St. James - Operator Education
Industrial Hygiene and Toxicology
August 8-9, 1979

Our intent in this presentation is to do two things. First, we want to discuss occupational hazards in general terms. This will include the types of hazards (chemical, physical, etc.) you may encounter, how they may harm you, and how your body responds to them. Secondly, we want to discuss the specific chemicals and products you work with at St. James and what their toxicity is. Let us start with the Occupational Safety and Health Administration.

OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA)

Let's first talk about OSHA: An act "To assure safe and healthful working conditions for working men and women". In Section 5, the duties of both employer and employee are spelled out.

Each employer shall furnish to each of his employees a place of employment which is free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees. The employer shall comply with occupational safety and health standards promulgated under this act.

Each employee shall comply with occupational safety and health standards, and all rules, regulations and orders issued pursuant to this act which are applicable to his own actions and conduct.

CHEMICAL HAZARDS

Chemical Stresses which are responsible for many health hazards arise from:

A) Inhalation (through the respiratory system)

B) Absorption (through the skin)

C) Ingestion (through the digestive system)

ROUTE OF ABSORPTION

Inhalation and skin absorption are the two most important routes for the entry of chemicals into the body in the workplace.

A) Inhalation

1. Particulates (dust, fumes, mist smoke, aerosols).

2. Gases (including vapors from volatile liquids).

Particulates may be divided into two classes:

i) The non-respirable particulates are the dust motes you can see in the air, and are big enough to be filtered out in the nose and throat so that they never reach the lungs.

ii) The respirable particulates are so small as to be invisible to the naked eye, and can be breathed into the lung. There they can cause damage to the lung tissue or be absorbed directly into the blood stream and be carried to other parts of the body.

All gas and vapor molecules are so small that they can penetrate into the lung without obstruction, thus becoming immediately available for solution and reaction in the blood.

These air contaminants can affect the body through various physiological actions:

Irritants, for example caustic dust, styrene, ethylbenzene.

Simple asphyxiant, for example nitrogen gas, ethylene.

Chemical asphyxiant, for example carbon monoxide, hydrogen sulfide.

Narcotic, for example benzene, toluene.

Systemic poisons, for example benzene, methanol, carbon tetrachloride.

Pneumoconiosis-producing dust for example asbestos, silica.

Living organisms, for example bacteria, viruses, fungi.

Allergens and sensitizers, for example toluene diisocyanate (used to make polyurethane).

Carcinogens, for example vinyl chloride.

Mutagens and teratogens, for example dimethylnitrosoamine.

B) Absorption occurs from direct exposure of the skin to liquids usually but also solids.

1. Irritants, for example TBC, ethylbenzene.
2. Sensitizer, for example TBC.
3. Systemic poisons, for example I-4.
4. Carcinogen, for example polyethylbenzene bottoms.

C. Ingestion

Indirectly these materials can be ingested because the mucus in the nose, throat, and upper lungs normally comes into the mouth area and is frequently swallowed. This mucus can carry with it all the materials filtered out in the nose and throat, and some of the material penetrating into the lung.

Also eating in a contaminated area can result in indirect ingestion by swallowing a substance that is on the food.

PHYSICAL HAZARDS

A) Radiation - no radiation exists at St. James
B) Noise - Noise induced hearing loss

BODY REACTION

Reaction of the body to a toxic material is dependent on a number of factors:

A) Dosage: The higher the concentration of the material causing the reaction, the more intense the reaction. Dosage is related to both concentration and duration of exposure.

1. Acute Effect: Resulting from sudden massive exposures to overwhelming concentrations of toxic compound, may cause immediate unconsciousness, shock or collapse, with death following.

2. Chronic Effect: Resulting from continual low grade sub-lethal exposures over extended periods of months or years. Chronic effects are usually not observed below the Threshold Limit Value (TLV).

B) Individual Susceptibility: Different people exposed to the same concentration of toxic material may show marked variations in reactions.

C) Site of Action and Route of Absorption: Discussed above.

D) Storage and Excretion: Some materials are cumulative poisons, that is, they are stored in some organ of the body for lengthy periods, and excreted over extended periods.

E) Reaction With Human Tissue Fluids: The greater the affinity for or the solubility in tissue, the more effective the poison is likely to be, because it can react more rapidly. Likewise, the finer the state of subdivision, the more rapid will be the rate of reaction.

F) Mixed Exposure: Frequently there is exposure to a mixture of compounds, each with varying effects at various dosages.

THRESHOLD LIMIT VALUES (TLV)

The TLV is the concentration of material in air to which nearly all workers may be exposed during their normal worklife without adverse effects. TLV's refer to "Time Weighted Average" (TWA) concentrations for an 8-hour workday, 40-hour work week. TLV's should be used only as guides in the control of health hazards, and should never be used as fine lines of distinction between safe and dangerous concentrations.

For gases and vapors, TLV is usually expressed in "parts per million" (ppm), that is, so many cubic feet of gas per million cubic feet of air (can also be readily converted to mg/m^3).

For dusts or fumes, TLV is usually given in terms of "milligrams per cubic meter" (mg/m^3), that is, weight of so many milligrams of substance per cubic meter of air.

(1 milligram = $\frac{1}{1000}$ gram; 1 ounce = 28,000 milligrams

1 cubic meter = 35 cubic feet

MEASURING EXPOSURE

There are three important ways of determining exposure to a potentially toxic material.

A) Area Analysis: Measures concentration of the substance in the air in the working area, from single spot analysis to continuous monitoring.

B) Personal Dosimetry: Measures concentration of compound in air breathed in specific time period by individual.

C) Biological Monitoring (or Bioassay): Measures change in body chemistry or physiology caused by absorption of chemical.

CONTROL

There are 4 major means of controlling exposures:

A) Engineering Controls: Reduce concentration of compound below TLV by various means.

1. Substitution of a less toxic material
2. Enclosure of a process
3. Segregation of a process
4. Ventilation, especially local exhaust ventilation
5. Wetting (used for dusts, for example asbestos).

B) Administrative Controls: Reduce time spent in a particular environment so that TWA exposure is below TLV, for example, by switching workers more frequently, change in job assignment.

C) Medical Controls: Prevent and detect potential problem areas.

1. Preplacement medical examination
2. Periodic examinations
3. Education

D) Personal Protective Devices: To reduce the immediate personal environment of the worker below TLV. Should not be used as a substitute for engineering and administrative controls, unless circumstances dictate.

SPECIFIC CHEMICAL HAZARDS

In the following Sections, we shall discuss some of the chemicals processed or used at this plant: benzene, toluene, ethylbenzene, styrene, tertiary-butyl catechol and I-4 inhibitors.

BENZENE

Benzene is probably the most toxic hydrocarbon known; certainly by far the most toxic processed at this plant. Although the federal permissible exposure limit is currently 10 ppm, an attempt has been made to change this to 1.0 ppm due to new toxicological data indicating benzene is a potential carcinogen. As a result of this a 1.0 ppm standard is being observed at St. James.

Because benzene is an excellent fat solvent, liquid benzene on the skin will readily remove natural oils and fats. This results in drying and irritation and may cause reddening and blistering. Prolonged contact will lead to dry scaly dermatitis. However, benzene is not easily absorbed through the unbroken skin. Therefore, the main route for absorption as a systemic poison is via inhalation.

Acute exposure by inhalation, following a spill or equipment failure, may result in loss of consciousness, that is, the benzene affects the central nervous system directly. If the victim is not removed and the exposure continued, death will follow by respiratory failure. If removed in time, recovery is usually complete and no permanent disability occurs.

Chronic exposure has a slow onset with vague symptoms: Fatigue, headache, dizziness, nausea, loss of weight. Later, pallor, nosebleeds, bleeding gums and other signs may develop. However, these would only occur after prolonged exposure at concentrations above the TLV. The chronic effects are upon the blood and bone marrow leading to numerous irregularities in the blood system. As you have been told in the past benzene is suspected of causing leukemia in some cases.

Animal studies indicate (1) that a low protein intake increases susceptibility to benzene poisoning and (2) that benzene poisoning results in lowering of resistance to infection.

Only about half of the benzene inhaled is absorbed by the lungs. Of this portion absorbed, about 10% is exhaled as unchanged benzene. About 0.1% is discharged unchanged in the urine. The main elimination products are phenolic compounds, largely phenol itself. Thus the proposed NIOSH Standard for Benzene calls for regular monitoring of phenols in urine of personnel exposed. It is believed that the phenols could be responsible for benzene's high level of toxicity. Most other benzene derivatives do not convert to phenolic compounds, thus are not as toxic as benzene itself (this includes toluene, ethylbenzene and styrene).

TOLUENE

In many cases toluene, the methyl derivative of benzene, may be substituted for benzene, as the TLV is 100 ppm. However, toluene does have different chemical and physical characteristics and direct substitution is not always possible. Toluene can be detected in air at about 2 ppm, so that odor can serve as a very good warning signal.

Toluene is an excellent fat solvent, so that liquid toluene on the skin will readily remove natural oils and fats, and has a strong irritant effect. Severe dermatitis may result.

Exposure to high concentration in air may result in headache, vomiting, disturbance of balance, and loss of consciousness, but recovery is usually complete. Toluene is usually regarded as having greater acute toxicity than benzene.

However, under chronic conditions toluene is considerably less toxic, especially to the blood system. Long-continued exposure to toluene at concentrations above the TLV results in headache, giddiness, insomnia, reduced appetite and nausea. Intolerance to alcohol is noteworthy.

Very often toluene is contaminated by benzene and the effects are complicated by the presence of the benzene.

About half of toluene inhaled is retained by the body. About 16% of the absorbed toluene is eliminated by the lungs and kidneys. Most of the remainder is converted to benzoic acid (not phenols as in the case of benzene) which is excreted in the urine as hippuric acid, within 24 hours.

ETHYLBENZENE

The toxicology of ethylbenzene is not as well-documented as benzene and toluene.

In high concentrations, it's behavior is similar to toluene's. That is, it acts as a narcotic. However, it is primarily a strong irritant to skin, eyes and mucous membranes. It is considered the strongest skin irritant of the benzene series, and can cause blistering. Aspiration of even a small amount of ethylbenzene (liquid) into the lungs may cause severe injury.

Irritant effect of the vapor on the eyes occurs at about 200 ppm, serving as a warning signal of excessive concentration. Thus the TLV of 100 ppm will provide reasonable protection against the irritant effect.

Ethylbenzene is not converted to phenols by the human body, thus it's toxicity resembles that of toluene rather than benzene.

STYRENE

Styrene is detectable by smell at less than 1 ppm. With increasing concentration, the smell becomes unpleasant, although appreciable eye or throat irritation only becomes evident over 200 ppm. Thus the TLV of 100 ppm should provide adequate protection against the irritant effect and the unpleasant odor.

In high concentrations, it will act as a narcotic. But it is primarily an irritant to eyes and mucous membranes. Prolonged exposure of the skin to styrene liquid may cause dermatitis.

No evidence of cumulative toxicity exists. Because styrene is not converted to phenols in the human body, it's toxicity resembles toluene's, not benzene's.

4-Tertiary-Butyl Catechol (TBC)

TBC is primarily a skin irritant, and a concentrated solution can burn the skin severely if left in contact without washing. Although TBC can be absorbed through the skin, normally insufficient to affect the body will penetrate as the irritant effect will act as a warning signal.

The vapor is also irritant, but as TBC is relatively nonvolatile (boiling point 285C) this presents no problem normally. (Fire)

It seems that TBC is a sensitizer, that is, skin contacts too light to cause obvious irritation or one severe single exposure may so sensitize the body that later contacts may cause a violent reaction at very low doses.

In wearing protective equipment, the user should make sure that the equipment which will contact the skin is clean of TBC, and that the surface is intact to prevent possible penetration through cracks or tears, especially in gauntlets. Gauntlets are preferable to gloves as they give more complete protection to the lower arm, and prevent TBC running in at the glove opening. Neoprene is the best material, although the other standard, impervious glove materials (natural rubber, BuNa-N and Butyl) may also be used.

If TBC contacts the skin, shower immediately with water, remove all affected clothing, thoroughly wash the skin with soap and water, and obtain medical attention immediately.

INHIBITOR I-4

I-4 is an organic chemical of considerable toxicity. As a solid, it can be absorbed either by inhalation or absorption through the skin. To avoid dusting, and reduce explosive tencency, the I-4 is usually kept moist, thus the inhalation route is usually negligible.

Suitable protective equipment should be used when the drums are opened, including respiratory filters.

The I-4 concentrated solution should be prevented from contacting the skin where direct absorption could take place. Suitable protective equipment, especially gloves, should be worn. Care should be taken to ensure that all protective equipment is kept clean, and discarded at intervals. If any yellow staining of the skin is observed, wash thoroughly with soap and water, and seek medical attention immediately.

I-4 acts as a systemic poison. The symptoms are fatigue, excessive and unusual sweating, thirst, insomnia, and loss of weight. The presence of I-4 may be checked by blood tests. The TLV of 0.2 mg/m^3 has a large safety factor and is sufficiently low to prevent onset of any debilitating symptoms.

St. James Operator Education

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GENERAL PRINCIPLES

1) Introduction

   a. OSHA
   b. Corporate Policy

2) Chemical Stresses

   a. Inhalation
   b. Absorption
   c. Ingestion

3) Physical Stresses

   a. Noise
   b. Radiation

4) Toxic Effects

   a. Principal Factors
   b. Dose Response
   c. TLV

5) Measuring Exposure

6) Exposure Controls

SPECIFIC HAZARDS

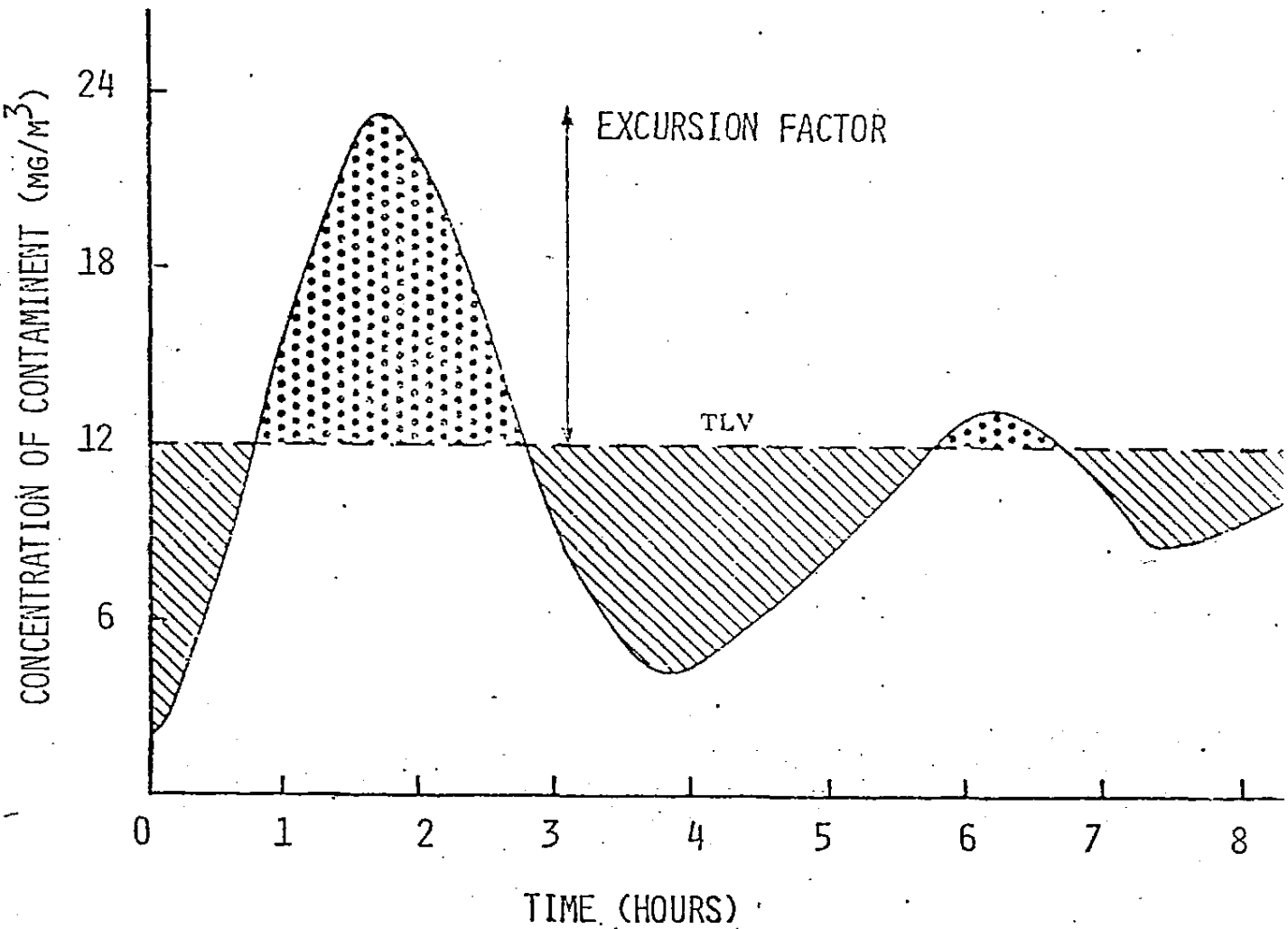
1) Benzene
2) Toluene
3) Ethylbenzene
4) Styrene
5) TBC
6) I-4
7) Styrene, PEB Residues

	BENZENE	ETHYL BENZENE	STYRENE	TOLUENE
TLV	1 (10)	100	100	100
ACUTE LOCAL				
IRRITANT	2	2	2	1
INGESTION	1	---	---	---
INHALATION	1	---	---	---
ACUTE SYSTEMIC				
INGESTION	2	2	2	2
INHALATION	2	2	2	2
SKIN ABSORTION	2	2	---	1
CHRONIC LOCAL				
IRRITANT	0	U	U	1
INGESTION	0	U	U	---
INHALATION	0	U	U	---
CHRONIC SYSTEMIC				
INGESTION	3	U	2	2
INHALATION	3	U	2	2
SKIN ABSORTION	3	U	---	2

	I-4 INHIBITOR	TBC
ACUTE LOCAL		
IRRITANT	3	3
INGESTION	-	3
INHALATION	-	2
ACUTE SYSTEMIC		
INGESTION	3	2
INHALATION	3	2
SKIN ABSORTION	3	3
CHRONIC LOCAL		
IRRITANT	3	2
INGESTION	-	2
INHALATION	-	2
CHRONIC SYSTEMATIC		
INGESTION	3	U
INHALATION	3	U
SKIN ABSORTION	-	3

TOXIC HAZARD RATING CODE

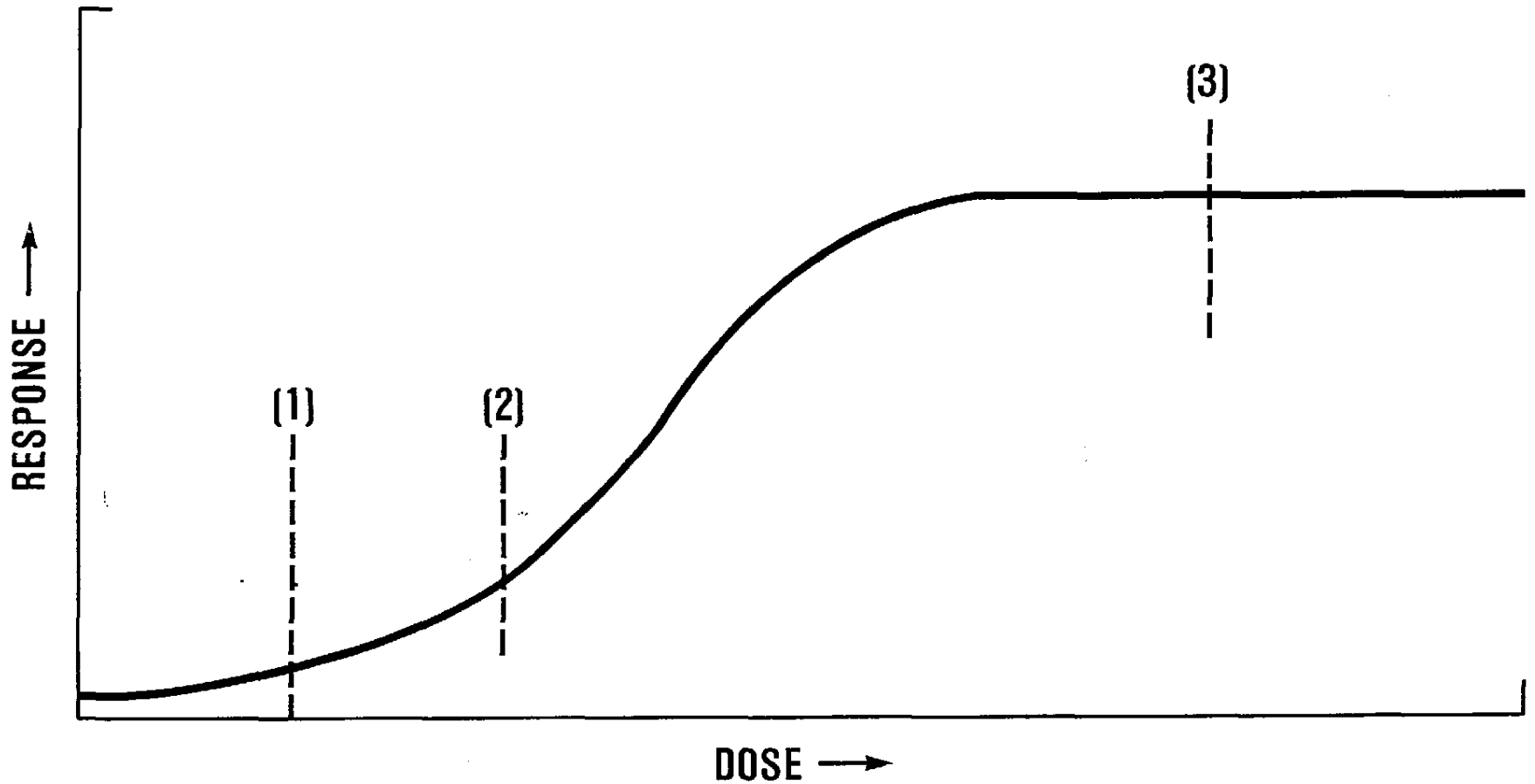
0	NONE	: A)	NO HARM UNDER ANY CONDITIONS
		B)	HARMFUL ONLY UNDER UNUSUAL CONDITIONS
1	SLIGHT	:	CAUSES READILY REVERSIBLE CHANGES WHICH DISAPPEAR AFTER END OF EXPOSURE
2	MODERATE	:	MAY INVOLVE BOTH IRREVERSIBLE AND REVERSIBLE CHANGES NOT SEVERE ENOUGH TO CAUSE DEATH OR PERMANENT INJURY
3	HIGH	:	MAY CAUSE DEATH OR PERMANENT DAMAGE AFTER VERY SHORT EXPOSURES TO SMALL QUANTITIES
U	UNKNOWN	:	NO VALID INFORMATION AVAILABLE



(AREA OF CURVE ABOVE TLV ⁞⁞⁞ MUST BE LESS THAN AREA BELOW TLV ▨ FOR TIME WEIGHTED AVERAGE EXPOSURE TO BE LESS THAN THE TLV.)

TIME-WEIGHTED AVERAGE AND THE EXCURSION FACTOR

DOSE RESPONSE



(1) HYPERSUSCEPTIBLE RESPONSE
(2) NORMAL RESPONSE
(3) DEATH

PHYSICAL HAZARDS

A.) RADIATION: SEALED SOURCES FOR LEVEL GUAGES
MICROWAVE OVENS

B.) NOISE: EXCESSIVE EXPOSURE TO NOISE CAN CAUSE NOISE-INDUCED HEARING LOSS

CHEMICAL STRESSES

MODE OF ENTRY

* INHALATION (RESPIRATORY SYSTEM)
* ABSORPTION (SKIN)
* INGESTION (DIGESTIVE TRACT)