. Working behavior is strongly influenced by group behavior and cultural patterns. Acceptance of shift work, for example, may be related to its acceptance or prestige within a particular social group or to its environmental suitability. Incentives (paychecks, bonuses, etc.) can be financial, environmental, or social. An understanding of the total behavior of an organization requires a variety of approaches and concepts.

Age, Fatigue, Vigilance, and Accidents

A worker's age affects the design of a task. The designer may need to increase lighting levels, reduce the speed required for a task, reduce memory demands, avoid strenuous movements or excessive postural changes, and reduce the duration of lessons in learning a task. For high-level skills, experience compensates for performance difficulties or decreased speed.

Fatigue is prevented or reduced by introducing more variety in work or work methods, and by allowing more frequent, but short, rest breaks. Rest need only be a change in activity. Different personalities show different reactions to fatigue. There is little correlation between the subjective feeling of fatigue and its effect on performance. One of the most common causes of fatigue is stressful posture.

Vigilance becomes more important and more difficult for workers the more the task requires monitoring and inspection. Fall-off in performance can be reduced by (1) design of optimal environmental conditions, (2) rest periods and frequent change of task, (3) increased perceptibility of signals or faults, (4) knowledge of the results of performance and non-performance (feedback), and (5) improved selection and training methods.

Accidents and near accidents are evidence of bad task design. Urging people to be more careful is not effective because the results are only temporary. Tasks should be designed with the understanding that all operators are subject to error.

References

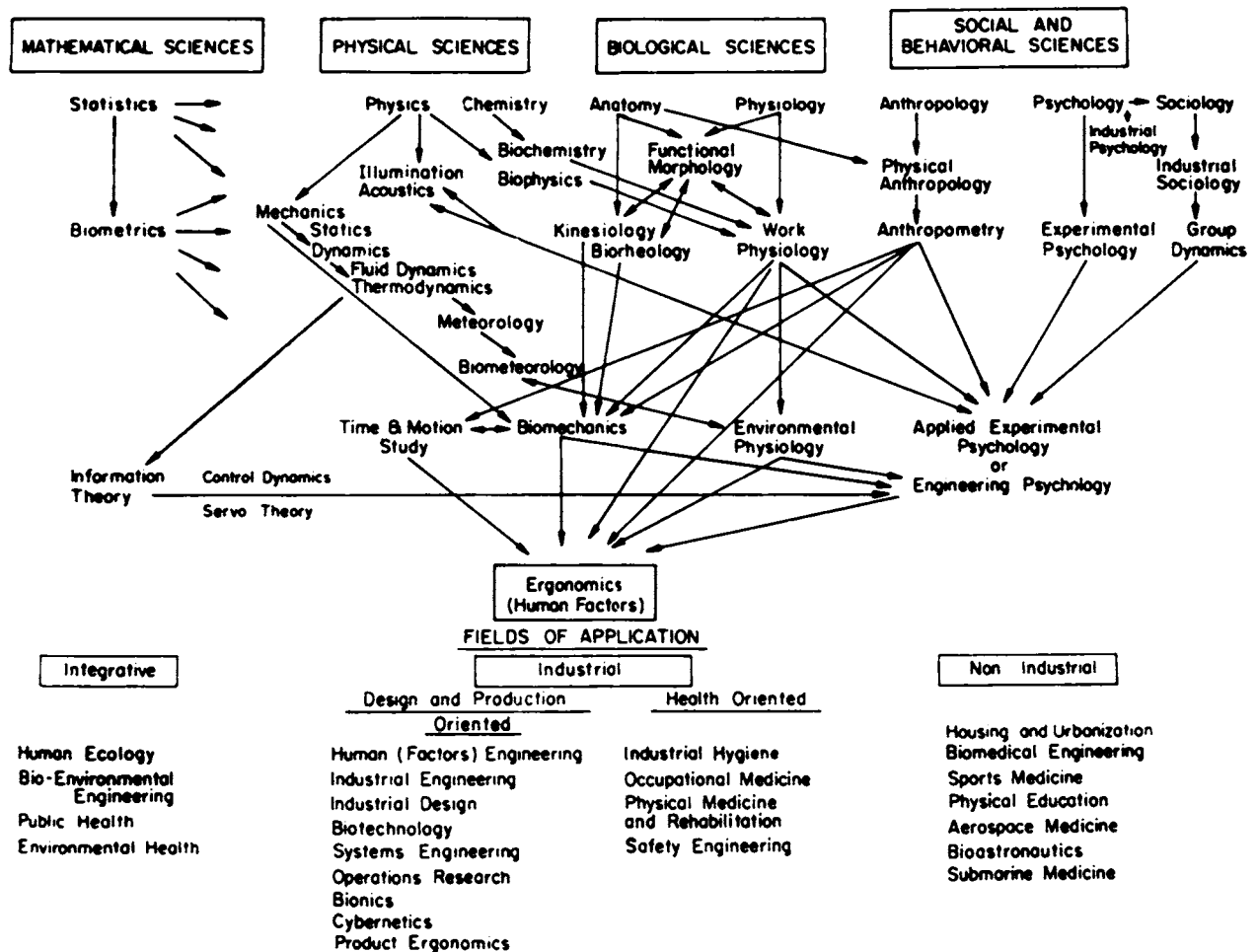
1. Dukes-Dobos, Francis N. "The Place of Ergonomics in Science and Industry," American Industrial Hygiene Association Journal, 31(5):565-571, September-October 1970.
2. Singleton, W.T. Introduction to Ergonomics. Geneva, Switzerland: World Health Organization, 1972.
3. Kvarnstrom, Sven. "Ergonomics--A Scientific Approach to Job Satisfaction," ASEA International, Winter 1973/74, pp. 23-27.

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SCHEMATIC ILLUSTRATION OF THE INTERDISCIPLINARY CHARACTER OF ERGONOMICS

Source: Dukes-Dobos, Francis N. "The Place of Ergonomics in Science and Industry,"
American Industrial Hygiene Association Journal, 31(5):565-571, September-October 1970.
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Visual 41-1

Module 41. Reprint



Ergonomics—A scientific approach to job satisfaction

By DR. SVEN KVARNSTRÖM

Ergonomics, or human engineering, means adapting the work place to

DR. SVEN KVARNSTRÖM, formerly active as a specialist in orthopedic surgery, is the head of ASEA's Health Department in Västerås, supervising a staff of 27, including six physicians and three engineers. He is chairman of the Swedish Association of Industrial Physicians, with nearly 500 members.

human operation. Archaeological finds from ancient Egypt clearly indicate that even in those days special steps were taken to adapt, for example, seat heights to the individual. In other remote periods measures were undoubtedly taken to try to design work places to prevent unnecessary fatigue. Simple measures initiated by the individual worker will probably always continue to be of great importance. Today, the experience of the operator/worker is systematically utilized at ASEA, during

the planning of new factories, through the institution of joint consultation groups.

Over a long period of development man was so superior to the machine that he could always adapt himself to its demands. This could result in exposure to unnecessary wear, even if simple ergonomic measures were adopted on the basis of common sense and in a rather primitive fashion. Attempts were made to avoid this wear by selecting operators on the

basis of "the right man in the right place." At ASEA, as far back as the beginning of the 1950s, a very complicated system was introduced for matching operators and jobs. Many different selection systems have been conceived over the years. However sophisticated they may be, their value as a tool in job allocation has been limited.



"Desk work" is recorded with video camera.

In some respects World War II meant a leap forward in developments towards more complicated machines. In the case of combat aircraft, for instance, it was soon established that man constituted the weakest link in the man-machine system. As a result of man's limitations, it was no longer possible to fully utilize the performance of the machines.

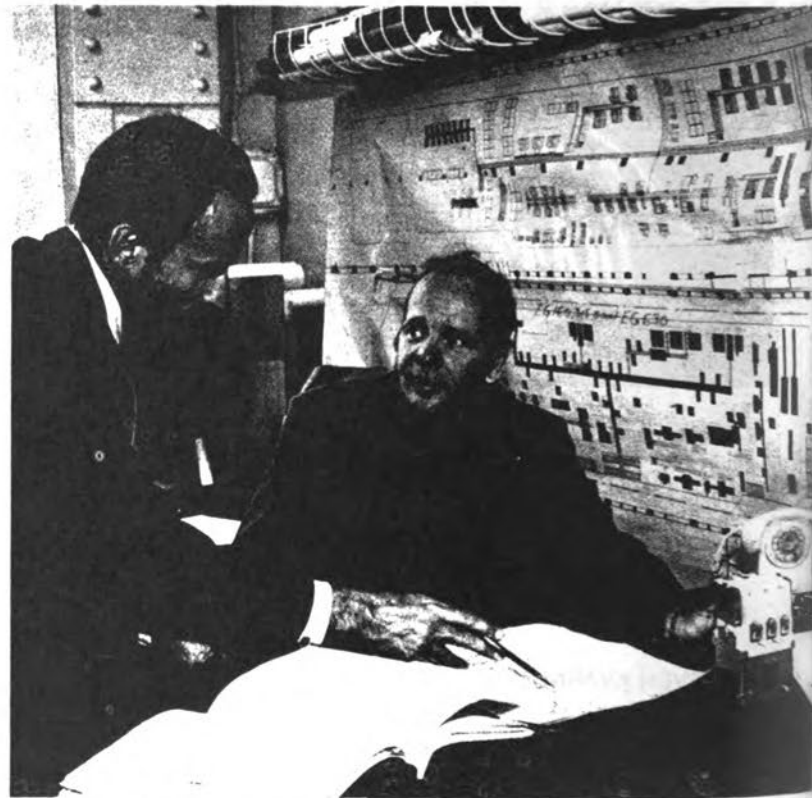
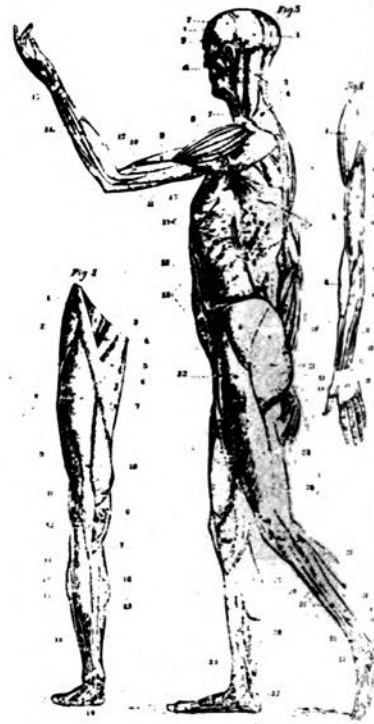
Technicians were suddenly faced with severe problems. They knew all about the performance and limitations of the machines, but possessed relatively little knowledge of the function of man as a link in the system. It became literally a matter of life and death to find solutions to the problems of how to design the work place in an aircraft so that the pilot and other members of the crew could accomplish their tasks quickly and proficiently.

This work necessitated cooperation between technicians, doctors and psychologists which led to the

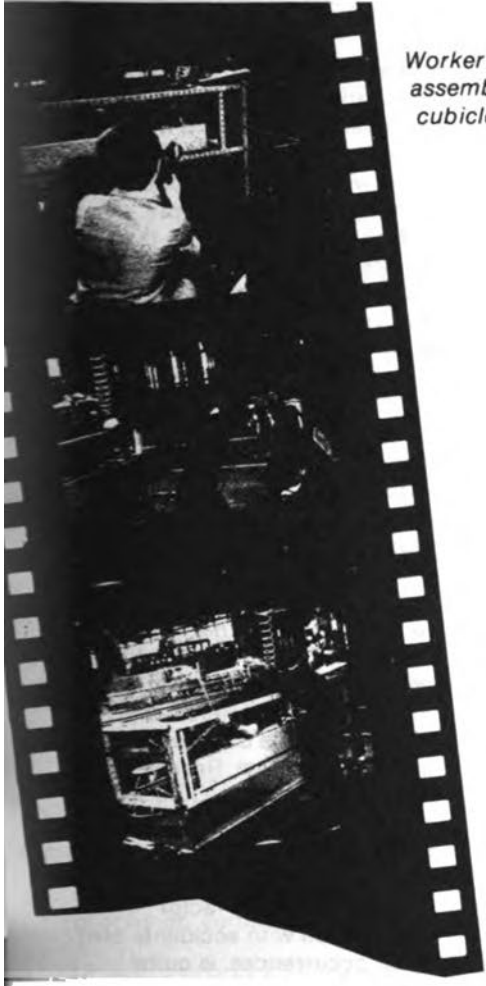
birth of modern ergonomics as an independent discipline. Since then, ergonomics has developed along various lines. In Europe, the main trend has been to adapt and apply experience to the designing of work places in general. In the United States, however, primary emphasis has been on space research, continued development of aircraft and on defense-related applications.

About 20 percent of the energy input can be converted in the human being into mechanical muscular work. Even though man is not therefore particularly efficient as a muscle machine, he is still functioning in this capacity in today's factories. It is thus clear that the traditional so-called "force" ergonomics has a very important role to play.

In this area, which primarily involves working positions and postures, two principles dominate. The first is the application of the lever



Author (left) discusses layout for new production unit with an associate.



Worker routines required in the assembly of low-voltage switchgear cubicles are taped for later analysis.

blood is the pumping effect which is achieved in a moving muscle due to the structure of the veins. If the muscle is kept under tension without any periods of relaxation, the pressure within the muscle will prevent the supply of blood, restricting the ability of the muscle to contract. Over a long period of time this will give rise to muscular inflammations, which are difficult to treat.

If a doctor working within ASEA observes troubles which may originate from work of the type mentioned above, an analysis is made of the work place. This is done by a nurse or physiotherapist. She interviews the patient and his foreman and tries to analyze the working posture. She also records it by means of sketches, photographs or, most frequently, with the aid of a portable, battery-driven video tape recorder. Later, a detailed discussion of the work place can be arranged, using a television monitor to play back the tape. Participants normally include the nurse, the doctor, the patient and the technicians who may have to be consulted regarding any corrective measures required.

Remedial ergonomics

This form of remedial ergonomic activity has proved to be very effective. By taking appropriate measures at the work place, it is possible to eliminate the actual cause of the patient's troubles and thus do more than cure him through medical treatment.

In order to tackle the ergonomic problem in a more active manner, systematic ergonomic workshop "inspections" have also been started in cooperation with the product division's doctor and the Company's ergonomic specialists. One objective is to try to detect ergonomic shortcomings before they have had time to affect operators. During these inspection tours, attention is paid not only to working postures but also to other environmental factors such as noise, air pollution and the risk of accidents. Where necessary, the

Company's specialists in these areas are consulted.

From having been involved with individual working postures and different applications of the lever principle, ergonomics in recent years has increasingly extended its scope. Social-psychological factors and job motivation, for example, are being discussed more and more widely today. Job motivation is not only a matter of pay, work supervision and physical environment, but also largely a matter of an adaptation of the work situation to the psychological needs of man.

Ergonomics today and tomorrow will be increasingly involved with job design from the psychological viewpoint. Job enlargement, job enrichment and job rotation are concepts widely used in discussions today during the planning of new factories. The doctors of the various ASEA product divisions are deeply involved in such work. By bringing together the manufacture of individual components in a limited workshop area, the individual operator is given a greater opportunity to acquire increased knowledge of the end product. This is a significant factor in job motivation.

The attempt to make jobs as interesting and stimulating as possible may, however, have certain

Machine work is studied.

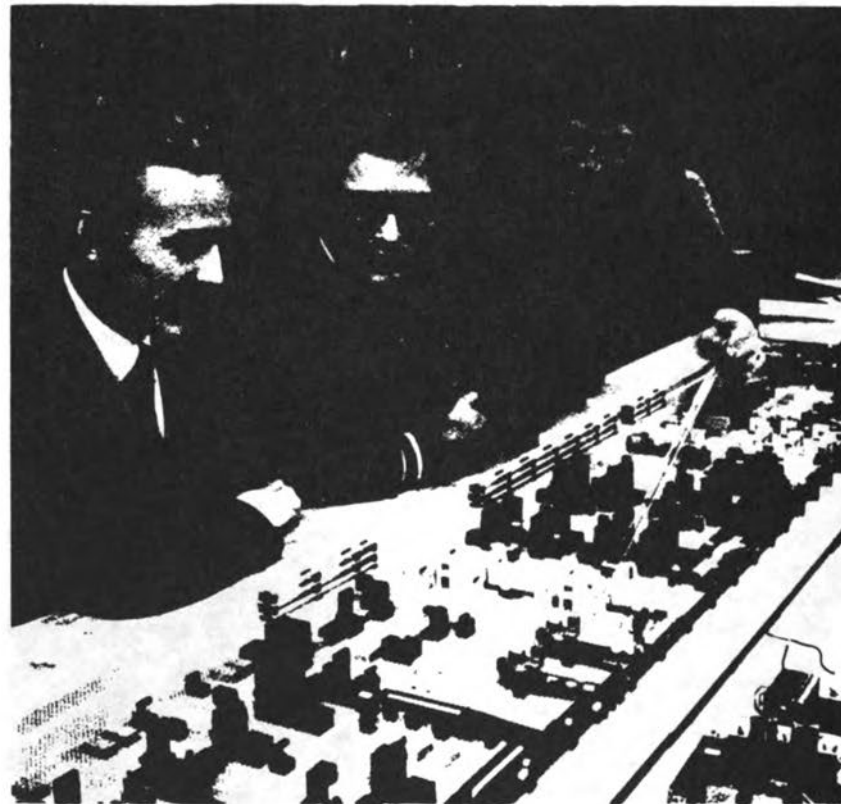
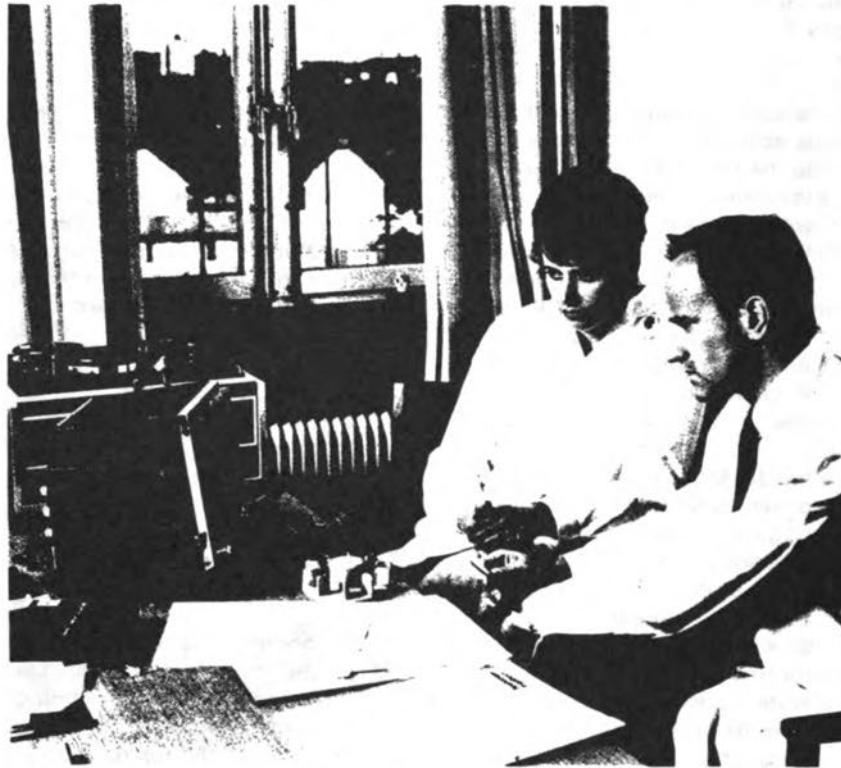


principle to the skeleton. It is practical to consider the skeleton as being built up from a large number of levers, which are stabilized or brought into motion by the forces developed by the muscles. A thorough knowledge of all aspects of skeletal structure, as well as of the functions of the various muscles, is essential for successful work on "force" ergonomic problems.

The other important principle applies to static muscular work; that is, muscular work which is not combined with motion. This occurs primarily in large muscle groups in the back and shoulders which stabilize the body in fixed working postures. The development of energy in the muscle demands the supply of oxygen via the blood. In addition, the combustion products, particularly lactic acid, must be removed, which also takes place via the blood. If lactic acid is accumulated in the muscle, it loses its ability to contract.

An important driving force for the

Author (right) and an assistant review videotape recording, looking for ways to make jobs safer and easier.



Production, engineering and ergonomics specialists study scale model layout for a new production unit.

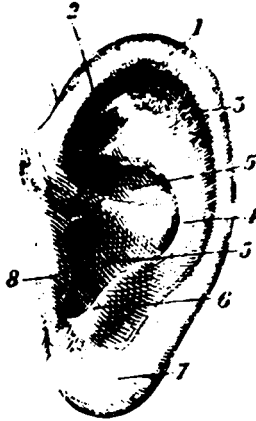
negative effects. In an average population group there exists a by no means insignificant number of persons who lack the ability to cope with a job which becomes too complicated. If the simple, routine and short-cycle jobs are taken away from these workers in order to enhance the psychological motivation factors, there may be no work left for them to do. Developments must therefore be controlled with some degree of care.

The general trend within industry today is increasingly to move away from the system where man is a power source in production towards systems where he has a monitoring and controlling function. This has necessitated systematic research to clarify those areas where man is superior to the machine and vice versa. Man and machine will be considered as an integrated system. Research is needed to show which functions must be allocated to man, and which to the machine. Researchers in this area like to maintain that talk about the "human factor" in conjunction with accidents and other occurrences, is quite irrelevant. Instead, one should state that in these cases there has been a wrong distribution of tasks between man and the machine.

Man's limited capability

Consider, for example, two aircraft flying at supersonic speed straight towards one another. They will collide during the interval it takes for the image of the oncoming plane to reach the pilot's retinas and for him to react by taking evasive action. This illustrates how limited the capability of man may be in certain control and monitoring functions in today's technological age.

Within certain areas, however, man is still superior to machines. His sensory organs are extremely efficient recording and scanning instruments. The eye is sensitive to a light intensity range of 1:100 million and the ear is so sensitive that we are almost capable of perceiving the collisions of the air molecules as a continuous noise.



"(Man's) sensory organs are extremely efficient recording and scanning instruments."

In the analysis of complex patterns and behaviours and in relating them to memories, as well as in decision-making, man is far superior to the most advanced machines, computers included.

In man's role as a controlling and monitoring element, increasing interest is being paid to his observation powers and his characteristic limitations and performance. Even if man with his various senses can monitor a large number of processes, only a single information channel at a time can be open. Monitoring will therefore be accomplished with a scanning technique, where the operator's attention is moved from one object to the next.

It is only in cases where certain routines have attained a high degree of automatism in the human brain that several tasks can be accomplished simultaneously. For example, a person can carry on intense conversation while at the same time driving a car, since driving is performed as a reflex activity. However, if the traffic density demands special attention, it is no longer possible for the driver to follow the discussion. The above-mentioned monitoring

technique involving shifting attention between different information sources is a definite human limitation compared with technical fault-scanning systems.

The sensory organs and the brain must also have variations to be able to function. It is possible to fix an image on the retina during optical experiments. It will then be found that the visual impression of the image will be erased in the visual center after only a few seconds, probably as a result of fatigue phenomena in the nerve cells of the visual apparatus. Similar fatigue phenomena affect the brain as a whole, if a person's attention must be concentrated continuously on a particular task.

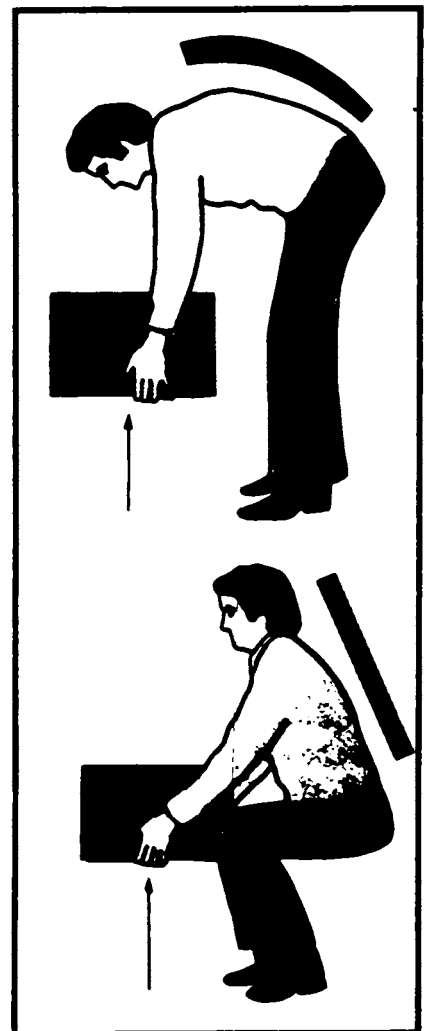
This is a phenomenon which frequently occurs during uneventful driving at night, for example. It can be recorded through the altered pattern of electrical impulses from the brain. The driver experiences the monotony as an almost completely insuperable tiredness, which may occur even though he is not suffering from any significant lack of sleep.

Impulses not recorded

On the other hand, if the nervous system is subjected to excessively frequent impulses, certain impulses will pass through without being recorded. Where different inspection or control tasks are involved, this may have extremely unfortunate consequences. Investigations have revealed, for example, that an average driver notices only 50 percent of the traffic and warning signs.

ASEA has not considered it necessary to define a written policy on ergonomic matters. It is self-evident to all who are aware of the problems that reasonable consideration must always be paid to these factors in planning new factories, the purchase of new machines, etc. Management's support of sound ergonomic programs is reflected in comprehensive and continuous training and informing of managers,

production engineers, foremen, industrial safety officers and works council members. In addition, those who are directly responsible for working environment questions in the Company also have access to qualified consultants. In addition to the medical officers, the Company has available a group of specialists in the fields of industrial safety, industrial hygiene, noise suppression and ergonomics. This group helps to formulate and enforce the requirements the Company makes in connection with the purchase of buildings or equipment. This group also acts as consultants to the Company's designers of products and equipment involving operators.



Lower figure is lifting container correctly.

MODULE 42. MORE ABOUT ILLUMINATION

ILLUMINATION

Vision is the dominant sense in man. The design of workplace lighting is therefore of corresponding importance.

Light for seeing ranges, in a narrow band of the electromagnetic spectrum, from about 3800 to 7500 Angstroms (380 to 750 nanometers). Natural light from the sun extends beyond the visible range through the infrared wavelengths up to the middle ultraviolet wavelengths. The science of illumination also includes the applications of these ultraviolet and infrared radiations, though they have no usual application in terms of lighting. They are used in many industrial processes and require parallel techniques and practices in system and equipment design, control methods and measurement principles.

Visible Light and the Physiology of Vision

Visible light frequencies are capable of stimulating the photoreceptors of the eye, producing a sensation called vision. Light rays reflected from an object pass through the cornea at the front of the eye, pass through the liquid (aqueous humor) in the anterior chamber directly behind the cornea, then through the lens and vitreous humor and onto the rods and cones of the retina. Most of the retina is used to detect movement in the periphery of vision, which is the cue for eye movement.

To be seen distinctly, all images must fall on the small area of the retina known as the macula lutea, or yellow spot. The retina is an expansion of the optic nerve fibres which terminate in rods and cones and which are the transducers that convert the incident photon energy to neuro-electrical signals. These signals are received, assembled, decoded, and interpreted by the brain (occipital cortex).

Cones are the light detectors that are involved in distinct center vision (photopic vision or foveal vision). Rods are located on the periphery of the center vision spot (fovea) and are the detectors that enable one to see when light is very dim (scotopic vision). The relative sensitivities of the rods and cones differ for various colors of light. The rods are more sensitive to a blue-green wavelength, while the cones are more sensitive to a green-yellow wavelength. Visual 42-1 shows the relative standard luminosity curves for rod and cone vision.

The pupil, which is an opening in the iris, changes in size in response to the amount of light entering it. The shape and curvature of the lens is controlled by means of special intraocular muscles. The ability to alter the shape and curvature and to focus the image on the macula lutea, or retina, is called the "power of accommodation." The failure of accommodation for near vision due to loss of elasticity of the lens is called presbyopia. This occurs in nearly every normal eye after age 45.

Six extraocular muscles control the movements of each eyeball in synchronization with the other. There is considerable muscular activity involved in seeing. For example, an eye may scan 10,000 four-inch lines of printed material in 8 hours, or about a mile of words. This may involve some 100,000 fixational pauses which, if these were footsteps, would represent walking 30 miles in one day. Blinking

is a wetting and cleaning and resting procedure with the eye turning upward during the blink.

Adaptability of the Human Visual System

The human visual system is highly adaptable to changes in the visual environment. Factors other than the visual environment can also have a pronounced effect upon the performance of the visual system. Drugs, carbon monoxide, oxygen deficiency, altitude (reduced oxygen), acceleration, vibration, and certain nutritional conditions can significantly reduce visual capabilities.

The discrimination of color, or the spectral responses of the eye, varies. Normal eye sensitivity is greatest at a wavelength of about 556 nm, or in the yellow-green range. The relative response decreases for longer wavelengths and does not respond to wavelengths greater than about 750 nm. Similarly, the response decreases for shorter wavelengths and response ceases at about 380 nm.

The luminance of light sources or reflective surfaces varies over an enormous range. This range is summarized in Visual 42-2, which shows common objects and their luminance (surface brightness or reflected light).

Visual Acuity

Visual acuity is a determining factor in the accomplishment of various visual tasks. The ability to see objects of small size or to discriminate depth, movement, flicker, brightness, and colors, are all factors in the determination of acuity. Thresholds for these visual capacities have been measured and determined statistically to provide values that define some probability of seeing a target object, usually in terms of a 50% probability. Since a higher probability of seeing is usually required in practical visual tasks, any experimental thresholds should be doubled, even under optimal conditions. As has been mentioned, resolution capabilities of the eyes can be adversely affected by vibration and other environmental stresses as well as non-optical visual factors, such as changes in contrast or rapid changes in illumination. Thus, experimentally determined thresholds serve to show the limits of seeing. These limits must be modified by appreciable factors when applied to work situations.

The minimum size or visual target angle is about 0.008 minutes of arc, with a background luminance of the order of 1000 millilamberts. This is the minimum perceptable acuity or the maximum ability to see small objects against a plain background. The minimum separable acuity, or the smallest space the eye can see between parts of a target, is 0.5 minutes of arc, with a background luminance of 10 millilamberts. The minimum vernier acuity (the minimum lateral displacement necessary for two portions of a line to be perceived as discontinuous) is 0.04 minutes of arc at 10 millilamberts. Stereoscopic acuity (perceptable difference in binocular parallax of two objects or points) is 0.03 minutes of arc at 10 millilamberts. Beyond 2,500 feet, one eye alone can judge depth as well as two eyes. In each of the above cases, as the background luminance decreases, the minimum of threshold size increases. If the target contrast is increased, the threshold size decreases.

The position of the visual target in relation to the visual axis has a marked affect on the threshold visual acuity, with an 80% relative acuity decrease for determining objects only 10° off from the visual axis. For lower levels of luminance, this is not the case, since photopic vision is no longer dominant. At about 0.001 footlamberts, all parts of the visual field are equal in sensitivity, and the position of the visual target relative to the line of sight does not decrease the visual acuity.

The extent to which color combinations can improve visual acuity varies with the colors used. The highest possible color contrast only produces a visual acuity equivalent to that produced by a brightness contrast of 35%. Acuity is increased much more by increasing brightness contrast than by increasing color contrast.

About six percent of the healthy male population show some reduced ability to differentiate colors. Only 0.003% of the population are completely color blind, seeing only shades of grey. Color coding for general population use should make use of colors that even color-deficient individuals can easily recognize.

It takes time to see. Fractions of a second may be sufficient if size, illumination, and contrast are great. Visual acuity is appreciably increased as the time of exposure to a viewed object is increased. At any luminance level, less time is required to see bigger objects. When size is held constant, less time is required to see at higher luminance levels.

Flashing lights can be seen more easily than steady lights. If the duration of a flash is over 0.2 seconds, the relative intensity necessary for visibility is increased only slightly with a decrease in flash duration. Flash durations shorter than 0.2 seconds must be much more intense to be visible. At a high frequency of flicker, a blinking light will appear as a steady light. This flicker fusion phenomenon varies with the degree of luminance. The flickering effect of low, intermittent light is often disturbing to some people.

Visual acuity is decreased if the target, the observer, or both are in motion. With motion exceeding 20° per second angular speed, the eye can no longer match exact movements and acuity is greatly impaired.

The sensitivity of the eye increases greatly when it adapts to darkness after exposure to a high level of illumination. The concentration of photosensitive materials is increased. But this increased sensitivity occurs at the cost of reduced resolution and an increase in time it takes to see.

In general, visual acuity is at a maximum when the eyes are adapted to the brightness levels of the target and the background. Acuity is best when the surroundings are only a little darker than the target. Excessive brightness in the field of vision, such as "glare," can seriously affect visual performance. It can also cause discomfort.

Illumination and Visual Acuity

In summary, there are four fundamental factors involved in seeing: (1) size, (2) contrast, (3) brightness, and (4) time. All are necessary. At threshold

visibility, any one may be reduced if one or more of the others are increased. Ease of seeing increases by increasing any one or all of these factors up to certain limits.

For any given seeing task, the brightness is usually most easy to control. Generally speaking, the illumination must be increased by a doubling increment to provide any obvious and significant improvement in the effectiveness of seeing. Visual acuity increases rapidly up to about 5 footcandles, and more slowly thereafter when the object is 3 to 5 minutes of arc. For smaller sized objects, up to 40 or 50 footcandles perceptibility improves vision. The greater the brightness contrast, the better the vision. Acuity and speed of vision continue to improve slightly up to and above 100 footcandles. However, little acuity is gained by increasing illumination above 25 footcandles. For small objects or improved speed of vision, there is improved discrimination at higher levels up to a level of about 40 to 50 footcandles. Excessive illumination will not compensate for small object size or poor contrast.

The intensity and distribution of light must be coordinated. Increasing the intensity without improving distribution may make a bad visual situation worse. When distribution is poor, relatively low levels of lighting tend to lessen visual discomfort.

Glare is the result of light entering the eyes from any visible light source or bright surface. It reduces the sensitivity of the visual sensors and reduces the visibility of an object. Glare should be removed whenever possible. Use of diffuse lighting and less reflecting surface should be considered. Light sources should be kept out of the field of vision. Most modern light sources have brightness values far greater than is desirable for comfort. The brightness of the glare source should be reduced in relation to its background. Sometimes glare cannot be avoided. The effect of glare can be reduced greatly if the brightness of a task or object is increased, or when the brightness contrast is increased. In some instances, a combination of increasing both object brightness and contrast can eliminate the objectional glare.

Illumination Design

The illumination requirements for the visual tasks in the workplace environment must be calculated before any new lighting is installed. The amount of light flux for the working plane must be determined or selected from tables of standards for illumination. Lumens which must be generated by the sources is determined by applying a coefficient of illumination suitable to the installation for which the lighting design is to be applied. Knowing the efficiencies of lamps, one may select the type and size to be used. For example, in a 20 x 40 foot room with a 12-foot ceiling, the tasks to be performed will require a minimum of 12 footcandles of well distributed general illumination. The room must have light-colored walls and ceiling, and individual tasks must not require local supplemental lighting above 125 footcandles.

The procedure to follow is:

- (1) Area of room = 800 square feet.
- (2) Dividing the room into eight equal sections will give reasonable uniformity of illumination using semi-indirect incandescent or fluorescent lamps.
- (3) 12 footcandles require 12 lumens of incident light per square foot.
12 x 800 square feet = 9600 lumens which must reach the working plane of the task.
- (4) Coefficient of utilization for this size room, light-colored walls and ceiling, and semi-indirect lamps is found to be 0.23 in the design tables (Visual 42-3).
$$\frac{9600}{0.23} = 41,700 \text{ lumens which must be generated by the lamps.}$$
- (5) $\frac{41,700}{8} = 5210 \text{ lumens per lamp.}$
- (6) Referring to the lamp efficiency tables, a new, clean 300-watt incandescent lamp will provide 5850 lumens.
- (7) The installation of eight 300-watt lamps in semi-indirect luminaires, will (in new condition with clean fixtures, ceiling, and walls) provide an illumination level of 12 footcandles of well-distributed, general illumination.
- (8) The provision of supplemental, local lighting for tasks requiring 125 footcandles can be accomplished with localized, well-positioned lamp fixtures. As a practical guide, the average general illumination should not be less than the square root of the local illumination in footcandles.

In the above example, the design illumination level will be met and will be maintained as long as the light output of the lamps and the condition of the reflecting surface of the fixtures, ceiling, and walls do not deteriorate appreciably. A lamp will deteriorate 20% in light output during its rated burning lifetime. About 50% of incandescent bulbs burn out before the end of their rated lifetime. Therefore, some replacement will be necessary before the 20% deterioration in lumen output occurs. Gas-filled tungsten lamps have an average life of 750 hours and provide some 17 lumens per watt at full voltage. Economic studies that take into account capital expenditures, power consumption, and maintenance costs for relamping and cleaning, indicate that the optimal operating voltage lies between 100 to 103 percent of rated voltage and group relamping every 500 to 600 hours.

The "lumen" method of design is straightforward but must be flexible enough to serve the total illumination needs for the tasks involved. The method may be expressed using this formula:

$$F = \frac{(FCT) \times A}{U \times M}$$

F = Total flux (lumens) required
 FTC = Footcandle illumination on task
 A = Area of the working plane
 U = Utilization factor
 M = Maintenance factor

Values for the above factors may be determined by referring to tables in lighting design handbooks and in the specification sheets of manufacturers of lamps and lighting fixtures.

Lamp Choice

Other lamps, such as a fluorescent, mercury vapor, mercury-tungsten, sodium discharge, or infrared tubular types may have characteristics desirable for particular installations. Energy conservation may dictate use of the most efficient lamps, especially where heat load must be paid for by use of cooling or air conditioning.

Comparing the 17 lumens-per-watt efficiency and the 750-hour lifetimes of incandescent lamps, it appears that fluorescent lamps have efficiencies of 40 to 50 lumens per watt, generally better distribution of light, and an average economical life of 5000 hours. Mercury vapor lamps exceed 50 lumens per watt, generally better distribution of light, and an economical life of 5000 hours. Mercury vapor lamps exceed 50 lumens per watt, have a long life (averaging 12,000 hours), and can be operated at higher voltages. These lamps produce a light spectrum proportionally large in the short wavelengths. If they are not color corrected, they mask color contrasts. The mercury tungsten lamp provides good color and long life, but is not as efficient as the mercury vapor lamp. The sodium vapor lamp has very high efficiency (some 70 lumens per watt), but is almost monochromatic, which limits its usefulness. The infrared tubular lamp is primarily a heat source (50 watts per square foot), but it also provides considerable illumination (5 foot-candles for each watt per square foot) when it is used for heating. Relative efficiencies of incandescent and fluorescent lamps are shown in Visual 42-4.

For low to moderate intensity lighting levels, visual acuity is better when sodium vapor or mercury vapor lamps are employed rather than tungsten incandescent lamps. For levels of intensity of light above 370 footcandles, all illuminants (with various frequency distributions) allow the same visual acuity. For monochromatic light sources, use of blue light or red light results in poor visual acuity. For ordinary situations involving non-critical visual tasks, the quality of lighting from daylight, mercury arc, tungsten filament, or fluorescent lamps are about equally effective.

Maintenance

Good maintenance of lighting is good economics, since through maintenance the user can be assured that he gets the light that he pays for as well as the conditions

for seeing that the system was designed to provide. Cleaning of the lighting system should be done correctly and at the right time. A good cleaning program provides: (1) more light; (2) minimal maintenance cost (since good maintenance requires that cleaning be done at the most economic time, using the most efficient methods and equipment, and reducing the time and materials used in the maintenance effort); and (3) clean lighting systems which improve the appearance of any work area, foster better housekeeping, and improve maintenance generally. Since walls and ceilings and other surfaces influence the reflectance of light, maintenance should include periodic cleaning and/or repainting as a part of a routine program.

Light losses are caused by a number of factors. Dust and dirt in the air may settle on all surfaces and diminish light transmission and reflectance. A dusty room demands more frequent cleaning of lamps and fixtures. Dirt losses and the lamp-lumen depreciation that invariably occurs with the age of lamps, are the principle factors causing light loss.

Lamp replacement may be done individually, as each lamp burns out (spot replacement) or entire installations can be replaced before the lamps reach the burn-out stage (group relamping). Group relamping may save on labor costs, especially in large systems. This procedure provides more light, fewer work interruptions, better appearance of the lighting system, and less maintenance of auxiliary equipment. In fluorescent systems, early lamp replacement will reduce or eliminate the distractions of blinking, flashing, or swirling, as well as the non-uniformity of brightness that occurs. It also increases the life of auxiliary ballasts and starters.

Ultraviolet Light

Ultraviolet light is the radiant energy that falls in the region between visible light and X-rays in electromagnetic spectrum, spanning wavelengths from 400 nm to 120 nm.

Light of wavelengths from about 250 nm to about 1400 nm penetrates the skin to some extent. The light absorption by the epidermal layer increases greatly for wavelengths shorter than 320 nm. Very little of this penetrates any deeper. The outermost layer of skin blocks the penetration of any ultraviolet radiation shorter than about 240 nm. The epidermal protein absorbs most of the radiation. The maximum light penetration into the skin occurs at about 1000 nm in the near infrared. There is essentially no penetration of wavelengths longer than 1400 nm.

The residual light that does penetrate the epidermis and is largely absorbed produces specific physiologic and pathologic effects. The obvious effect of skin exposure to ultraviolet light is sunburn, or erythema. In addition to swelling, blistering, peeling, and pain, a rapid proliferation of cells or thickening of the epidermis occurs. This reaction adds to the effectiveness of the corneum (outermost horny layer of the skin) as a filter or absorber of the offending radiation. A marked decrease occurs in the amount of sunburn-producing radiation that reaches the radiation-sensitive cells. The thickening of the corneum is clearly the principal cause of reduced sensitivity to ultraviolet exposure.

About 20 hours following exposure to ultraviolet radiation, a migration of a skin pigment (melanin) occurs, moving from its source in the deep, basal layer of skin toward the surface. This is followed by the production of new melanin in the deep skin. Later, some of this pigment becomes incorporated in the corneum and further increases the opacity of the corneum to incident light. The resulting "suntan" has a lessor protective effect than the earlier thickening of the epidermis.

The eye has no horny layer, as does the skin. The eye transmits, with little absorption and scattering, all of the wavelengths of visible light (390 nm to 650 nm), except at the very short wavelengths of visible light (390 nm) where 50% of the light is scattered. Absorption of all wavelengths of visible light is complete in the retinal pigment layer. Water absorption blocks wavelengths longer than 1400 nm at the eye surface. Ultraviolet light shorter than 320 nm penetrates very little, but some may reach the lens. The wavelengths that cause sunburn are absorbed in the outer layer of the eye and may cause cellular damage in the cornea, symptoms of which are pain, light intolerance, tear formation, swelling, and visual disturbance. This is known as keratitis or welder's flashburn. The wavelength causing maximal keritosis effect is about 288 nm. The corneal absorption peaks at about 265 nm. Therefore, the effects result from the 288 nm ultraviolet absorption and from disruption of a minor constituent of the cornea.

Crown, or spectacle-glass, lenses filter out a large proportion of ultraviolet light shorter than 300 nm. For high-intensity exposures to ultraviolet, such as in welding, plasma jet operations, or the use of ultraviolet lamps, special glass lenses are necessary to prevent keratitis. These high levels of ultraviolet radiation will also cause formation of ozone in the air and result in respiratory irritation.

Ultraviolet light does not damage the retina or cause cataracts. It is the longer wavelengths (infrareads) that have penetrating capability, causing localized heating in the eye which has little capacity for heat dissipation. Thus, persons exposed to infrared sources, such as furnaces or infrared lamps, should be shielded from these radiations not only for their possible contribution to excessive radiant heat load, but also for the prevention of cataract formation. The total intensity of ultraviolet (both direct and reflected) should not exceed 0.5 micro-watts per cm^2 every eight hours on human skin, and should not exceed 0.1 micro-watt per cm^2 for continuous exposure. Use of protective clothing, creams, glasses, screens, or shades is necessary to prevent skin effects where exposures are repetitive and exceed 0.1 micro-watts per cm^2 . Glasses or screens should not allow ultraviolet transmittance to exceed a total energy incident upon the skin or cornea of 1.5×10^5 ergs/ cm^2 per 24 hours.

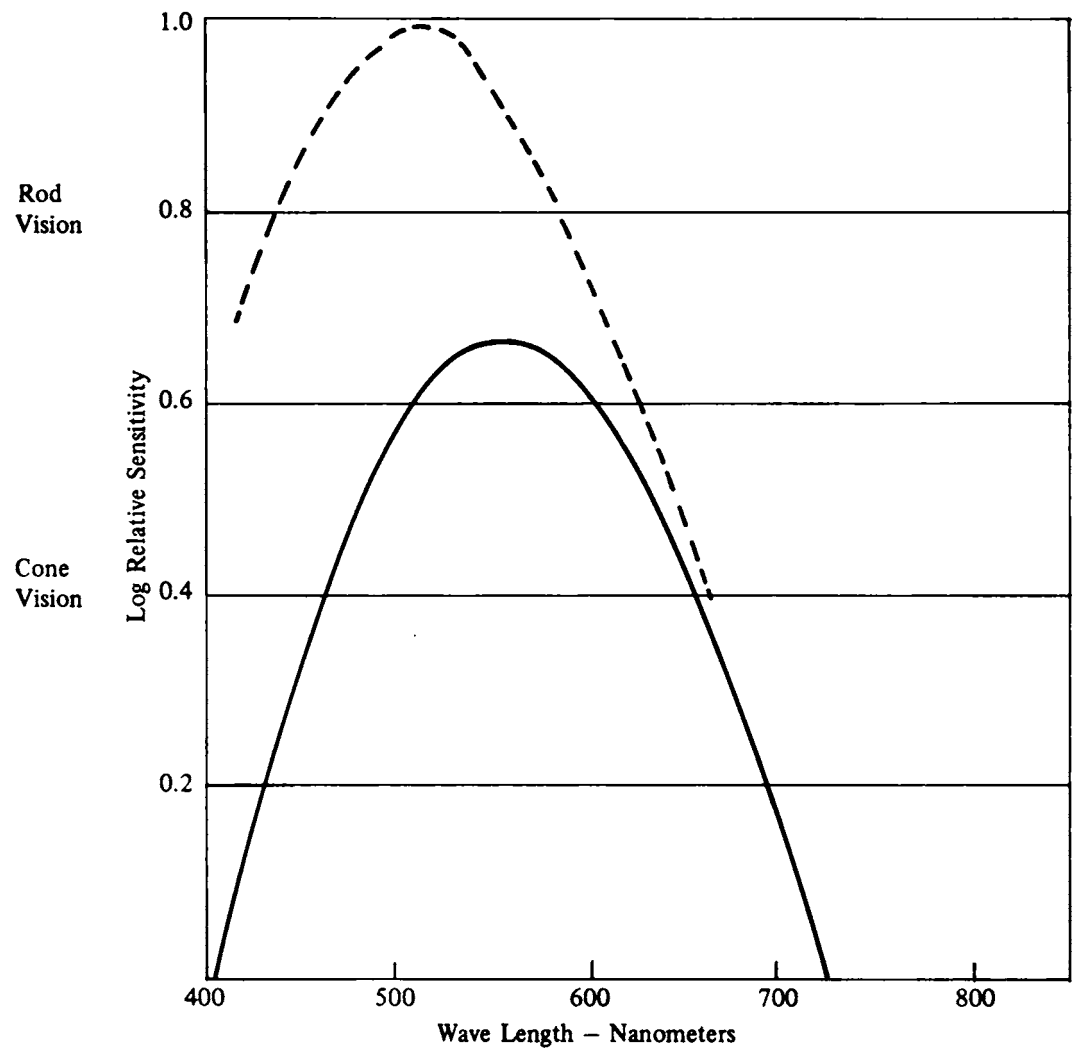
Visual 42-5 gives conversion tables for various units of measurement used in lighting design.

Selected References

1. American National Standard Practice for Industrial Lighting, ANSI A11.1-1973. New York: Illuminating Engineering Society, 1973. Revision of ANSI A11.1-1965 (R1970).
2. Brown, J. L. Study of Visual Perception in Humans and Animals: Sensitivity and Spectral Response at Low Luminance. Technical Report 2. Manhattan, Kansas: Kansas State University, 1966.
3. Burg, J. "Visual Acuity as Measured by Dynamic and Static Tests," Journal of Applied Psychology, 50(6):460-466, 1966.
4. Davson, H. (Ed.). The Eye: Volume 1, Vegetative Physiology and Biochemistry; Volume 2, The Visual Process; Volume 3, Muscular Mechanisms; Volume 4, Visual Optics and the Optical Space Sense. London: Academic Press, 1962.
5. Duntley, S. Q., et al. "Visibility," Applied Optics 3:549-598, May 1964.
6. Graham, C. H. (Ed.). Vision and Visual Perception. New York: John Wiley & Sons, Inc., 1965.
7. Lighting Survey Committee. "How to Make a Lighting Survey," Illuminating Engineering, February 1963. Reprinted in part, November 1963.
8. O'Brien, P. F. "Numerical Analysis for Lighting Design," Illuminating Engineering, 60:169-178, April 1965.
9. Ulett, G. A. "Flicker Sickness," Archives of Ophthalmology, 50:685-687, 1953.

Note: References 1 and 7 should be part of every industrial hygienist's own professional library. Orders should be addressed to:

Illuminating Engineering Society
345 East 47th Street
New York, N.Y. 10017



STANDARD LUMINOSITY CURVES:
RELATIVE SENSITIVITY TO RADIANT FLUX
AS A FUNCTION OF WAVELENGTH

Source: Adapted from Hecht, S. and Williams, R. F. "The Visibility of Monochromatic Radiation and the Absorption Spectrum of Visual Purple," Journal of General Physiology, 5, September 1922, pp. 1-33.

Visual 42-1

Visual 42-2

LUMINANCE OR SURFACE BRIGHTNESS
OF COMMON OBJECTS

<u>Object</u>	<u>Luminance</u> (millilamberts)	
Sun (providing 12,700 footcandles of incident illumination)	4.8×10^8	 Photopic Vision (cones)
500W clear incandescent bulb (filament)	3.4×10^7	
110W T12 fluorescent lamp (cool white)	3.5×10^3	
Sky (clear day)	2×10^3	
Moon (full)	1.6×10^2	
Candle	1.6×10^2	
White paper in good reading light	2×10^1	 Mesopic Vision (cones and rods)
TV Screen	1×10^1	
Snow in light of full moon	8×10^{-1}	
Lower limit for useful colorvision	2×10^{-2}	
Upper limit for night vision	1×10^{-3}	 Scotopic Vision (rods)
Threshold for dark-adapted eye	1×10^{-3}	
Lower limit for night vision	1×10^{-3}	
Moonless night sky (not stars)	1×10^{-5}	

Source: White. NASA Publication SP3006,
1964, pp. 307-341.

Visual 42-3

Coefficients of Light Utilization

Ceiling (12 ft.)		Floor Area (sq. ft.)			
Type of lighting unit	Color of walls and ceiling	200	400	800	1600 & over
Direct	Light	0.30	0.34	0.38	0.41
	Dark	0.28	0.32	0.36	0.39
Semi-indirect	Light	0.16	0.20	0.23	0.26
	Dark	0.095	0.12	0.14	0.16
Indirect	Light	0.12	0.15	0.18	0.20
	Dark	0.045	0.065	0.080	0.090

Coefficient of utilization gives proportion of light produced by sources which reach plane of work. Value varies with type of lighting unit, color of walls and ceiling, and the size of the room. Values above are typical for a 12-foot ceiling.

Note: The tables in Visuals 42-3 and 42-4 are representative of more extensive tables found in standard lighting handbooks, such as those published by the Illuminating Engineering Society.

Visual 42-4

Efficiencies of Electric Lamps

INCANDESCENT			FLUORESCENT		
Input to Lamp Watts	Output Lumens	Efficiency Lumens Per Watt	Input to Bulb Watts	Output Lumens	Efficiency Lumens Per Watt
15	140	9.3		Daylight Color	
25	260	10.4	15	495	33
40	465	11.6	20	760	38
60	835	13.9	30	1230	41
100	1620	16.2	40	1800	45
200	3650	18.2		White Color	
300	5850	19.5	20	900	45
500	9850	19.7		Blue Color	
1000	21000	21.0	20	460	23
				Green Color	
			20	1300	65

CONVERSION CHART

Luminous Flux (Intensity of a Source)

- 1 candle power = 4π lumens
- = $5.882\pi \times 10^4$ ergs/second (at 550 nm)
- = $5.882\pi \times 10^{-3}$ watts (at 555 nm)

Illuminance (Illumination Incident upon a Surface)

- 1 footcandle = 10.764 meter candles
- = 1 lumen/square foot
- = 10.764 lumens/m²

Luminance (Surface Brightness or Reflected Light)

- 1 footlambert = 10.764×10^{-4} lamberts or lumens/cm²
- = 1.076 millilamberts
- = $1/\pi$ candles/square foot
- = $10.764/\pi$ candles/m²

Energy Emitted by a Source

- 1 candle power = 4π lumen - seconds
- second = 5.882×10^{-3} watt - seconds (at 555 nm)
- = 5.882×10^{-10} ergs (at 555 nm)

Energy Received by a Surface

- 1 footcandle = 10.764 meter - candle - second
- second = 15.83×10^{-7} watt - seconds/cm² (at 555 nm)
- = 15.83 ergs/cm² (at 555 nm)

Wavelengths

- 1 nanometer (nm) = 1 millimicron
- = 10 Angstroms

MODULE 43. MORE ABOUT VIBRATION

VIBRATION

Since almost the beginning of the industrial revolution, it has been recognized that vibratory tools and machines were capable of causing physical damage to the operator. However, little has been accomplished until recently to eliminate or control this hazard. To gain some idea of the seriousness of the problem, one need only observe the operation of a pneumatic drill and note the energy which is transmitted from the drill to the operator. The pneumatic drill was developed almost a century ago. Since that time, much has been done to increase its mechanical efficiency, but little has been done to reduce energy transmission to the operator.

Most of the information on biologic effects and corrective measures with respect to vibration has been gathered by European investigators. As a result, European industries are more advanced than American industries in the application of this knowledge.

The reprint at the end of this module reviews the literature of vibration as a potential safety and health hazard and discusses a NIOSH program for establishing vibration exposure criteria.

VIBRATION

What is Vibration?

Vibration is the transmittal of energy to the human body, usually by contact with a surface or system that is in oscillatory motion. This motion can be harmonic or extremely complex. The oscillation may be periodic or completely random, steady state or transient, continuous or intermittent. During vibration one or more components of a system oscillates around some position of equilibrium.

Sinusoidal Vibration

Vibration is considered periodic if the oscillation around a position of equilibrium repeats itself exactly at regular intervals. The simplest form of periodic vibration is called harmonic motion. Harmonic motion is a function of time and can be represented by a sinusoidal curve. Such a relationship is illustrated in Visual 43-1, where T represents the period of vibration. The motion can be characterized at any time by (1) displacement from the equilibrium position, (2) velocity or rate of change of displacement, and (3) acceleration or rate of change of velocity.

Random Vibrations

Random vibrations frequently occur in nature. They are motions in which the vibrating bodies undergo cycles of irregular motion that never repeat themselves exactly.

Energy Transmittal to the Body

Suppose that a worker were standing on a platform that was in harmonic vibration. The energy transmitted to the body would be a factor of the displacement--the distance the body was moved--and the frequency with which it was moved. If the oscillation occurred at a frequency of one cycle per second, and the displacement was only 0.1 inch, then obviously not too much energy would be transmitted to the body. On the other hand, if the frequency were increased to 100Hz (or cps) while retaining the same displacement, then the amount of energy transmitted would be significantly greater. To some extent, the same effect would occur by keeping the frequency constant and increasing the displacement.

In a free moving system, the energy absorption of the body would not be great. But if a worker attempts to overcome the displacement by applying an opposing force, such as he would with a pneumatic drill, energy absorption increases greatly. By applying an opposing force, the worker absorbs the energy of the system. In another case, the worker moves with the system, as in the case of a tractor operator. Here he is not overcoming a force except as the weight of his own body tends to resist the force. Until recently, tractor seats were attached to the tractor frame by means of a spring-suspended seat. This meant

that the operator was subject to whole-body vibration which could be harmonic or random or a combination of both, depending on the terrain and other operating conditions.

Types of Vibration Exposure

When considering the effects of vibration, it is necessary to determine the type of exposure. Whole-body vibration is an exposure in which the whole body mass is subjected to mechanical vibrations, such as vibration from the tractor seat mentioned above, or any other heavy mobile equipment. Segmental vibration is an exposure in which only a part of the body is in direct contact with the vibrating medium, and the bulk of the body rests on a stationary platform. In this type of exposure, parts of the body other than those in direct contact with the vibrating surface may be affected. If the whole body is considered a mechanical system, then forces from vibration may be transmitted from one part of the body to another, as illustrated in Visual 43-2.

Effects of Whole-Body Vibration

Research in the United States has shown that for whole-body vibration, a seated man is least able to tolerate frequencies between approximately 3 to 14 Hz. It is possible to apply externally generated vibrations to the human body at certain frequencies and in such a manner that the body resonates with the vibrating sources. These studies have indicated that such whole-body resonances occur in the frequency range of 3 to 6 Hz and 10 to 14 Hz. It has also been shown that the presence of resonant effects in some body sub-systems occurs as a result of exposure to whole-body vibration. For example, resonance of the head-shoulders sub-system has been found in the 20-30 Hz range. Disturbances that suggest eye-ball resonance have been indicated in the 60-90 Hz range. A resonance effect in the lower jaw and skull sub-system has been reported for the 100-200 Hz range.

Besides mechanical responses to vibration, there are pronounced physiological and psychological effects resulting from exposure to whole-body vibration. Although these effects are rather complex and usually difficult to measure, the subjective responses of man to whole-body vibration have been fairly well documented in European scientific literature. Physiological effects include evidence of a slight acceleration in the rate of oxygen consumption, pulmonary ventilation, and cardiac output. There is evidence of abnormal tendon reflexes and an impairment in the ability to regulate the body posture, possibly by actions through both the vestibular and spinal reflex pathways. Alterations in the electrical activity of the brain have been recorded, and there has been evidence of effects on visual acuity and performance at various levels of motor activity during exposure to whole-body vibration. These and other European studies indicate that whole-body vibration has an effect on the endocrine, biochemical, and histopathologic systems of the body.

Effects of Segmental Vibration

Extensive investigations of industrial exposures to vibration have been made on repeated exposures to low-frequency vibration transmitted through the upper extremities. Such exposures are common among workers who use hand-held power tools that have rapidly rotating or reciprocating parts. Although the observations of different investigators vary greatly, there is evidence of a vibration syndrome. Symptoms accompanying this syndrome can be conveniently grouped into four categories in the order of their appearance.

1. A traumatic vaso-spastic syndrome in the form of Reynaud's Syndrome.
2. Neuritis and degenerative alterations, particularly in the ulnar and axillar nerves; that is, a loss of the sense of touch and thermal sensations as well as muscular weakness or even paralysis, and abnormalities of the central nervous system.
3. Decalcification of the carpal and metacarpal bones; fragmentation, deformation, and necrosis of carpal bones.
4. Muscle atrophy; tenosynovitis.

Reynaud's Syndrome

Since this disability is by far the most significant biologic effect, it deserves further consideration. The Reynaud's Syndrome is characterized by impaired blood circulation in the hand. When exposed to cold conditions, the fingers become white and void of sensation. Hence, workers commonly refer to the condition as "white fingers" or "dead hand". The appearance of the syndrome seems to be a function of the cumulative absorption of vibration energy and its harmonic content, and of personal factors such as age of the worker.

Vibrations in the frequency range of 40 to 125 Hz have been implicated most frequently in reported vibration disorders. In most cases it was found that an exposure time of several months was generally needed before symptoms appeared. With continued exposure, there was a progressive diversification and intensification of symptoms. With cessation of exposure to vibration, some improvement of symptoms has been reported, but rarely complete recovery. In the opinion of many European investigators, Reynaud's Syndrome is a widespread and alarmingly common occupational disorder. Symptoms of overexposure are reported to be grave or moderately grave in about half of those affected. In all cases, however, there is a varying loss of working capacity.

Occupations or Operations Involving Vibration Hazards

In industrial situations, whole-body vibration is largely limited to heavy equipment vehicles, such as those found in agriculture, forestry, lumber, mining, and the transportation industries. Exposure to segmental vibration is great

among workers using pneumatic tools, pneumatic drills, jackhammers, chain saws, rock drills, pneumatic stripping tools, stamping equipment, sewing machines, and looms.

Standards and Exposure Criteria for Vibration

The biologic effect of vibration, whether whole-body or segmental, is related to the amount of vibration energy being absorbed by the body. Unfortunately, no method has yet been developed that permits this kind of measurement. Therefore, the critical energy dose is not known. Other parameters, such as subjective responses, must be used for evaluating the effects of vibration. A number of studies have been made to determine subjective and actual vibration effects, but these have been limited largely to military and aerospace situations that involve acute exposures of relatively short duration. For many reasons, it is impossible to transfer these findings to industrial situations. Industrial workers are usually exposed to vibration for 40 hours per week for periods up to 40 years. These kinds of exposures cannot be compared to the military/aerospace findings. At present, there are no official standards for either whole-body or segmental vibration. Perhaps the single best guide to vibration exposure is the set of criteria prepared by the International Standards Organization. These criteria relate a subjective factor called "fatigue/decreased-efficiency" to vibration frequency and acceleration. The criteria are shown in Visual 43-3. They are valid only for vibrations transmitted to the torso of a standing or sitting person and are, therefore, guides to whole-body vibration exposure. Since acceleration is a measure of force, the energy concept is inherent in these criteria. Acceleration is measured as the root mean square. (For the derivation of this term, refer to Chapter 26, "Vibration", by Robert D. Soule, in The Industrial Environment--Its Evaluation and Control.)

The curves shown in Visual 43-3 relate equal "fatigue/decreased-proficiency" over the frequency range of 1 to 100 Hz. Vibrations in frequencies below 1 Hz produce annoyances that are individually unique (as in air or motion sickness), whereas at frequencies above 100 Hz, vibrations are mainly perceived on the skin and depend greatly upon the nature of the body part and on the damping layer, such as clothing or shoes.

NIOSH has established a program for determining vibration exposures. Studies are based upon identification and characteristics of exposed workers in U.S. industries. Studies are being implemented to ascertain the extent of the industrial vibration hazard and to determine criteria for standards to prevent adverse exposure to industrial vibration. The International Organization for Standardization has developed a guide for evaluating human exposure to segmental vibration, but its adoption is pending and not yet available for use.

Vibration Measurements

A wide variety of component systems are available for measuring vibration. The most common system uses a vibration pick-up to transform the mechanical motion into an electrical signal. An amplifier enlarges the signal, an analyzer

measures the vibration in specific frequency ranges, and a metering device calibrates the vibrational units. The use of instruments and the interpretation of results require a high level of skill and training. Chapter 26 of The Industrial Environment--Its Evaluation and Control contains further information about these instruments.

Control of Vibration

Vibrations may be reduced by: (1) isolating the source to keep it away from radiating surfaces; (2) reducing the response of radiating surfaces; and (3) reducing the mechanical disturbance causing the vibration. A simplified method for vibration control includes the following steps.

Select equipment that has vibration controls. Most manufacturers of industrial equipment are becoming increasingly aware of the necessity to eliminate unnecessary vibrations. This is particularly true for manufacturers of heavy mobile equipment and hand-held vibrating tools. When comparing quality, also compare vibration controls.

Substitute non-vibratory methods or equipment. Determine if the job can be done by methods that do not depend on vibratory equipment.

Use equipment that has lower rotational speeds. If the task can be done equally as well by using lower rotational speeds, the frequency of the vibration source can be changed. This may eliminate or reduce the offending vibration.

Do not overload machines or equipment. Pushing the machine beyond its design capacity often intensifies vibration problems.

Select the proper size machine for the job. Vibration problems can often be prevented by selecting the right size equipment. This is especially true of fans and blowers.

Keep equipment and attachments well maintained. Improperly maintained equipment and attachments are often a source of unnecessary vibrations.

Isolate the vibration. Isolation means confining the vibration to the source, where it may be inherent to the task, and reducing the transfer of the vibration to structural members that tend to transmit or radiate the vibration. If a machine transmits vibration through its mountings, properly designed isolation mounts may be effective. It is important that these mounts be carefully designed for the particular machine, considering its weight and frequency of vibration. If this is not done, amplification of the offending vibration may occur. It may also be beneficial to change the center of gravity of the vibrating mass by mounting it first on a heavy base, and then attaching isolation mounts to the base.

Block transmission of the vibration. Blocking the transmission of a vibration from one object to another can be done by interposing a layer of damping material that allows the one object to move without imparting an appreciable

amount of vibratory motion to another object. This procedure is called interface damping. External coatings of mastic materials are sometimes used to dissipate the vibration energy. The thickness and the elasticity of the damping material and the nature of the structural element are factors in the resulting vibration energy loss. Sandwiching a thin layer of visco-elastic material between panels has proved to be an even more effective damping method than using a thick external coating.

Medical Control of Vibration Hazards

The medical profession has no techniques as yet for screening workers who may be unusually sensitive to vibration. However, it would be desirable in pre-placement examinations to tell the physician that the worker will be exposed to whole-body or segmental vibration, since workers having certain health conditions and physical abnormalities should not be exposed to extensive vibration. Workers who are extensively exposed to vibration should be examined at regular intervals. Workers who show any evidence of contracting a vibration syndrome should be immediately referred to a physician. He should have no further exposure to vibration until assured by the physician that he is fit for this kind of work. This is especially important if the "white finger" or "dead hand" symptom appears.

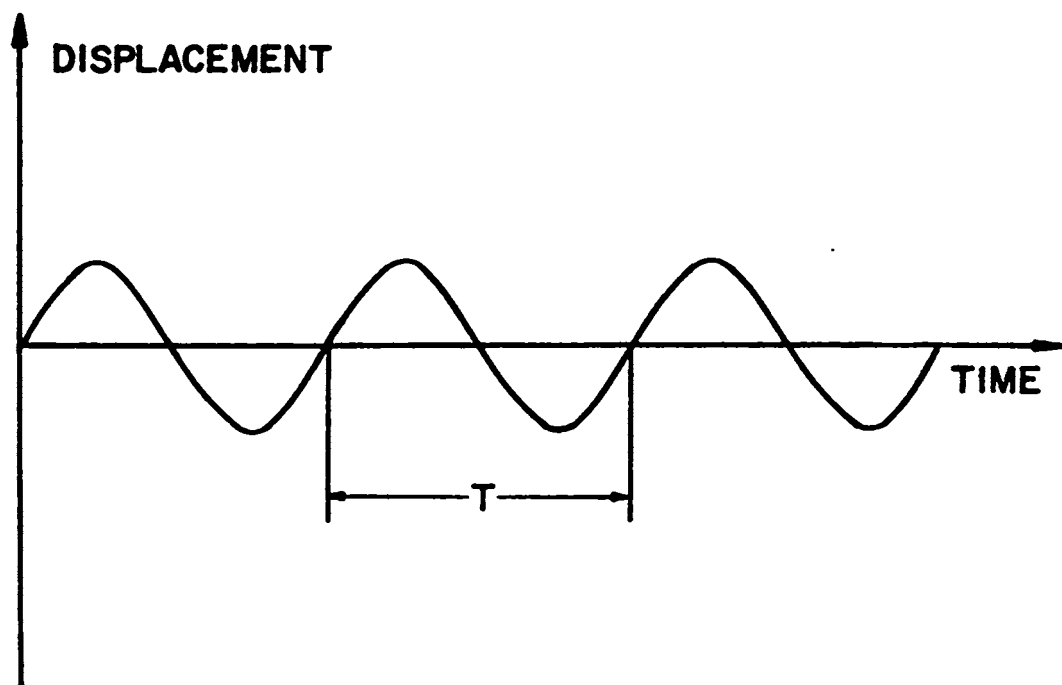
References

1. Soule, Robert D. "Vibration," The Industrial Environment--Its Evaluation and Control. Washington, D. C.: U.S. Government Printing Office, 1973, pp. 333-348. Chapter 26.
2. Wasserman, Donald E. and Badger, Donald W. "The NIOSH Plan for Developing Industrial Vibration Exposure Criteria," Journal of Safety Research, 4(4):146-154.

The Journal of Safety Research is published by the National Safety Council.

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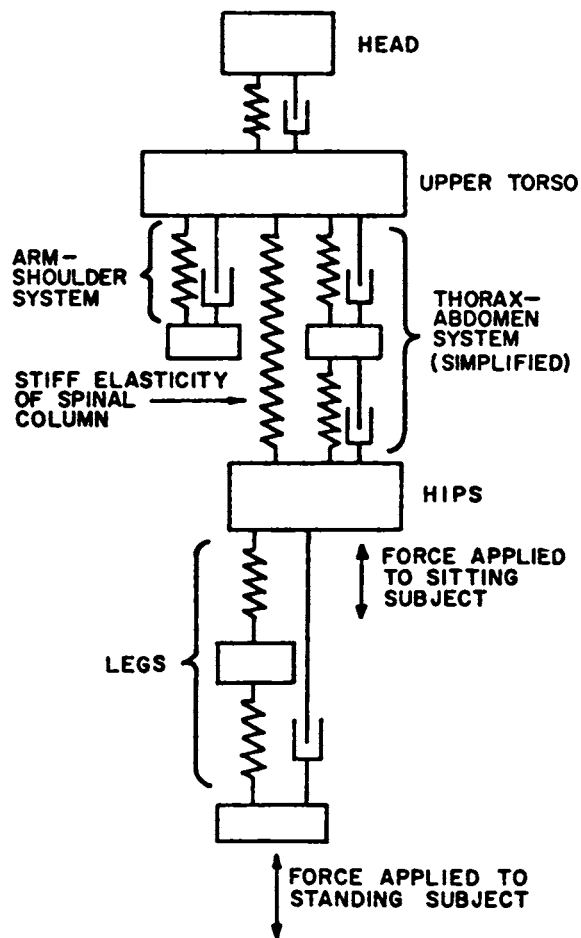


Representation of Pure Harmonic (Sinusoidal) Vibration.

Reprinted from "Mechanical Vibration and Shock Measurements" courtesy of Brüel & Kjaer Instruments, Cleveland, Ohio.

Source: NIOSH, The Industrial Environment—Its Evaluation & Control, 1973, p. 338.

Visual 43-1

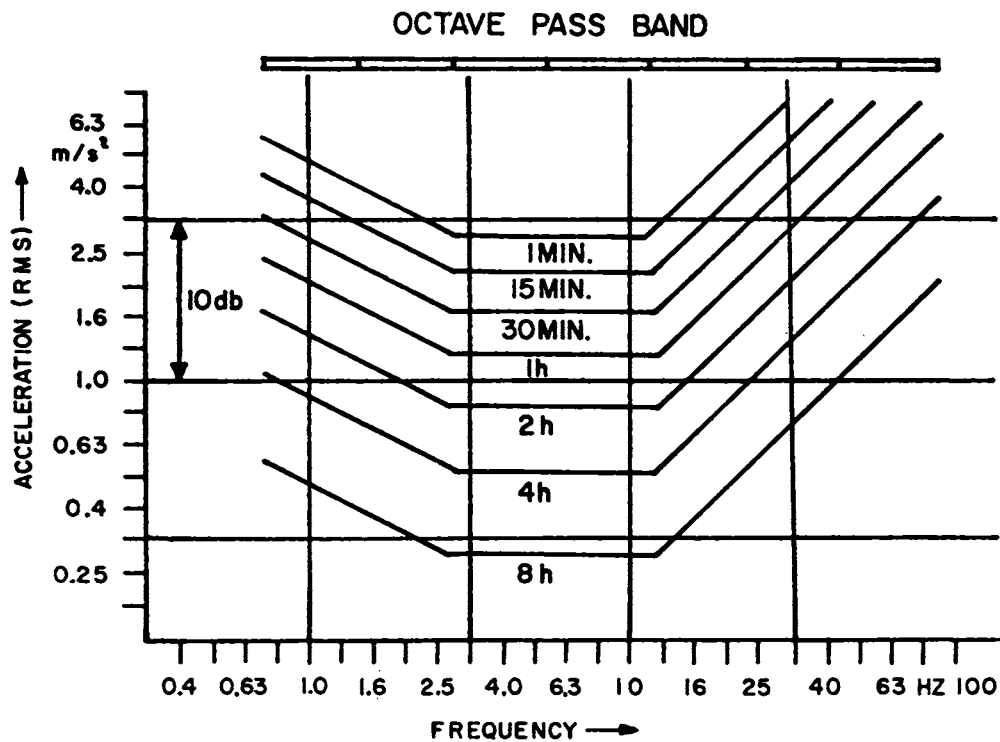


Simplified Mechanical System
Representing the Human Body Standing (or
Sitting) on a Vertically Vibrating Platform.¹

Reprinted from "Mechanical Vibration and Shock Measurements" courtesy of Brüel & Kjær Instruments, Cleveland, Ohio.

Source: NIOSH, The Industrial Environment—Its
Evaluation & Control, 1973, p. 333.

Visual 43-2



Vibration Exposure Criteria Curves. The vibration levels indicated by the curves in Figure 26-5 are given in terms of RMS acceleration levels which produce equal fatigue-decreased proficiency. Exceeding the exposure specified by the curves, in most situations, will cause noticeable fatigue and decreased job proficiency in most tasks. The degree of task interference depends on the subject and the complexity of the task.

Reprinted from "Mechanical Vibration and Shock Measurements" courtesy of Brüel & Kjaer Instruments, Cleveland, Ohio.

Source: NIOSH, The Industrial Environment—Its Evaluation & Control, 1973, p. 337.

Visual 43-3

Module 43. Reprint

The NIOSH Plan for Developing Industrial Vibration Exposure Criteria

Donald E. Wasserman and Donald W. Badger

Industrial vibration is identified as a potential safety and health hazard in various types of industries. The literature is reviewed, and a program for establishing vibration exposure criteria is discussed.

Probably even before the time of the ancient Phoenicians when man first took to the sea in his search for goods, the debilitating and often incapacitating effects of vibration were known. Beginning with the industrial revolution, man has been exposed to vibration in the industrial environment. Less than a century ago, a disorder similar to Raynaud's Disease, termed Raynaud's Syndrome,¹ was found to be common among men who worked with vibrating, hand-held tools.

The advent of high performance aircraft about 30 years ago marked the real beginning of studies on how vibration affects man's ability to perform work. It was soon apparent that the severe high-energy transient vibration or "buffeting" associated with aircraft operation had a profound effect upon air crew performance. Studies

of heavy equipment operators exposed to vibration showed early onset of fatigue and impairment of the operator's ability to perform effectively. More important, radiological studies suggested alterations in bone structure.

Thus, it appears that vibration above a certain level affects man's ability to work safely and effectively and may affect his health. The National Institute for Occupational Safety and Health (NIOSH) is particularly interested in the long-term physiological, psychological, and safety consequences of industrial vibration exposure; this paper will present its proposed plan.

Terminology. If the effect of a vibrating media surrounding man (i.e., noise) is excluded from consideration, then basically the worker is exposed to two types of vibration: (1) "whole body" vibrations or vibrations transmitted to the entire body through some supporting structure, such as a vehicle seat; (2) "segmental" vibrations, usually referring to vibrations applied locally to specific body parts, such as the limbs, by a vibrating chain saw, for example.

The human body is much like other solids on earth and has so-called "resonances" associated with it. It is possible to

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¹An incurable condition manifested by an abnormal degree of vascular spasm of the superficial blood vessels of the hands (64). The etiology of Raynaud's Syndrome is not well understood.

apply externally generated vibrations so that at certain frequencies the human body becomes more in "tune" (i.e., in resonance) with the vibrating sources than at other frequencies. Vibration is also characterized in terms of peak acceleration (in "g's"²), motion relative to the human body, frequency (in Hertz or Hz), and exposure time.

THE PROBLEM

Assuming that an individual works at the same vibration-susceptible job for 30 years, 50 weeks per year, at a 30-hour work week, he can receive up to 45,000 hours of possible vibration exposure!

Aerospace and tractor vibration research have shown that, for whole body vibration, the tolerance of a seated man is lowest in the frequencies from approximately 4 to 14 Hz, with whole body resonances occurring at 4 to 6 Hz and 10 to 14 Hz. In addition, various segments of the body respond individually to other vibration frequencies. Hence, it is possible to have the entire human body, or segments thereof, affected by mechanical vibration. Receptivity to the potentially harmful effects of the vibration is probably greatest when the human body is in resonance with mechanical vibration sources (35, 23, 24, 42, 89, 46).

Acceleration levels in some industrial situations are generally not much greater than 1 g, yet laboratory studies reveal that physiological and/or psychological changes are noticeable at these levels (85, 45, 37, 13, 83). In other industrial situations, levels up to several g's can be experienced by workers during "transient" whole-body vibration. Also, it should be recognized that vibration does not necessarily occur alone; it may occur in combination with other stresses such as noise and heat.

LITERATURE SEARCH

As part of the NIOSH vibration program, an annotated bibliography³ was prepared with emphasis on industrially related vibration studies. The bibliography was

²1 g = 32.2 ft/sec² = 9.81 m/sec²

compiled on a country-by-country basis to emphasize areas of national priority, since much of the research is government supported. An abbreviated version of the report is presented here to highlight the international effort in the industrial vibration area. The references cited herein are representative of the research taking place in a particular country.

Most previous studies of industrial vibration have been conducted in Europe. In Western Europe, Italian researchers have done field and laboratory vibration studies of shipyard workers, sheet metal workers, miners, and vibrating hand tool workers; these showed, in general, abnormal changes in the vascular, gastric, and muscular systems and in body chemistry (20, 12, 32, 22, 26, 48, 1, 66, 33, 97, 65, 68). One of these studies (32) showed occupationally induced bilateral arthrosis of the wrist of a worker using air chisels. In another study (60), approximately 42% of 110 shipyard workers using vibrating pneumatic tools had an angiospastic crisis in their fingers when exposed to a cold hand bath test. A study (33) of 60 sheet metal workers using stamping equipment revealed signs of lumbosacral arthrosis in 60% of the cases; and, in 66%, arteriolar disorders of varying severity were discovered.

In Germany, vibration studies of heavy equipment operators, fitters, boiler workers, stove dressers, and vehicular operators revealed, in general, abnormal vascular, gastric, neurological, enzyme, and visual acuity changes (25, 53, 54, 70, 73, 30, 50). Specifically, in one study (54), 42% of the 131 stove dressers investigated had injuries to bones and hands attributable to vibration in combination with other physical agents. In a study on animals, rats (50) were exposed to 5 Hz vibration, 20 mm amplitude, for 2 hours per day; a reduction was found in DPNH-diaphorase, adenosine triphosphatase, and alkali phosphatase as well as an increase in general activity. These findings were interpreted as stress reaction to vibration.

³Copies of the annotated bibliography containing a complete listing of references are available from the authors of this paper at NIOSH, 1014 Broadway, Cincinnati, Ohio 45202.

The French have studied miners, iron and steel workers, construction workers, rubber industry workers, and vehicle passengers and operators (5, 103, 80, 21, 98). Results of some of these studies indicate that for heavy equipment operators (5) some physiological reactions are dependent upon the constancy and acceleration levels of the vibration "buffeting" to which the operators are subjected. Another study (21), in the rubber industry, indicated that "stripping" of rubber products with compressed air tools produced vascular disorders of the fingers after three to four months of exposure in the eight workers studied. Muscular cramp and cavities in the bones of the fingers were observed.

In Great Britain, chain saw operators, iron foundry workers, and vehicle operators were studied (95, 38, 47). Results indicate that, for vehicle operators exposed to whole body vibration (47), task performance was adversely affected by vibration. When compared with nonvibration performance, these adverse effects were manifested in fine motor control and as vision impairments. Study of 142 chain saw operators (95) showed 44% had vibration-related syndromes. An increase in prevalence of the vibration syndrome (i.e. Raynaud's Phenomenon) with exposure time was also shown; for chain saw operators with eight years exposure, vibration syndrome occurred 73% more than among those with two years of exposure.

After studying their machine tool and textile industries (75, 44, 79), Swiss researchers recommended modifications or new engineering designs for cutting tool frames, balancing of revolving parts, and floor mounting schemes.

In Austria and Holland, major research emphasis has been on vehicle and tractor operators (59, 102, 40). The effects of vertical and horizontal vibration in motor vehicles are elucidated in one study (40), as well as the effects of various body positions of exposed individuals; it was concluded that back and abdominal disorders are more pronounced in sitting than in standing persons.

In Eastern Europe, there has been a considerable number of industrially relat-

ed vibration research studies. Most studies conducted in Czechoslovakia and Russia were on crane operators, miners, railroad workers, construction workers, shipyard workers, foundry workers, diamond cutters, machinery operators, forestry workers, saw operators, precast concrete workers, and others. Generally, the results show abnormal changes in the neurological system, lesions, skin changes, bone changes, headache, backache, gastric and liver changes, body chemical changes, Raynaud's syndrome, changes in visual field and in sense of balance (49, 57, 76, 84, 63, 100, 90, 72, 14, 94, 3, 88, 77, 69, 58). A study (49) of uranium ore workers in Czechoslovakia revealed gangrenous changes in two workers who had used vibrating pneumatic tools over a period of several years. Another study (63) of workers using vibrating saws and drilling machinery showed neurological changes in the peripheral neuron of the workers' upper extremities.

A Russian study (88) examined 222 mold makers, riveters, and fitters, all of whom had suffered from vibration disease for a period of two to three years. Improvement, found in only 7.2% of the cases, occurred mainly in persons who changed to other work as soon as the first symptoms of vibration disease became apparent. In 23% of those studied, deterioration of their condition continued, especially when vibration exposure was not ended. In another Russian study (77), biochemical examination of the blood of 404 vibration-exposed workers in the reinforced concrete industry showed hypoglycemia in 29.7%, hypocholesteremia in 43.6%, and a low ascorbic acid level in 92.4%. A third Russian study (58) of 100 workers suffering from vibration disease found changes in liver and stomach function that interfered with glycogenic and detoxication functions. These factors caused changes in the balance between the various protein fractions of the blood plasma, leading to gastric secretion disorders and changes in the digestive power of the gastric juice and mucous membrane of the stomach. Other studies in Eastern European countries such as Bulgaria, Hungary, Poland, Rumania, and

Yugoslavia have yielded results similar to the aforementioned Russian and Czech studies (2, 4, 67, 51, 55, 10, 48, 36, 31, 92).

In Scandinavia, Swedish and Finnish studies of tractor operators, chain saw operators, lumberjacks, miners, and some factory workers generally show the presence of Raynaud's syndrome and abnormal vascular and neurological changes (8, 82, 17, 16, 52, 96). For example, one Swedish study (82) of 1175 underground and surface workers in iron ore mines revealed that 50% of all the rock drillers employed in this work for more than one year suffered from symptoms of Raynaud's Syndrome. A study (8) of chain saw operators and brush-wood-cutting saw operators showed that the severity of vibration injury was dependent upon such parameters as the intensity of the vibrations at the saw handles, vibration exposure time, ambient temperature, and the nature of the work involved.

In Asia, the Japanese have studied construction operators and chain saw operators subjected to vibration (90, 87, 34). Similarly, the Australians studied chain saw operators and tractor drivers (39, 11, 101). One Australian study (11) reported 50% of 80 chain saw operators had symptoms of Raynaud's Syndrome; in another study (39), 20 of 22 timber fellers using chain saws were stricken with Raynaud's Syndrome.

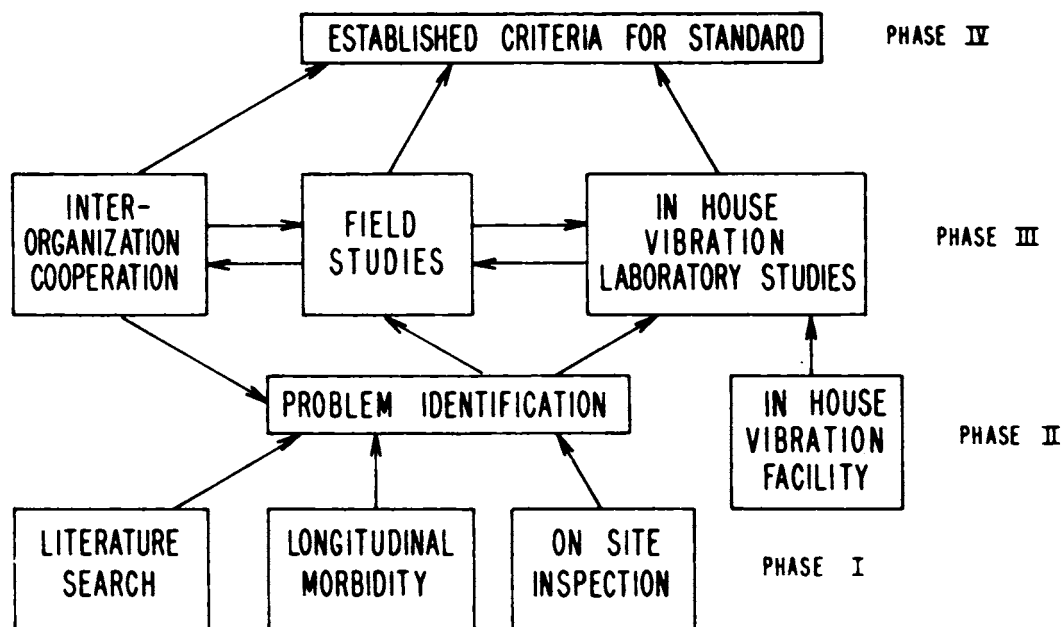
On the North American continent, the small amount of Canadian vibration research going on is concerned primarily with agricultural workers and the relationship of agricultural machinery to hearing loss and farm accidents (28), as well as vibration.

Very little industrially related vibration research has taken place in the United States, except for a few areas of product improvement. This has been primarily in improved seats for farm tractors, heavy equipment, and trucks, and lately in the area of improved construction pavement breakers (86, 74, 61, 89, 46). Most of the human vibration studies have been aerospace and military oriented and are concerned with impact, mechanical shock, and vibration in military situations; subjects are usually young and physically fit,

often pilots. From the industrial vibration point of view, the general working population is not necessarily as physically fit as pilots, and certainly the age range of the worker is wider, including individuals from 16 to 65 years of age. The industrial worker also can be female as well as male. In addition, most of these military studies represent "short-term" vibration exposure, which does *not* necessarily coincide with the worker's vibration exposure to low frequency, varying amplitudes over long time periods. The military studies may thus have limited application in the industrial situation.

Many psychomotor and perceptual studies have been carried out, but again mostly under typical military vibration situations as opposed to the workplace setting. Significantly, these psychomotor studies have demonstrated that manual tracking capabilities, visual acuity, and other motor functions can be seriously impaired by low frequency vibration exposure (35, 23, 24, 85, 45, 37, 13, 83, 43, 81, 29). In a review performance of individuals subjected to vibration, Grether (37) states between 10-25 Hz can cause severe impairment of visual acuity; at 5 Hz or less, manual tracking is severely affected. Tests of reaction time, monitoring, and pattern recognition also appear to reflect adverse effects due to vibration. Thus it appears that vibration could well have profound "safety" implications for those exposed. Certainly additional work is necessary in this area, and plans are to include related studies in the NIOSH vibration program.

Standards criteria. Individual standards criteria and corrective methods for coping with industrial vibration have been quite varied, even within a given country. Some approaches have been isolation and correction of vibration at the sources, new corrective designs for tools and tractors, and protection for the worker in the workplace (27, 56, 71, 18, 15, 78). Probably the most encompassing program is that of the Russians, where strict standards are in effect for workers and for vibrating machinery, new tool and seat designs are in use, new antivibration protective clothing is either proposed or in effect, and



Proposed NIOSH Vibration Program

a regular maintenance program on vibrating machinery is required (19, 6, 9, 91, 93, 41). In the United States, presently, there are no tolerance standards for the workers subjected to industrial vibration, although the American Standards Association has published recommendations for specific vibrating *machine* performance (7). NIOSH plans to help fill this void.

There have been a few attempts to obtain international cooperation in establishing vibration standards criteria; for example, the Organization for Economic Cooperation and Development has proposed a Tractor Testing Code which tentatively includes seat testing. Perhaps the single most encompassing vibration exposure tolerance guide to date is that of the International Standards Organization. There is a proposed ISO guide for "whole-body vibration" (ISO/TC108/WG7, same as MIL-STD-1472A) and a tentative ISO Czechoslovakian proposed

guide for hand-arm-system vibration is in preparation.

The ISO whole-body guide effort has been led by Von Gierke and coworkers of the Aerospace Medical Research Labs at Wright-Patterson Air Force Base, working with representatives of Belgium, Czechoslovakia, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom, U. S. S. R., and Yugoslavia.

The whole-body vibration tolerance guide may have only restricted applicability in the industrial work situation, since some of the studies used in formulating the guide were short-term exposures, usually of a military nature with optimunly fit military personnel as subjects. Additional objections stem from reports that this guide is not completely encompassing when more than one vibration frequency is impinging upon the subject at the same time (56). One of our initial efforts at NIOSH will be

to ascertain the applicability of this proposed ISO guide as it relates to the American industrial situation.

NIOSH VIBRATION PROGRAM

Under PL 91-596, NIOSH has responsibility for developing safety and health standards "criteria" for the nation's working population. The proposed NIOSH vibration program is part of this effort and is outlined in the accompanying figure. The program consists of four phases. Phase I is concerned with identification and preliminary characterization of the number and types of exposed workers and the nature of their work environment. Phase II is concerned with the establishment of a modest vibration facility at NIOSH and the design of preliminary relevant experiments upon which to base meaningful field studies. Phase III is concerned with establishing on-site vibration field studies and coordinating these field studies with relevant controlled laboratory studies. The evaluation of the proposed ISO guide as it relates to the worker will be carried out in this phase. Phase IV is concerned with establishing "criteria" for vibration exposure standards, based upon information obtained in Phases I, II, and III. Throughout all Phases, NIOSH vibration activities will be coordinated with other recognized vibration laboratories in universities, industry, other government agencies, and various military medical research laboratories.

It should be pointed out that Phase I is highly dependent upon the cooperation of industry, labor, and others with NIOSH in helping to identify the exposed workers.

SUMMARY

Industrial vibration appears to be a potential safety and health hazard to workers in various work situations. An extensive vibration literature search has revealed, mostly from foreign studies, the affected industries, the approximate magnitude of the physical parameters

involved, a view of the severity of industrial vibration as a potential safety and health hazard, and the extent of corrective emphasis being implemented on an international scale. A NIOSH program for establishing vibration exposure "criteria" is planned; it will include identification and characterization of exposed workers and industries in the United States, implementation of relevant studies to ascertain the extent of the hazard in the United States, and determination of criteria for standards to prevent harm from industrial vibration.

REFERENCES

1. Alberti, N. et al. Raynaud's syndrome caused by vibration trauma. *Chir. Pat. Spec.*, 1968, Suppl. 5, 123. (in Italian)
2. Alejeva, T. S. The gastric function in vibration disease. *Works of the Scientific Institute of Labor-Protection and Occupational Diseases*, 1967, 15, 41-45. (in Bulgarian)
3. Andreeva-Galanina, E. C. *Occupational health and the use of power tools*. Leningrad, U. S. S. R.: Izdatelstvo Medicina, 1967. (in Russian)
4. Angelova, M. A study of vibrations and their influence on the bodies of miners working with pneumatic tools. *Nauchni trezova na Naucnoizslodovatel'skija institut po ohrana na Tr. Prof. Zabol.*, 1962, 9, 29-35. (in Bulgarian)
5. Anonymous. Report of Occupational Physiology Centre of the French National Safety Institute, Drivers of heavy earth moving equipment. *Travail et Securite*, 1963, 5, 207-212. (in French)
6. Anonymous. Safety techniques. *Masinstroital*, 1967, 7, 26-35. (in Russian)
7. Anonymous. *Specifying the performance of vibrating machines*. Report of Group S2-W-31. New York: American Standards Association, 1962.
8. Axelsson, S. A. Analysis of vibrations produced by power saws. *Stidia Forestalia Succica*, No. 59, Stockholm, 1968. (in Swedish)
9. Babec, K. K. et al. Our experience in suppressing vibration. *BCZ opashosf Truda Preomy-slenesti*, 1964, 8 (11), 25-26. (in Russian)
10. Barizynski, M. et al. Changes in the bone system in drillers. *Przegl. Lek.*, 1968, 24, 858-859. (in Polish)
11. Barnes, R. et al. Vibration disease. *Medical Journal of Australia*, 1969, 1, 901-905.
12. Barsi, C. et al. Osteo-arthritis caused by vibrations: Radiological examination of 84 miners using pneumatic percussion drills. *Rassegna di Medicina industriale e di*

- igiene del lavoro, 1963, 32 (6), 592-599. (in Italian)
13. Beaupreurt, J. E. et al. *Ten years of human vibration research*. Report No. D3-7888. Wichita, Kansas: The Boeing Company, 1969.
 14. Beider, S. I. Results of long-term dispensary observation of foundry cleaners. *Gig. Tr. Prof. Zabol.*, 1971, 15, 41-43. (in Russian)
 15. Berthoz, A. et al. *Development and field testing of a criteria for low-frequency vibration tolerance*. Report No. 14. Paris, France: Conservatoire National des arts et metiers, laboratoire de physiologie du travail et d'ergonomie, 1967-1970. (in French)
 16. Bjerker, N. et al. Changes in the vibratory sensation threshold after exposure to powerful vibration. *Work-Environment-Health*, 1970, 7 (1), 3-7.
 17. Bjerninger, S. Vibrations of tractor drivers. Mechanical engineering series, No. 23. *Acta Polytechnica Scandinavica*, Stockholm, 1966. (in Swedish)
 18. Bulgarian Ministry of Public Health (Inspector General of Health). Provisional order regarding the prevention of vibration-induced lesions in work producing local vibration, No. 58, 3-4, July 1969. (in Bulgarian)
 19. Butkovskaja, Z. M. et al. Measures to prevent vibration disease in drilling and drift driving work. *Gornij Zurnal*, 1966, 9, 73-76. (in Russian)
 20. Casciu, G. et al. The frequency of radiological changes in the osteo-articular apparatus in Sardinian miners, especially in workers using pneumatic hammers; Note 1-the skeleton of the hands and wrists. *Folia Medica*, 1968, 51 (5), 370-384; Note 2- the elbow joint. *Folia Medica*, 1968, 51 (5), 385-395. (in Italian)
 21. Champeix, J. et al. Angioneurotic disorders of the fingers in rubber tube strippers-radiological changes. *Proceedings of the 10th Conference on Occupational Health*, 1969, 703-708.
 22. Chierchi, P. et al. Study on the vibrations produced by pneumatic hammers. *Securitas*, 1968, 53 (7), 65-90. (in Italian)
 23. Coermann, R. R. Mechanical vibrations. *Proceedings of a Symposium of Ergonomics and Physical Environmental Factors*, Sept. 16-21, 1968. Geneva, Switzerland: the International Labour Office.
 24. Coermann, R. R. et al. The passive dynamic mechanical properties of the human thorax-abdomen system and of the whole body system. *Aerospace Medicine*, 1960, 31, 443-445.
 25. Coermann, R. R. Physiological problems of vibration in motor vehicles. *Zentralblatt für Verkehrs-Medizin*, 1965, 11 (3), 150-166. (in German)
 26. Cossu, F. et al. Cervical spondylosis in workers using vibrating instruments. *Nunt. Radiol.*, 1967, 33, 209-212. (in Italian)
 27. Czechoslovakian Ministry of Health. Ordinance concerning the protection of health against the harmful effects of mechanical vibrations, 1967. (in Czechoslovakian)
 28. Dennis, C. Agricultural health investigation into health effects in agriculture with special reference to the relationship of agricultural machinery with hearing loss, vibration effects and farm accidents (on going project), Occupational Health Branch, Prov. Dept. of Health, Regina, Canada.
 29. Division of Defense Research and Engineering. *Proceedings of the 33rd Symposium on Shock, Vibration, and Associated Environments*, Washington, D. C., 1963.
 30. Dupuis, H. The behavior of the stomach under the influence of sinusoidal and stochastic vibrations. *Internationale Zeitschrift für Angewandte Physiologie Einschliesslich Arbeitsphysiologie*, 1966, 22 (2), 149-166. (in German)
 31. Eskenasy, J. Neuropathy caused by vibrations. *Stud. Cercet. Neurol.*, 1970, 15, 211-229. (in Rumanian)
 32. Farina, G. Osteo-arthritis of the wrist in a furniture maker, due to vibration. *Medicina del lavoro*, 1968, 59 (8-9), 510-515. (in Italian)
 33. Fusco, M. et al. Effect of vibration on the peripheral vascular system and on the vertebral column. *Folia Medica*, 1963, 46 (5), 361-372. (in Italian)
 34. Futatsuku, M. Studies on vibration hazards due to chain saws. *J. Kumamoto Med. Soc.*, 1969, 43, 467-524. (in Japanese)
 35. Goldman, D. E., & Von Gierke, H. E. The effects of shock and vibration on man. *Report of American Standards Association and Naval Medical Research Institute*, Lecture and Review Series No. 60-3, Bethesda, Maryland, 1960.
 36. Gorska, D. The emotional balance of workers using pneumatic tools. *Biuletyn Instytutu Medycyny Moiskig W Gdansk*, 1969, 20 (3-4), 203-215. (in Polish)
 37. Grether, W. F. Vibration and human performance. *Human Factors*, 1971, 13 (3), 203-216.
 38. Grieco, A. et al. The ergonomic evaluation of two jobs in an iron foundry. *Ergonomics*, 1968, 11 (5), 467-472.
 39. Grounds, M. D. Raynaud's phenomenon in users of chain saws. *Medical Journal of Australia*, 1964, 1, 270-272.
 40. Guinee, F. Problems of vibration in motor vehicles. *Tijdschrift Voor Sociale Geneeskunde*, 1964, 42 (14), 490-496. (in Dutch)
 41. Guk, A. P. Regular maintenance of drill hammers and anti-vibration mountings to prevent vibration disease. *Bezopasnost Truda-Promyslennosti*, 1970, 14 (2), 16-17. (in Russian)
 42. Haack, M. Human tolerance to vibrations occurring in tractors and agricultural machinery. *Agricultural Engineering*, 1956, 253-257.
 43. Hercules, W. L. *Shock and vibration environ-*

- ment. Armed Services Technical Information Agency Report No. 411, 277-392, 1962.
44. Horn, H. P. et al. Measuring the vibration on sulzer looms. *Technische Rundschau Sulzer*, 1963, 45 (1), 27-30. (in Swiss)
45. Hornick, R. J. et al. *The effect of low frequency, high amplitude, whole body longitudinal transverse vibration upon human performances*. Milwaukee, Wisconsin: Bostrom Research Labs, 1961.
46. Huang, B. K., & Suggs, C. W. Vibration studies of tractor drivers. *Trans. Amer. Soc. Agric. Engres.*, 1967, 10 (4), 476-482.
47. Huddleston, H. F. Vertical sinusoidal vibration as a psychological stress. *Nature* (London), 1966, 211 (5046), 324-325.
48. Jakubowskij, R. General characteristics of vibrations at various workplaces in agriculture and forestry. *Medycyna Wiejska*, 1969, 4 (1), 47-54. (in Polish)
49. Jesensky, J. et al. Occupational health problems affecting forestry workers exposed to vibrations in the course of felling and cutting timber. *Prakticky Lekaf*, 1969, 49 (4), 148-150. (in Czechoslovakian)
50. Jonek, J. et al. Histochemical examination of the reaction of certain enzymes in the suprarenals to whole body vibration. *Internationales Archiv für Gewerbepathologie und Gewerbehygiene*, 1964, 20 (5), 411-418. (in German)
51. Kakosy, T. et al. Occupational vasoneurosis in medical instrument grinders. *Orv. Hetil.*, 1969, 110, 2159-2163. (in Hungarian)
52. Kanka, A. Vibration measurement of chain saws. *Work-Environment-Health*, 1970, 7 (1), 1-2.
53. Kellringer, R. Effects of vibration on drivers of trackless earth moving equipment. *Industrie der Steine und Erden*, 1966, 76 (6), 210-212. (in German)
54. Kouba, R. Injury due to use of pneumatic tools in stone dressing. *Zentralblatt für Arbeitsmedizin und Arbeitsschutz*, 1967, 17 (3), 67-73. (in German)
55. Kozminska, A. et al. Detection of lesions in small blood vessels of the hands in patients with vibratory disease, preliminary report. *Pol. Med. Journal*, 1969, 8, 227-229. (in Polish)
56. Kryze, B. The Czechoslovakian hygiene regulation on protection against vibration. *Work-Environment-Health*, 1970, 7 (1), 51-56.
57. Kuzelova, M. et al. Contribution to the differential diagnosis of vascular diseases in work with pneumatic tools. *Pracovní Lékar*, 1964, 16 (7), 321-328. (in Czechoslovakian)
58. Labadze, P. F. The functional state of the stomach and liver in vibration disease. *Gig. Tr. Prof. Zabol.*, 1970, 14, 30-32. (in Russian)
59. Lasser, M. The prevention of occupational accidents and diseases by means of technical improvement to tractors. *Proceedings of the International Symposium on Accidents and Occupational Diseases Attributable to Mechanized Forestry Work*, 1968, 69-84.
60. Lerza, P. et al. Vascular trauma due to vibrating tools in ship yards. *Lavoro Medicina*, 1961, 15 (4), 69-75. (in Italian)
61. Lewis, D. *The effect of noise and vibration on certain psychomotor responses*. Civil Aeronautics Admin. Div. of Research Report No. 8, Washington, D.C., 1943, (PB 50288).
62. Louda, L. Perception and effects of the mixture of two vertical sinusoidal vibrations on sitting man. *Work-Environment-Health*, 1970, 7 (1), 62-66.
63. Lukas, E. Lesion of the peripheral nervous system due to vibration. *Work-Environment-Health*, 1970, 7 (1), 67-79.
64. Lyght, C. E. (Ed.) *Merck Manual*. Rahway, N. J.: Merck & Company, 1956.
65. Maachiani, P. et al. Rheographic evaluation of peripheral vascular damage in workers using vibrating instruments. *Folia Medica*, 1968, 51, 103-109. (in Italian)
66. Maggio, M. Predisposition to occupational disease induced by vibrating tools. *Securitas*, 1965, 50 (4), 71-100. (in Italian)
67. Magos, L. et al. Raynaud's phenomenon. The situation in the hungarian iron, steel, and engineering industry. *Archives of Environmental Health*, 1963, 7 (3), 341-345.
68. Magri, R. et al. Occupational myelopathy, amyotrophic lateral sclerosis type, in pneumatic drill operators. *Acta Neurol.*, 1969, 24, 29-37. (in Italian)
69. Manchak, L. V. Changes in the cardiovascular system in vibration disease patients. *Vrach. Delo.*, 1968, 1, 97-99. (in Russian)
70. Muller, H. Changes in the bones of boiler makers and fitters. *Der Arztliche Dienst*, 1970, 31 (4), 41-44. (in German)
71. National Swedish Testing Institute for Agricultural Machinery. *Testing and assessment of seats for agricultural tractors*. Report 1930. Uppsala, Sweden: Author.
72. Otavaga, I. S. et al. Changes of the nervous and skeletal system in diamondcutters with vibration disease. *Vrach. Delo.*, 1969, 7, 107-110. (in Russian)
73. Pauzke, K. J. Mechanical vibrations on hand-guided vibrating tools used in construction, and their effects on man. *Ergonomische Berichte*, No. 3, Berlin, 1970. (in German)
74. Paulson, E. C. Tractor drivers complaints. *Minnesota Medicine*, 1946, 32, 386-387.
75. Poget, R. Vibration in machine tools, its effect on production and means of reducing it. *Industrial Organization*, 1964, 33 (9), 399-416. (in Swiss)
76. Pulchart, M. et al. Hazards associated with the vibration from electrical tamping machines. *Zeleznični Zdravotníci*, 1969, 11 (5-6), 238-242. (in Czechoslovakian)
77. Puskina, N. M. Biochemical blood values in workers exposed to vibrations. *Gig. Tr. Prof. Zabol.*, 1961, 2, 29-32. (in Russian)
78. Puzyna, C. Z. Methods of evaluating and reducing the harmful effects of vibration on

- man. *Prace Centralnego Instytutu Ochrony Pracy*, 1967, 17 (52), 17-43. (in Polish)
79. Reiss, F. Raynaud-like phenomenon produced by a sewing machine. *Dermatologica*, 1969, 139, 154-157. (in Swiss)
 80. Roche, L. et al. Upper limb damage in pneumatic drill workers. *Arch. Maladies Profess.*, 1961, 22, 57. (in French)
 81. Roth, E. M. et al. *Compendium of human responses to the aerospace environment vibration*, NASA CR-1205 (2). United States: NASA, 8-1-112, 1968.
 82. St. Clair-Renaud, K. G. Vibration injuries in the fingers of miners in northern Sweden. *Internationaler Bergbaukongress*, 1964. (in Swedish)
 83. Schaefer, V. M. et al. *Some behavioral and physiological studies in vibration*. Report No. 389-1959, Aerospace Medical Research Labs.
 84. Sekyrova, M. Causal analysis of turnover, morbidity, and accident rate in construction workers operating vibrating machinery. *Pracovní Lékar*, 1966, 18 (2), 60-64. (in Czechoslovakian)
 85. Shoenberger, R. W. *Human performance as a function of direction and frequency of whole-body vibration*. Report No. AMRL-TR-70-7, Aerospace Medical Research Labs, 1970.
 86. Smith, K.M. Effects of vibrating tools on workers. *Proceedings of the 14th Annual Chemical Engineers Conference*. (Bulletin 4). Pittsburgh, Pa.: Industrial Hygiene Foundation of Mellon Institute, 1949.
 87. Sobue, I. Disturbances due to the vibration of industrial machinery. *Naika*, 1968, 21, 907-910. (in Japanese)
 88. Sokolik, L. J. et al. The dynamics of bone changes in vibration disease and relationship to the type of work performed. *Gig. Tr. Prof. Zaboli.*, 1970, 14, 28-30. (in Russian)
 89. Suggs, C. W., & Huang, B. K. Tractor cab suspension design and scale model simulation. *Trans. Amer. Soc. Agric. Engrs.*, 1969, 12 (3), 283-289.
 90. Sugiura, Y. et al. Diseases among vibration machine operators-muscle strength of the index finger. *Orthopedic Surgery*, 1969, 20, 1478-1479.
 91. Suponitskii, M.I.A. et al. Problems of industrial hygiene in the production of high-grade commercial glass. *Gig. Tr. Prof. Zaboli.*, 1970, 14, 37-40. (in Russian)
 92. Susnik, J. Raynaud's phenomenon in workers forming steel springs. *Arhiv za Higijenu Rada i Toksikologiju*, 1963, 14 (1), 1-6 (in Yugoslavian)
 93. Tartakovskaja, L.J.A. et al. The effectiveness of some methods of vibration protection in work with portable power tools. *Gig. Sanit.*, 1966, 31 (9), 105-107. (in Russian)
 94. Tartkovskaja, L. J. A. et al. Effects on the body of the vibration from high-speed compressed-air tools. *Gig. Tr. Prof. Zaboli.*, 1969, 13, 16-19. (in Russian)
 95. Taylor, W. et al. Vibration syndrome in forestry commission chain saw operators. *Brit. J. Ind. Med.*, 1971, 28, 83-89.
 96. Tiilila, M. A preliminary study of the white finger syndrome in lumberjacks using thermographic and other diagnostic tests. *Work-Environment-Health*, 1970, 7 (1), 85-87.
 97. Timparo, V. et al. Incidence of disease caused by vibrating instruments among workers of the drilling type in sulfur mines. *Folia Medica*, 1967, 50, 677-689. (in Italian)
 98. Tolot, F. et al. Elbow arthropathy due to the use of pneumatic drills (Medico-Legal Repercussions). *Arch. Mal. Prof.*, 1968, 27, 727-729. (in French)
 99. Vdovin, M.I. et al. Experience with protection of workplaces against vibrations. *Bezopasnost Truda Promyshlennosti*, 1969, 13 (4), 44-45. (in Russian)
 100. Volkov, A.M. The development and results of the study of noise and vibration in railroad transportation. *Gig. Tr. Prof. Zaboli.*, 1967, 11, 58-60. (in Russian)
 101. Wilson, H. G., et al. Vibration disease—a report of an early Australian case with discussion. *Medical Journal of Australia*, 1970, 2, 417.
 102. Wink, A. Raynaud's phenomenon to metal grinders. *Tijdschrift Voor Sociale Geneeskunde*, 1959, 37 (21-22), 721-725. (in Dutch)
 103. Wisner, A. et al. *Evaluation of vibrations at various workplaces in the iron and steel industry*. Report No. 11. Commission des Communautés Européennes, Laboratoire de physiologie du travail et d'ergonomie du conservatoire national des arts et metiers, 1969. (in French)

MODULE 44. MORE ABOUT INSTRUMENTATION

MORE ABOUT INSTRUMENTATION

Instruments that measure exposures to chemical and physical agents are essential to an industrial hygiene investigation. Equally as important as having the proper instruments is the ability to use them properly. An industrial hygiene laboratory may have a wide variety of instruments capable of evaluating practically any airborne chemical contaminant and physical agent. However, most industries have a limited number of exposures, so their instruments need relate only to their problem areas.

Instruments fall into four broad classes, based on the physical properties of the agent to be sampled.

- Gas and Vapor Samplers
- Dust and Fume Samplers
- Mists and Fog Samplers
- Physical Agent Samplers

Subclassifications can be made for colorimetric indicators, direct reading instruments, adsorbers, absorbers, impactors, and electrical precipitators.

This text will concentrate on instrument selection, rather than instrument theory. The reader interested in further information should refer to the Air Sampling Instruments Manual, published by the American Conference of Governmental Industrial Hygienists.

The fact that an instrument is used does not assure reliable results. Some of the factors which contribute to reliability are:

- Correctly designed sampling procedures
- Proper use of the instrument
- Correct calibration of the air mover
- Proper handling of the collected sample
- Avoidance of contamination
- Use of the proper analytical methods

An establishment without its own chemical analytical capability should use direct reading instruments as much as possible, even though their accuracy is usually not so great as sampling that requires analytical procedures. However, even the use of direct reading instruments requires minimum laboratory facilities to care for, calibrate, and store instruments. Many contaminants, including those with very low permissible concentrations, cannot be determined by direct reading instruments. In such cases, samples may be sent to a certified commercial laboratory for analysis.

Standard Methods for Sampling

Insofar as possible, an establishment should use the recommended NIOSH or OSHA sampling method. A summary of these methods for selected contaminants is presented in Visual 44-1. Further information can be found in the appropriate NIOSH Criteria Document or OSHA Sampling Data Sheets.

NIOSH certifies sampling instruments by type and manufacturer. Although the approval program currently does not include all instruments, it is wise to refer to this list before purchasing any new instruments. The latest list may be obtained from NIOSH, Office of Technical Publications, Post Office Building, Cincinnati, Ohio 45202.

Instrument Terminology

In selecting instruments, one normally turns to catalogs from manufacturers. Familiarity with the "jargon" of the trade is essential in interpreting the manufacturers' descriptions. Visual 44-2 contains a list of terms you will encounter. These are defined in the Glossary of the ACGIH publication on Air Sampling Instruments.

Manufacturers

A partial list of manufacturers of industrial hygiene equipment and instruments is included as a starter. These are keyed by number to instruments covered in the next section. Some are specialized companies which manufacture or distribute a limited number of products. In addition to this list, there are other manufacturers who produce specialized equipment or a particular instrument for a specialized purpose.

1. Bacharach Industrial Instrument Co., 200 N. Braddock Ave., Pittsburgh, Pa. 15208.
2. Beckman Instruments, 2500 Harbor Blvd., Fullerton, Ca. 92634.
3. Bendix-Representative, National Environmental Instruments, P.O. Box 590, Warwick, R.I. 02888.
4. Brinkman Instruments, Catiague Road, Westbury, N.Y. 11590.
5. Central Scientific Co., 2600 So. Kastner Ave., Chicago, Ill. 60623.
6. C. F. Cassella, Inc., London. See 13.
7. Gelman Instrument Co., 600 So. Wagner Rd., Ann Arbor, Michigan.
8. Mine Safety Appliance Company, 201 N. Braddock Ave., Pittsburgh, Pa. 15208.
9. ICN Instruments Division, 630 20th St., Oakland, Ca. 94612.

10. Research Appliance Co., Route 8 at Craighead Rd., Allison Park, Pa. 15101.
11. Scott Aviation Co., Representative--National Mine Service Co., 220 Koppers Building, Pittsburgh, Pa. 15219.
12. SKC Inc., P.O. Box 8538, Pittsburgh, Pa. 15220.
13. The Staplex Co., 777 5th Ave., Brooklyn, N.Y. 11232.
14. Sunshine Scientific Instrument Co., 1810 Grant Ave., Philadelphia, Pa. 19115.
15. U. S. Safety Service Co., 1535 Walnut St., Kansas City, Mo. 64108.
16. Willson Products, P.O. Box 622, Reading, Pa. 19603.
17. UNICO Environmental Instruments, P.O. Box 590, Falls River, Ma. 02722.

Instrument Descriptions

This section contains brief descriptions of some instruments normally required to evaluate air contaminants. It does not include special-purpose instruments or those needed for rarely-encountered contaminants. For the physical hazards, it includes only instruments for noise and heat evaluations. Ionizing and non-ionizing radiations require unusual skills to operate the instruments and evaluate the results. Establishments with no in-house expertise in radiation control should rely on consultants or official agencies to make such evaluations.

Air Sampling Pumps (Personal Samplers)

The air sampling pump is essential for sampling airborne chemical agents. This instrument should meet all sampling requirements for most industrial establishments. The design of the pump may vary among manufacturers, but all must meet performance requirements established by NIOSH.

Light-weight samplers generally use a diaphragm pump as the air mover. However, one model uses a piston pump. Flow control is obtained through a combination sample valve and a bypass valve, equipped with a pulsation damper in order to produce uniform suction. These pumps can be used to power various sampling devices such as filter media, micro or midget impingers, bubblers, two-stage respirable mass samplers, or open-end filter samplers. All are powered by rechargeable batteries and can operate from 7-8 hours on a full charge. Recharging requires about 16 hours. Pumps offered by most manufacturers have a sampling rate of 0.5-3.0 lpm. However, one manufacturer offers one model with a sampling rate of 0-2 CFM and another with a flow rate of 0-10 CFM. All instruments have a built-in rotometer for determining air flow.

Each manufacturer will furnish a calibration chart for each instrument, but this calibration is good for only one set of conditions. The instrument must be calibrated for the collection and filter media being used. Each type of filter has a different resistance.

More about the calibration of personal sampling pumps is included here in the reprinted material and in Section H of the ACGIH manual.

For information about other air movers, see Section K in the ACGIH reference.

Manufacturers: 3,7,8,9,11,14,15.

Gas and Vapor Samplers

Colorimetric Indicator Tubes

These specially treated tubes are designed to indicate the concentration of gas or vapors. A hand-operated air mover draws a definite volume of air through the tube containing a specially treated material, such as silica gel. The material reacts with the gas or vapor being sampled and produces a stain on the absorbent. The length of the stain is a function of the concentration of the contaminant. Each contaminant requires a specially treated tube bearing a standardized number. Each tube set has a calibrated scale which indicates the concentration based on the length of the stain and the volume of air drawn through the tube. The air mover may be either a hand-operated bellows pump or a hand-operated displacement pump. Displacement devices do not need calibration, but they should be tested frequently for possible leaks. Each manufacturer furnishes specific instructions and these should be followed.

Currently, over 100 gases and vapors can be determined with colorimetric tubes. Their primary advantage is instantaneous results with $\pm 25\%$ accuracy. They are especially useful in identifying areas or operations which may later require more accurate sampling. In terms of compliance determinations, their disadvantages include the following:

1. Represent an instantaneous sample. May be overcome in part by taking a large number of samples during the exposure period.
2. Accuracy is in the range of $\pm 25\%$.
3. Presence of other contaminants may invalidate the results. Each tube set identifies the known interfering substances.
4. Limited shelf life. Can be extended by storing in a refrigerator.

Despite these disadvantages, colorimetric indicator tubes are an essential item for establishments with exposures to gases and vapors. A full discussion can be found in Section S of Air Sampling Instruments. NIOSH also certifies colorimetric indicator tubes. See the latest issue of NIOSH Certified Personal Protective Equipment.

Manufacturers 1,3,5,8,11,14.

Charcoal Tubes

An approved method for determining organic vapor concentrations for a number of substances is the use of charcoal tubes. Sealed charcoal tubes may be purchased from the manufacturer. NIOSH has a list of approved tubes. In sampling for organic vapor, a definite volume of air is drawn through the tube with either the personal sampler pump or a pump offered by some manufacturers especially for this purpose. The sample may be collected over the entire shift or at intervals. If the concentration is at or near the permissible exposure, an 8-hour sample can usually be taken without exceeding the limits of the tube. Since a volume as little as 10 liters can be sampled with acceptable results, the tubes can be used to construct an exposure profile.

After the sample has been taken, the tube is sealed with rubber caps and sent to the laboratory for analysis by chromatographic methods. The charcoal tube method is the only acceptable OSHA method for the following organic vapors:

Benzene	Styrene
Carbon tetrachloride	Tetrachloroethylene
Chloroform	Toluene
Dioxane	1,1,2 Trichloroethane
Ethylene dichloride	Trichloroethylene
Methyl chloroform	Xylene
Methyl ethyl ketone (2,butanone)	

NIOSH has a research program to determine other vapors that can be accurately determined with charcoal tubes.

Manufacturers: NIOSH will supply a list.

Bubblers or Impinger Tubes (Gas Washers)

Gas washing techniques have been used extensively in the past for sampling gases and vapors. Charcoal tubes have generally replaced gas washers, especially for organic vapors. However, gas washing is a preferred technique for acid and alkaline gases, nitrogen dioxide, nitric oxide, and sulfur dioxide. The absorbing medium must be carefully selected.

Use of the midget impinger tube is an example of a simple absorber. Air is drawn through a tube immersed in the absorbing medium into which the contaminant is dissolved. A more efficient absorber is the multiple contact absorber, such as the fritted or sintered glass absorbers. These break up the air stream into finer bubbles and provide more contact with the absorbing medium and more rapid solution.

Although gas washers can be operated at rapid flow rates, 2-3 lpm is satisfactory when the personal sampler is used as the power source. Gas washing techniques are excellent for obtaining an integrated sample, so that the average exposure or concentration may be easily obtained.

The sampler should be used for about 15 minutes each hour. It can also be used for a full 8-hour work cycle.

Manufacturers:

Ace Glass Incorporated, P.O. Box 688, Vineland, NJ 08360.

Corning Glass Works, Corning, NY 14830.

Scientific Glass Apparatus Co., 755 Broad Street, Bloomfield, NJ 07003.

Scientific Glass Blowing Co., P.O. Box 18353, Houston, TX 77023.

Direct Reading Electronic Instruments

A wide variety of direct reading instruments are available for gases and vapors. However, most are not portable and, therefore, have limited use in industrial hygiene. Some of these instruments may be used in the industrial environment for fixed site monitoring. A full discussion may be found in Section U of Air Sampling Instruments.

The following portable instruments may be useful for industrial hygiene purposes. However, all instruments are good only for instantaneous samples. As in the case of colorimetric indicator tubes, they are good for preliminary screening and problem identification. If properly maintained and calibrated, portable direct reading instruments have a high degree of accuracy.

Carbon Monoxide Indicators

All CO indicators draw air over a catalyst which oxidizes CO to CO₂. The heat of oxidation causes an imbalance of resistance in the circuit, resulting in a proportionate scale reading calibrated in ppm. The range of these instruments is 0-500 ppm. The two available types have (1) a self-contained, battery-operated pump as an air mover, and (2) an aspiration bulb.

Manufacturers: 8

Explosive Meters

The primary purpose of the explosive meter is to indicate the explosive range of a combustible gas or vapor. Results are given in terms of the percentage of the lower explosive limit (LEL). Variations can measure combustible mixtures of hydrogen and oxygen as well as vapors of leaded gasoline. All instruments draw air over a heated platinum wire that burns the contaminated gas without a flame. The heat of combustion changes the resistance in the circuit. This resistance change produces a meter reading proportional to the quantity of explosive gas present.

Some models may be calibrated in terms of ppm for certain combustible vapors, but it is not an accurate method except at concentrations above about 1000 ppm.

Manufacturers: 1,8,11,17.

Mercury Vapor Indicators

These detectors are almost essential for environments where mercury vapor is present. The meter is quite accurate, with a detection range of 0.005 to 3.0 mg/M³. All instruments have a self-contained small fan for moving air. No calibration for air flow is necessary, as the performance of the instrument is not a function of air volume. The operation of the detector is based on a 2537A° UV source lamp and a reference photoelectric cell. When contaminated air passes between the lamp and the cell, the mercury vapor absorbs the light and causes a deflection of the meter. The extent of deflection is a measure of the mercury vapor concentration. The instrument is available in models for rechargeable batteries and 110V/60 cycle operation.

Manufacturers: 1,2.

Static Method for Gases and Vapors

A frequently used method for determining gas and vapor concentrations is to trap a known volume of the contaminated air with an evacuated flask, by water displacement, or by passing the air through a container of known volume with stop cocks on each end. The containers must then be sent to the laboratory for analysis by chromatographic methods. The temperature and pressure of the contaminated air must be recorded so that the concentration can be based on air at stp.

Plastic bags of various compositions and configurations have been used for the collection of atmospheres from contaminated workrooms. The plastic bag is collapsed and filled by an air mover to insure complete replacement of the air in the bag. Flow rates are not important, as the gas will be analyzed in the laboratory on a volumetric basis. Air temperature and pressure should be noted. For selection of the proper types of plastics for this method, refer to Section R of Air Sampling Instruments.

Dust and Fume Samplers

Filter Samplers

Except for special circumstances, filter instruments are used almost exclusively for sampling dusts and fumes. In both cases, the air sampling pump (personal sampler) is used as the air mover. For sampling an individual, the pump is attached to the worker's waist with a belt and the sampling device is attached to the worker's lapel, near the breathing zone. The two units are connected by a plastic tube.

For pneumoconiosis-producing dust, except asbestos, the sampling device is a two-stage respirable dust sampler. The first stage is usually a 10 mm nylon cyclone which removes by centrifugal force particles greater than 10 microns. The air stream containing particles less than 10 microns is directed onto a filter contained in a plastic cassette where the particles are removed by filtration. After completion of the sampling period, the filter is removed, placed in a sealed plastic container, and sent to the laboratory for weighing and analysis, if indicated.

Complete dust-sampling units, including the cyclone and filter cassettes can be purchased from several manufacturers. The instrument should be operated at the flow rate recommended by the manufacturer (1.5 - 2.0 lpm). Flow rates that differ from the recommendation will alter the collection characteristics of the first stage collector.

The manufacturer furnishes a calibration chart, but the collecting system should be calibrated about every three months, or whenever misuse of the pump may affect its calibrations. The calibration should be done with the filter paper supplied with the instrument or the system must be recalibrated. Except in very heavy dust concentrations, the unit should be operated for a full 8-hour work shift. Shorter sampling periods may not deposit sufficient mass on the filter for accurate weighing. The filter must be weighed before and after sampling on a highly accurate and sensitive balance, since the weight difference may be only a few milligrams. Although the filter is unaffected by moisture, it should be allowed to equilibrate for several hours in a laboratory dessicator before weighing. During the sampling period the rotometer on the sampling pump should be checked every two hours and adjusted, if necessary. The volume sampled is a function of the flow rate and the time of sampling.

For toxic dusts and fumes, such as lead and beryllium, standards require that total particulates be determined. For this purpose, the sampling device is an open-end filter holder which removes all particulates. Otherwise, the instrument is operated in the same manner as the respirable-dust sampler and with the same precautions. With the open-end sampler, the flow rate is not critical so long as the limits of the instrument are not exceeded. However, 2 lpm is the usual flow rate. The duration of the sampling period is a function of the concentration of the contaminant. The sample must be sufficiently large to provide adequate mass to meet the requirements of the analytical method. Usually, two 4-hour sampling periods during an 8-hour work shift are recommended. After the sample has been completed, the filter paper must be removed carefully (to prevent contamination) and sent to a laboratory for analysis, usually by atomic absorption methods.

Both the respirable-dust sampler and the open-end sampler can be used as area instruments as well as personal instruments. Good practice dictates that a blank sample be submitted along with the actual sample. The blank is processed in the same manner.

Manufacturers: 3,8,9,10,13,16,17.

High Volume Samplers

These samplers are designed to collect large samples of aerosol contaminants on filters for weighing and analysis. The instruments are not useful for calculating permissible exposures to toxic agents, but they can be used to collect large amounts of the contaminant for identification purposes. They are powered by 110V/60 cycle current and weigh 10-20 pounds. Typically, these instruments use a high speed centrifugal fan to draw air through a 4-inch diameter or an 8 x 10-inch filter with the flow rate indicated by either a by-pass rotometer or a calibrated orifice meter. If they are only being used to collect samples

for qualitative analysis, the accuracy of the flow rate is not important. Flow rates vary from 15 to 50 CFM.

Manufacturers: 3,8,13,17.

Electrostatic Precipitators

Until the development of filter samplers, the electrostatic precipitator was used for collecting toxic dust and fume. Some establishments may still find it useful for certain purposes, even though it is not a standard sampling instrument for OSHA inspections.

The electrostatic precipitator has three advantages over the filter sampler:

1. The sampling rate is not affected by mass loading.
2. The sample is in a readily recoverable form.
3. A much shorter sampling time is possible.

The instrument cannot be operated in an explosive atmosphere.

Electrostatic precipitators differ from other collecting instruments in that the forces acting to separate the particulates from the atmosphere are electrical rather than mechanical. For the theory of operation, refer to Section P of Air Sampling Instruments.

All models of the electrostatic precipitator have a self-contained air mover designed to operate at a fixed rate of 3 CFM. Air is drawn through a grounded tube which surrounds a center electrode. High voltage applied to the center electrode causes ionization of the atmosphere. Particles in the ionized field acquire an electrical charge and are deposited on the grounded tube. Efficiency of most commercially available instruments at the recommended flow rate is 90% or greater for particles of less than 0.1 micron and 100% for particles of 5 microns or more. After a sampling cycle, usually about 10-15 minutes, the grounded tube is removed, capped, and sent to the laboratory for analysis.

Manufacturers: 3,8, and the following:

Del Electronics, 250 E. Sandford Blvd., Mt. Vernon, NY 10553.

Thermo-Systems, Inc. 2500 Cleveland Ave. No., St. Paul, MN 55113.

Mists and Fogs

Mists and fogs are sampled with gas washers, as described under Gases and Vapors.

Instruments for Measuring Physical Agents

Sound Level Meters

The standard sound level meter consists of a microphone, an amplifier with a

calibrated volume control, and an indicating meter. All instruments measure the root-mean square (rms) sound pressure level in decibels, proportional to intensity or sound energy flow. Sound level meters of the same type differ mainly in external shape, arrangement of controls, and other convenient features that influence a prospective user.

Three weighing networks are provided to duplicate the response of the human ear to various sounds. These weighing networks cause the sensitivity of the meter to vary with frequency and intensity of sound like the sensitivity of the human ear. The three networks are designated as the A, B, and C Scales. Some meters provide a D Scale or network for approximating the "perceived noise level" used in evaluating aircraft noises. The A Scale is the most useful, as this is the reference for the industrial noise standard.

Action of the meter may be selected as "fast" or "slow". Relatively steady sounds are easily measured on the "fast" response, while unsteady sounds can be averaged with the more sluggish "slow" response to reduce meter needle swings. American standard sound level meters are furnished in three types, offering varying degrees of precision. Type 1 is a precision sound meter. Type 2 generally measures within 2 or 3 dB of the true level, which is satisfactory for most purposes.

The overall accuracy of sound measuring equipment may be checked by using an acoustical calibrator. It consists of a small, stable sound source that fits over the microphone and generates a predetermined sound level within a fraction of a decibel. If the meter reading is found to vary from the known calibration level, the meter may be adjusted to eliminate this error. Sound level calibrators should be used only with the microphone for which they are intended in order to avoid errors and microphone damage.

Manufacturers: 3 and the following:

General Radio Co., Concord, Mass.

Sound Monitors

Statistical analyzers are available for sound measurements which vary erratically over a wide range. These instruments indicate the percentage of time that the sound level exceeds a predetermined range. From such data, the mean level, standard deviation, and other statistical data may be calculated. The sound monitor must be accompanied by a system readout unit. The monitor may be worn by a worker or it may be used to monitor an area. A single system readout unit will accommodate a large number of monitors.

Manufacturers: 3 and the following:

E. I. duPont de Nemours & Co., Wilmington, Delaware.

Heat Stress Monitors

Heat stress monitors have been designed to measure the factors recommended by NIOSH in its recommended standard for heat stress. These are wet bulb temperature, dry bulb temperature, and globe temperature. The units consist of a sensor assembly, a readout meter, and a storage box. Manufacturers claim an accuracy of $\pm 1^{\circ}\text{F}$. Available instruments are area monitors rather than personal monitors.

Manufacturers: 3 and the following:

Reiter Stokes, Inc., 18532 South Miles Parkway, Cleveland, Ohio 44128.

References

1. American Conference of Governmental Industrial Hygienists. Air Sampling Instruments Manual. 4th ed. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1972.
2. General Purpose Sound Level Meters. IEC/123. New York: American National Standards Institute, 1961.
3. Intersociety Committee. Methods of Air Sampling and Analysis. Washington, D. C.: American Public Health Association.
4. National Institute for Occupational Safety and Health. Approved or Certified Personal Protective Devices and Industrial Hazard Measuring Instruments. Morgantown, West Virginia 26505: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, February 1974 with Cumulative Supplement of May 1974.
5. National Institute for Occupational Safety and Health Technical Information. Evaluation of Portable, Direct-Reading Carbon Monoxide Meters. HEW Publication No. (NIOSH) 75-106.
6. National Institute for Occupational Safety and Health Technical information. Evaluation of Portable, Direct-Reading Sulfur Dioxide Meters. HEW Publication No. (NIOSH) 75-105.
7. National Institute for Occupational Safety and Health. The Industrial Environment -- Its Evaluation and Control. Washington, D. C.: U.S. Government Printing Office, 1973. Chapters 11, 15, 16, 25, 31, and 40.
8. National Institute for Occupational Safety and Health. Manual of Analytical Methods. (P & CAM-178).
9. Precision Sound Level Meters. IEC/179. New York: American National Standards Institute, 1965.
10. Specification of Sound Level Meters. ANSI S.1, 13-1971. New York: American National Standards Institute, 1971.
11. Young, Ronald, "Calibration of Personal Sampling Pumps," Evaluation and Control of Occupational Lead Poisoning, A Six-Hour Training Course developed by Henry N. Doyle. Nashville, Tennessee: Department of Public Health, Bureau of Environmental Health, Division of Occupational and Radiological Health, September 1974.

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