Industrial Health and Safety

Lecture 6: Hazards of Heat and Radiation

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Hazards of Heat and radiation

Agenda

- **Heat and Temperature**
- **Radiation**

Heat and temperature

High and low temperatures, heat, and cold can all be directly injurious to personnel and damaging to materials and equipment. Other effects can also be generated which lead to accidents and therefore indirectly to injures and damage.

Effect on personnel

The principal means by which temperature and heat can injure personnel is through burns which can injure the skin and, sometimes, muscles and other tissue below the skin. Skin burns are classified into three degree of severity.

First-Degree Burns

Experimental data on burns which resulted from subjecting persons to various heat intensities for slightly more than half a second.

Degree of Burn	*Thermal Energy*	
	White Subjects (cal/cm^2)	Black Subjects (cal/cm^2)
First degree	3.2	Not stated
Second degree	3.9	1.8-2.9
Third degree	4.8	3.3-3.7

*C.S. White and I.G. Bowen, *Comparative Effects Data of Biological Interest,* Lovelace Foundation for Medical Education and Research, Albuquerque, N.M., Apr. 1959.

First-Degree Burns

First-degree burns involve only a redness of the skin, which indicates a mild inflammation. The most common first-degree burn is sun-burn. First-degree burns from fires may result from a much greater amount of radiation received during a shorter period of time.

Contacts between the skin and a hot surface will produce similar types of burns.

First-Degree Burns

EFFECTS ON SKIN IN CONTACT WITH SURFACES AT DIFFERENT TEMPERATURES*

Temperature (°F)	*Sensation or Effect*
212	Second-degree burn on 15-second contact
180	Second-degree burn on 30-second contact
160	Second-degree burn on 60-second contact
140	Pain; tissue damage (burns)
120	Pain; "burning heat"
91 ± 4	Warm; "neutral" (physiological zero)
54	Cool
37	"Cool heat"
32	Pain
Below 32	Pain; tissue damage (freezing)

*R.F. Chaillet et al., *Human Factors Engineering Design Standard for Missile Systems and Related Equipment*, U.S. Army Human Engineering Laboratories, AD 623-731, Sept. 1965.

Second-degree burns

Second-degree burns are much more serious than first-degree burns. Blisters of the skin will form, and in the severer cases, fluid will collect under the skin.

- **Skin beneath the blisters is extremely sensitive, red in color, and exudes considerable amounts of fluid.**
- **Sometimes much more painful than third-degree burns.**
- **The most common cause, like the first-degree burns, is solar radiation.**

Third-degree Burns

- In third-degree burns, the skin, subcutaneous tissue, red blood cells, capillaries, and sometimes, muscle are destroyed.

Burns may be white, light gray, brown, or even charred black.

Although the damage is more serious, the destruction of the never endings in third-degree burns can cause less pain than lesser burns which leave them exposed.

Third-degree Burns

- Cryogenic burns, caused by skin contact with an extremely cold metal surface, will also cause third-degree burns, destroying skin and underlying tissue, and possibly resulting in gangrene.

Classification of burn Severity

How serious can burns of each of these degree be?

1. Critical burns

a. Second-degree burns exceeding 30 percent of the body surface (BS).

b. Third-degree burns exceeding 10 percent of the BS.

C. Burns complicated by respiratory-tract injury, major soft tissue injury, and fractures.

d. electrical burns.

e. Third-degree burns involving critical areas, for example, the hands, face, or feet.

Classification of burn Severity

2. Moderate burns

a. Superficial second-degree burns of more than 15 percent of the BS.

b. Deep second-degree burns of 15 to 30 percent of the BS.

c. Third-degree burns of less than 10 percent, excluding the hands, face, and feet.

Classification of burn Severity

3. Minor burns

a. First-degree burns.

b. Second-degree burns of less than 15 percent of the BS.

c. Third-degree burns of less than 2 percent of the BS.

A second system of rating burns was developed at University of Rochester[1952] using six levels of severity.

Burns to the Eyes

- Welding and new processes and technologies can cause damage to the eye, which is more sensitive than the skin. Some of these new processes use strong electromagnetic radiations, such as ovens and other drying processed, radars, and most recently, laser. The injury that can result are principally thermal in nature.

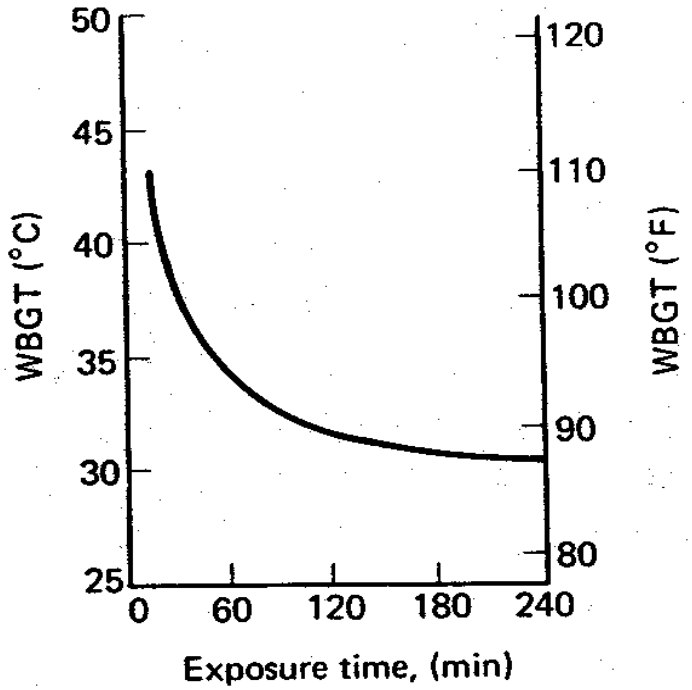
Effects of High Temperature & Humidity

Continued exposure to high temperatures and humidity or to hot sun is the common cause of heat cramps, heat exhaustion, and heat stroke.

- Heat cramps involve muscular pains and spasms, cold sweat, and vomiting.
- Heat exhaustion is caused by excessive perspiring because of a hot environment or strenuous physical excertion.
- Heat stroke is more serious than heat exhaustion or cramps.

High Temperature

The graph shows the upper limits of exposure for unimpaired mental performance. Exposure should not exceed that of the following chart.



Effect of Cold

In industrial plants cold is generally not a problem, the exceptions being in those activities where cryogenic liquids are used. In such places the chief hazard from the effect of cold is in contact between the skin and a cold metal surface.

Other problems

Increased temperatures can generate other problems which result in conditions leading to failures and possibly to accidents.

- **Corrosion**
- **Fluid decomposition**
- **Reliability**
- **Increase gas pressure**
- **Freezing of water**
- **Liquid expansion**
- **Effect on metals**
- **Loss of ductility**

Hazards check list-Heat and Temperature

Possible effects

High temperature:

- Burns to personnel
- Reduced efficiency and errors
- Ignition of combustibles
- Reduced strength of materials
- Distortion and warping of parts
- Increased electrical resistance

Possible causes

High temperature:

- Heat engine operation
- Fire or explosion
- Electric heating
- Solar heating
- Friction between moving parts
- Hot climate or weather
- Nuclear reaction

Hazards check list-Heat and Temperature

Possible Effects

Low temperature

- Frostbite or cryogenic burns
- Ice in operating equipment
- Freezing of liquids
- Reduced reaction rate
- Increased brittleness of metals
- Pressure change

Possible Causes

Low temperature

- Loss of heat because of:
- Mechanical cooling or refrigerating processes
- heat loss by radiation,
  - Endothermic reactions
- Rapid evaporation

Hazards of Radiation

"Radiation is radiation. It cannot be seen; it cannot be felt; it cannot be smelled; it cannot be heard; and it cannot be touched. Yet it exisits, and though its proper use has been immeasurable benefit to mankind, its abuse or improper use presents great hazards."

The speaker was concerned with x-radiation, but his statement is applicable with minor exceptions to all types of electromagnetic radiation.

Hazards of Radiation

Ionizing Radiation:

Alpha, beta, and neutron particles, and x-rays and gamma rays are ionizing radiation.

Each of these may cause injury by producing ionization of cellular components, leading to functional changes in the tissues of the body.

Fig.4 Effects of Ionizing Radiation on Body Tissues and Organs

- **Blood: White cell are the most sensitive to radiation.**
- **Bone marrow: can be damaged by radiation, so that blood cell replacement cannot take place.**
- **Eyes: are the part of the body most sensitive to radiation.**
- **Reproduction organs: Immediate effects would be the same as those on other cells.**
- **Lymphatic system: the lymphatic system nodes would be the first affected in this system by a heavy dose of radiation.**
- **Digestive system: The various portions of the digestive system vary in sensitivity and types of damage.**
- **Nervous system: Nerves are highly resistant to radiation.**
- **Hair: radiation will lead to loss of hair.**
- **Other organs: kidneys, circulatory system, respiratory system, liver are generally highly resistant to ionization.**

Nonionizing Radiations

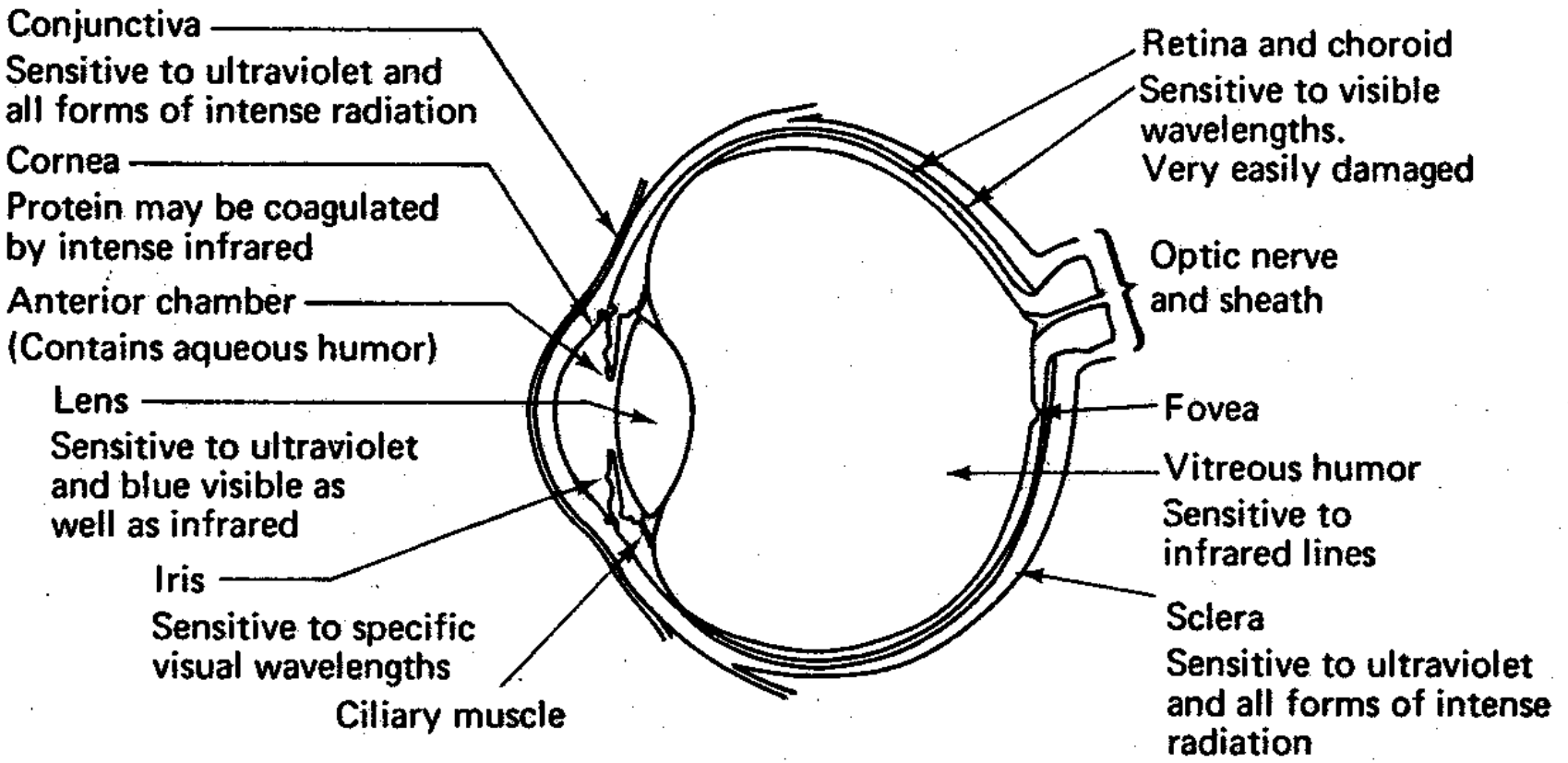
Three types can cause injury:

Ultraviolet Radiation: thermal or photochemical. Principal absorbers of ultraviolet energy- the cornea and conjunctiva of the eye (Fig.).

Infrared: Skin burns, body salts, eye damage et al.

Microwaves:

Nonionizing Radiations



Construction and Radiation Sensitivity of the Human Eye

Hazards Checklist-radiation

Possible effects

Ionizing:

- **Tissue damage**
- **Degradation of electronic components & characteristics changes**
- **Degradation of metal strength**

Microwave:

- **Heat of metals and tissue by induction.**
- **Eye injury**
- **Interference with other electronic Equipment**
- **Activation of sensitive electroexplosives**

Hazards Checklist-radiation

Infrared radiation:

- Undesirable heat again & temperature rise
- Temperature increase in enclosed space
- Overheating; Skin burns
- Charring of organic materials
- Initiation of combustion of flammables

Visible light:

- Temporary blindness

Ultraviolet light:

- Vision damage & other eye injuries
- Deterioration of rubber, plastics, and other materials
- Ozone or nitrogen oxide generation
- Color fading of fabric

Hazards Checklist-radiation

Possible cause

Ionizing:

- Radioactive materials
- Exposure to ionizing source
- Inadvertent production of rays by radar, communications,etc.
- Use of x-ray equipment
- Nuclear reaction

Microwave:

- Radar equipment operation
- High power & microwave equipment operation
- Other microwave generator generation

Hazards Checklist-radiation

Possible cause

Infrared radiation:

Flame; Solar; Infrared heaters

Highly heated surface;Lasers

Visible light:

Strong sunlight; High-intensity lights & flashlamps

Electric arcs

Ultraviolet light:

Sunshine; Welding arcs

Germicidal lamps

Lasers; Photocopying machines