



# INDUSTRIAL HYGIENE

## NPC TRAINING PROGRAM

### STUDENT HANDOUT



Presented by  
**Demetrio Guzzardi**



# Table of Contents

<b>INDUSTRIAL HYGIENE .....</b>	<b>1</b>
COURSE OBJECTIVE .....	1
<b>INTRODUCTION TO INDUSTRIAL HYGIENE.....</b>	<b>2</b>
DEFINITION OF INDUSTRIAL HYGIENE.....	2
FOUR MAIN CLASSES OF HEALTH HAZARDS .....	2
TOOLS USED TO EVALUATE WORKPLACE FOR THESE HAZARDS.....	5
CONTROLS FOR REDUCING OR ELIMINATING WORKPLACE HAZARDS.....	6
<b>DRILLING / EXPLORATION .....</b>	<b>8</b>
DRILLING MUDS .....	8
CHEMICALS IN DRILLING FLUIDS .....	8
<b>CONTROL .....</b>	<b>9</b>
<b>PRODUCTION .....</b>	<b>12</b>
<b>PIPELINE OPERATIONS .....</b>	<b>14</b>
<b>PETROLEUM REFINING.....</b>	<b>16</b>
FLUID CATALYTIC CRACKING (FCC).....	18
<b>PRODUCT STORAGE .....</b>	<b>20</b>
<b>INTERNATIONAL STANDARDS.....</b>	<b>21</b>
<b>ROUTES OF EXPOSURE TO PHYSICAL, CHEMICAL &amp; BIOLOGICAL AGENTS .....</b>	<b>22</b>
ROUTES OF EXPOSURE .....	22
SAMPLING STRATEGIES.....	24
RESOURCES FOR MONITORING HAZARDS IN THE WORKPLACE .....	25
EXPOSURE MONITORING PROGRAM.....	26
CASE STUDY .....	29
<b>SAMPLING INSTRUMENTATION AND ANALYTICAL METHODS – NIOSH</b>	<b>30</b>
ACTIVE SAMPLING .....	30
UNITS OF MEASUREMENT .....	31
TIME WEIGHTED AVERAGE CONCENTRATIONS (TWA).....	36
NOISE: PRINCIPLES AND MONITORING STRATEGIES.....	37
MONITORING STRATEGIES .....	38
PRELIMINARY NOISE SURVEYS .....	39
DETAILED NOISE SURVEYS.....	39
<b>TECHNIQUES FOR CALIBRATING IH EQUIPMENT .....</b>	<b>41</b>
TECHNIQUES FOR CALIBRATING IH EQUIPMENT .....	41
SECONDARY STANDARD .....	42

INSTRUMENTATION FOR MONITORING CHEMICAL, BIOLOGICAL & PHYSICAL AGENTS.	43
CALIBRATION OF NOISE EQUIPMENT .....	44
OTHER RECOMMENDED EQUIPMENT THAT CAN BE USED .....	44
<b>VENTILATION .....</b>	<b>46</b>
PURPOSE OF VENTILATION.....	46
DEFINITIONS .....	46
PRINCIPLES OF AIR FLOW: .....	46
TYPES OF VENTILATION SYSTEMS .....	47
VENTILATION TESTS:.....	48
INSTRUMENTATION APPLICATIONS:.....	49
<b>ILLUMINATION .....</b>	<b>50</b>
ILLUMINATION PRINCIPLES .....	50
LIGHTING TERMINOLOGY: .....	50
ELECTRIC LIGHT SOURCES: .....	51
ILLUMINATION REQUIREMENTS FOR INDUSTRY: .....	52
LIGHT SURVEYS:.....	52
<b>SAMPLING DOCUMENTATION .....</b>	<b>54</b>
SAMPLING DOCUMENTATION.....	54
HANDLING AND SHIPPING .....	54
RECORD KEEPING .....	55
<b>HEALTH MONITORING.....</b>	<b>56</b>
HEALTH MONITORING/HEALTH SURVEILLANCE IN THE WORKPLACE .....	56
EFFECTIVENESS OF TREATMENT .....	57
EFFECTIVENESS OF CONTROLS.....	58

# INDUSTRIAL HYGIENE

## *Course Objective*

The objective of this course is to give students an understanding of Industrial Hygiene (IH) and how this discipline can help the Health and Safety professional to protect the company's most important asset, its people.

There will be three practical exercises to test the knowledge learned.

- Exercise #1: Case study.
- Exercise #2: Calibrate equipment.
- Exercise #3: Review a light meter and conduct a light survey.

## **PLEASE NOTE:**

**This course is an introduction to Industrial Hygiene. It is NOT designed to qualify course participants as Certified Industrial Hygienists.**

# INTRODUCTION TO INDUSTRIAL HYGIENE

## *Definition of Industrial Hygiene*

Industrial Hygiene has been defined as “the science and art devoted to the anticipation, recognition, evaluation and control of environmental factors or stresses that may cause sickness, impaired health and well being, or significant discomfort and inefficiency among workers or among citizens of the community”.

## *Four Main Classes of Health Hazards*

### **1. Chemical Agents:**

Major active ingredients of potentially hazardous substances are chemically active. Presence of chemical agents can exist in different states:

- airborne contamination
- surface contamination
- occasionally a combination of airborne and surface contamination, e.g.:
  - splash or re-suspension of liquid
  - particulate matter under specific work operations, such as:
    - ❖ welding

### **Routes of entry of chemical agents are:**

- inhalation:
  - breathing airborne particles
  - gases or vapour
- dermal:
  - skin contact with liquids or absorption of gases and vapours through the skin
- gastro-intestinal:
  - accidental ingestion of contaminated food or water
- ocular:
  - unprotected eye contact with particles, vapours or splashed liquids.

## **2. Physical Agents:**

- noise
- ionizing and non-ionizing radiation
- temperature extremes
- pressure extremes
- vibrations

## **3. Biological Agents:**

They can come from a broad range of sources, both indoors and outdoors. Biohazards that are encountered in the workplace include:

- fungi
- pollen
- bacteria
- viruses
- parasites

There are 193 biological agents known to produce infectious allergic, toxic and carcinogenic reactions in workers.

### **Routes of entry into the body:**

- contact between an animal and a human
- indirect contact:
  - contact with a contaminated surface
- vector-borne infection:
  - transmitted by a living vector (mosquito, or tick)
- airborne infection:
  - inhalation of infectious particles, e.g., *Mycobacterium tuberculosis*

#### **4. Ergonomic Agents:**

Ergonomics is the scientific study of the relationship between man and his working environment. Workers can be overwhelmed or become over-exerted from:

- mental,
- physical, or
- environmental demands of a work task or work conditions.

These demands can result in physical stresses that can cause injury (muscle pulls, strains or sprains) or even psychological disorders. These conditions, in turn, can reduce workers' performance.

**Ergonomics tries to reduce stresses caused from interactions amongst:**

- man
- machines
- the environment

## ***Tools Used to Evaluate Workplace for these Hazards***

### **◆ Recognition:**

This starts with a walk-through survey of the facility during which one becomes familiar with processes and work practices. During this survey it is important to identify all chemicals and substances involved in these processes. Existing controls measures, such as ventilation systems, should be identified.

### **NOTE:**

Materials having toxic properties are not necessarily hazardous. The degree of hazard depends on the potential duration and intensity of exposure as well as the nature of the material. Routine work practices and non –routine work practices should be reviewed to assess potential employee overexposure.

### **◆ Evaluation:**

This is the process by which the degree of a potential health hazard is quantified.

- The first step is to determine if an employee health hazard exists.
- Monitoring instruments are selected and calibrated.
- A sampling strategy is devised which specifies the types of samples to be taken, the number of samples to be taken, the sampling procedures, and personnel and areas to be monitored.
- Samples are collected and analyzed, or direct measurement methods are used to determine exposure levels.

### **NOTE:**

These results are compared with international standards, Threshold Limit Values (TLVs) set by the American Conference of Governmental Industrial Hygienists (ACGIH). The information, along with initial observations, will assist in the selection of engineering controls or other procedural modifications.

### **◆ Controls:**

When the survey is complete, implementation of specific controls measures may be recommended, depending upon observations and sampling results. Options available are the following:

- substitution, isolation or enclosure of operations

- removal of the contaminant at its point of generation
- dilution ventilation
- suppression of toxic dusts by water
- use of personal protective equipment
- good housekeeping

### ***Controls for Reducing or Eliminating Workplace Hazards***

#### ◆ **Substitution:**

Toxic substances may be replaced by less toxic ones.

#### ◆ **Isolation or enclosure of operations:**

Highly toxic materials may be physically isolated in remote locations or enclosed to prevent workers' exposure to them.

#### ◆ **Removal of the contaminant at its point of generation (local ventilation):**

Contaminants can be removed by local exhaust ventilation. Negative pressure is generated in a duct causing air to flow into the duct with velocity sufficient to capture contaminants before they enter the general atmosphere.

#### ◆ **Dilution of the contaminant with uncontaminated air:**

Large volume of uncontaminated air may be introduced into the work area in order to dilute the concentration of a toxic substance.

#### ◆ **Suppression of toxic dusts by water (wet methods):**

Principle is applicable to dust-producing operations such as drilling or asbestos removal. This control is also used in some paint spray booths.

#### ◆ **Using of Personal Protective Equipment (PPE):**

PPE clothing may be used to prevent skin contact and is most effective when it is impervious to the agent in question. Safety glasses and chemical goggles protect the eyes. Respirators may be used in certain operations either to remove contaminants by filtration or absorption, or to provide a supply of uncontaminated air.

◆ **Good Housekeeping:**

This involves proper storage, handling and labeling of toxic substances. In addition, a large number of biological hazards can be controlled through good sanitary practices.

## DRILLING / EXPLORATION

### *Drilling Muds*

- water based muds
- oil based muds
- air, gas, mist and foam (non-liquid base)
- silica gel (rare)

### *Chemicals in Drilling Fluids*

- bactericides (paraformaldehyde, chlorinated phenols)
- corrosion inhibitors ( zinc carbonate, sodium sulfite, etc.)
- defoamers
- emulsifiers
- foaming agents
- lubricants

<b>WATER-BASED MUDS</b>		
<b>MUD TYPE</b>	<b>HAZARD</b>	<b>CONTROL</b>
SPUD MUD	LIME HYDRATE (CHEMICAL)	FLUSH IF CONTACTED, VENTILATION FOR FUMES
NATURAL MUD		
CHEMICALLY TREATED MUD: PHOSPHATE, LIGNOSULFONATE, CALCIUM, POLYMER, SALTWATER	CHEMICAL ADDITIVES, CAUSTIC SODA, DIESEL FUEL, KEROSENE, CRUDE OIL	FLUSH IF CONTACTED, VENTILATION FOR FUMES

<b>OIL BASED MUDS</b>		
<b>MUD TYPE</b>	<b>HAZARD</b>	<b>CONTROL</b>
OIL MUD: OXIDIZED ASHPHALT, ORGANIC ACIDS, ALKALIES, STABILIZING AGENTS, HFP DIESEL OIL	LIME HYDRATE CHEMICAL ADDITIVES, CAUSTIC SODA, SODIUM CHROMATE/DICHROMATE	FLUSH IF CONTACTED VENTILATION FOR FUMES, WEAR RESPIRATORY PPE FOR CHROMATES
INVERT/OIL BASED: WATER, CLAY, BARITE/BaSO <sub>4</sub> , DIESEL OIL, CHEMICAL ADDITIVES	CHEMICAL ADDITIVES, CAUSTIC SODA, -	FLUSH IF CONTACTED VENTILATION FOR FUMES,
INVERT EMULSION: SOAPS, FATTY ACIDS	N/A	N/A

<b>DRILLING</b>	
<b>ISSUE</b>	<b>HEALTH HAZARD</b>
WELL FIRES	SMOKE INHALATION
CONTACT WITH DRILLING MUD, CRUDE, CRUDE OILS	BURNS
BLOWOUTS	CHEMICAL EXPOSURE: CANCER-CAUSING AGENTS: BENZENE
H <sub>2</sub> S RELEASE	CHRONIC: CNS DEPRESSION
ENVIRONMENT	NOISE
NORM EXPOSURE	COLD STRESS
	RADIOACTIVE EXPOSURE

<b>WELL SERVICING</b>	
<b>ACTIVITY / PROCESS</b>	<b>HEALTH HAZARD</b>
WELL SERVICING	FIRES/BURNS FROM FLAMMABLE ATMOSPHERES
GUN PERFORATING AND PERCUSSIVE SAMPLING	CONTACT WITH ACIDIZING AGENTS
ACIDIZING	INHALATION OF CHLORINE GAS OR H <sub>2</sub> S GAS

<b>OFFSHORE OPERATIONS</b>	
<b>ISSUES</b>	<b>HEALTH HAZARD</b>
WELL FIRES	SMOKE INHALATION
CONTACT WITH DRILLING MUD, CRUDE, CRUDE OILS	BURNS
BLOWOUTS	CHEMICAL EXPOSURE: CANCER-CAUSING AGENTS: BENZENE
H <sub>2</sub> S RELEASE	CHRONIC: CNS DEPRESSION
ENVIRONMENT	NOISE
DIVING	THERMAL STRESS
	PSYCHOLOGICAL STRESS
	PRESSURE STRESS AND DROWNING

## PRODUCTION

### COMPRESSOR PACKAGES

ACTIVITY OR PROCESS	HEALTH HAZARD
INTAKE & START GAS SYSTEMS PIPING, CONNECTIONS AND VALVES  COMPRESSOR INSTRUMENTATION	FLAMMABLE ATMOSPHERE: FIRE (BURNS)  EXPOSURE TO TOXIC CONTAMINANTS  NORM EXPOSURE (INTAKE SYSTEMS)  THERMAL BURNS (PIPING SYSTEMS)

### OTHER PRODUCTION PACKAGES

SYSTEM OR PROCESS	HEALTH HAZARD
HEATER PACKAGE PUMP PACKAGE  SEPARATOR PACKAGE  TREATER PACKAGE DEHYDRATORS	FLAMMABLE ATMOSPHERE: FIRE (BURNS)  EXPOSURE TO TOXIC CONTAMINANTS: INHALATION AT SEPARATOR  THERMAL BURNS (HEATER PACKAGE)  INHALATION OF BENZENE (DEHYDRATOR)

<b>LIQUEFIED PETROLEUM GAS (LPG) HANDLING FACILITIES</b>	
<b>ACTIVITY OR PROCESS</b>	<b>HEALTH HAZARD</b>
HANDLING FACILITIES  RELEASE OF LIQUEFIED PETROLEUM GAS (LPG)	FLAMMABLE ATMOSPHERE: FIRE (BURNS)  NORM EXPOSURE  NOISE EXPOSURE  EXPOSURE TO TOXIC CONTAMINANTS: H <sub>2</sub> S OR SO <sub>2</sub> VAPOURS  LPG RELEASE: INHALATION BENZENE/ HYDROCARBONS CENTRAL NERVOUS SYSTEM (CNS) DEPRESSANT

<b>OTHER PRODUCTION SYSTEMS</b>	
<b>SYSTEM / PROCESS</b>	<b>HEALTH HAZARD</b>
PUMPING UNITS  •REFRIGERATION PROCESS UNITS  PRODUCTION TANKS AND OIL BATTERIES  FLARE SYSTEMS / VENT STACKS	FLAMMABLE ATMOSPHERE: FIRE (BURNS)  EXPOSURE TO TOXIC CONTAMINANTS: INHALATION AT REFRIG UNITS, TANKS AND BATTERIES (BENZENE)  NOISE (TANKS AND BATTERIES)

## PIPELINE OPERATIONS

<b>PIPELINE PRODUCTS</b>	
<b>PRODUCT</b>	<b>HEALTH / FIRE HAZARD</b>
<p><b>CRUDE OIL:</b> HYDRO CARBONS, NAPHTHENE AND AROMATIC FRACTIONS. CONTAMINANTS OF O<sub>2</sub>, N<sub>2</sub> AND SULFUR</p> <p><b>NATURAL GAS:</b> METHANE, ETHANE AND H<sub>2</sub>S</p> <p><b>NATURAL GAS LIQUIDS:</b> NGL, BENZENE &amp; OTHER AROMATICS, H<sub>2</sub>S</p>	<p>INHALATION: CNS DEPRESSION</p> <p>BENZENE EXPOSURE</p> <p>SKIN CONTACT: BURNS, DERMATITIS</p> <p>EXTREMELY FLAMMABLE &amp; EXPLOSIVE</p> <p>POTENTIAL ASPHYXIANT</p> <p>AS FOR NATURAL GAS; FROSTBITE BURNS IF CONTACTED OR INHALED</p> <p>BENZENE(CANCER-CAUSING)</p>
<p><b>NATURAL GAS LIQUIDS WITH ODORANT:</b> NGL, BENZENE, H<sub>2</sub>S, METHYL ETHYL SULFIDE AND TERT-BUTYL MERCAPTAN</p> <p><b>LIGHT HYDROCARBONS:</b> ETHANE OR PROPANE OR BUTANE, ODORANT(ETHYL MERCAPTAN) CAN BE ADDED</p> <p><b>LPG:</b> PROPANE, PROPYLENE, BUTANES &amp; BUTYLENES</p>	<p>EXTREMELY FLAMMABLE &amp; EXPLOSIVE</p> <p>POTENTIAL ASPHYXIANT</p> <p>AS FOR NATURAL GAS; FROSTBITE BURNS IF CONTACTED OR INHALED</p> <p>BENZENE (CANCER-CAUSING)</p> <p>AS ABOVE</p>

<b>PIPELINE OPERATIONS</b>	
<b>OPERATION</b>	<b>HEALTH HAZARD</b>
PIGGING LINE (SCRAPING)	FLAMMABLE ATMOSPHERE: FIRE (BURNS) •EXPOSURE TO TOXIC CONTAMINANTS
START-UP/SHUT DOWN	INHALATION BENZENE, H <sub>2</sub> S AND HYDROCARBONS (PIGGING)
BLANKING/BLINDING	EXPOSURE TO ABNORMAL PRESSURES (PIGGING)
FILTER CHANGES	NOISE (PIGGING/ DEPRESSURIZATION)
MAINTENANCE	
MODIFICATIONS: PIPELINE EXCAVATION, HOT TAPS, HOUSEKEEPING	
EMERGENCY RESPONSE: SPILL/LEAK DETECTION, CONTAINMENT/CLEAN-UP, DEPRESSURIZATION	

## PETROLEUM REFINING

<b>REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
CRUDE OIL PRETREATMENT	DESALTING	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: AMMONIA, DRY CHEMICAL, DEMULSIFIERS, CAUSTICS/ACIDS  HEAT STRESS
FRACTIONATION	ATMOSPHERIC DISTILLATION (TOWER)  VACUUM DISTILLATION (TOWER)	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, AMMONIA, CHLORIDES, PHENOL MERCAPTANS  CHEMICAL BURNS  NOISE

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
TREATMENT	SOLVENT EXTRACTION AND SOLVENT DEWAXING	FIRE / EXPLOSION EXPOSURE TO TOXIC GASES/LIQUIDS: 1. PHENOL, FURFURAL, GLYCOLS, MEK  2. H <sub>2</sub> S, SODIUM HYDROXIDE (NaOH), SPENT CATALYST (MEROX), DUST, SWEETENING AGENTS (SODIUM CARB/BICARB) NOISE
	SWEETENING & TREATING PROCESS	FIRE / EXPLOSION EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, AMINES ( MEA, DEA, MDEA), CO
	UNSATURATED & SATURATED GAS PLANTS	

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
TREATMENT	AMINE PLANTS	FIRE / EXPLOSION EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, AMINE CMPDS, CO HEAT STRESS NOISE
	SOLVENT DEASPHALT PRODUCTION	FIRE / EXPLOSION EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, SO <sub>2</sub> , FORMALDEHYDE, POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
CONVERSION: THERMAL CRACKING	<i>VISBREAKING</i> COKING	FIRE / EXPLOSION EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, SO <sub>2</sub> , PAH CONFINED SPACE: <ul style="list-style-type: none"> <li>• OXYGEN DEFICIENT</li> <li>• NOISE</li> <li>• HEAT STRESS</li> </ul> BURNS: <ul style="list-style-type: none"> <li>• PHYSICAL</li> <li>• CHEMICAL</li> </ul>

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
CONVERSION: CATALYTIC CRACKING	<i>FLUID CATALYTIC CRACKING (FCC)</i> MOVING BED CATALYTIC THERMOFOR CATALYST	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, CO, HYDROCARBONS, PHENOL, MERCAPTANS, NICKEL CARBONYL  HEAT STRESS/ BURNS  NOISE
	HYDROCRACKING	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, AMMONIA, CO

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>FIRE / EXPLOSION</b>
CONVERSION	CATALYTIC REFORMING  ALKYLATION	EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, CO, BENZENE  NOISE  FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: SULFURIC AND HYDROFLUORIC ACID  CHEMICAL BURNS  NOISE

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
CONVERSION	CATALYTIC HYDROTREATING HYDRO- SULFUFIZATION	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> S, PHENOL
	ISOMERIZATION	
	POLYMERIZATION	FIRE / EXPLOSION
	HYDROGEN PRODUCTION	EXPOSURE TO TOXIC GASES/LIQUIDS: H <sub>2</sub> , HCl, DUST, NaOH, PHOSPHORIC ACID, CO, CO <sub>2</sub>

<b>HAZARDS IN PETROLEUM REFINING PROCESSES</b>		
<b>OPERATION</b>	<b>PROCESS</b>	<b>HAZARDS</b>
FORMULATING AND BLENDING	BLENDING	FIRE / EXPLOSION
	WAX MANUFACTURING	EXPOSURE TO TOXIC GASES/LIQUIDS: DUSTS, MISTS, VAPOURS, METALLIC SALTS, ADDITIVES
	LUBRICATING OILGREASE	
	COMPOUNDING	FIRE / EXPLOSION  EXPOSURE TO TOXIC GASES/LIQUIDS: DUSTS, MISTS, VAPOURS, METALLIC SALTS, ADDITIVES

## PRODUCT STORAGE

<b>PRODUCTS STORAGE FACILITIES</b>	
<b>ACTIVITY OR PROCESS</b>	<b>HEALTH HAZARD</b>
CLEAN-UP OF LEAKS OR SPILLS TANK CLEANING AND MAINTENANCE	FLAMMABLE ATMOSPHERE: IGNITION SOURCES - COMBUSTION ENGINES / POOR ELECTRICAL LIGHTING.  EXPOSURE TO TOXIC GASES / LIQUIDS  EXPOSURE TO LEAD, H <sub>2</sub> S (ANTI-KNOCK COMPOUNDS), DUSTS, HYDROCARBONS, BENZENE, WELDING FUMES (MAINTENANCE)  ASPHYXIATION ATMOSPHERE (MAINTENANCE)  NOISE (MAINTENANCE)

## **INTERNATIONAL STANDARDS**

The instructor will open the classroom up for discussion regarding Threshold Limit Values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH).

## ROUTES OF EXPOSURE TO PHYSICAL, CHEMICAL & BIOLOGICAL AGENTS

### *Routes of Exposure*

**Chemical agents usually enter the body by:**

◆ **Inhalation:**

- breathing airborne particles
- breathing gases or vapours

◆ **Dermal:**

- skin contact with liquids
- absorption of gases and vapours through skin

◆ **Gastro-intestinal (GI):**

- through accidental ingestion of contaminated food or water

◆ **Ocular:**

- unprotected eye contact with particles
- vapours or splashed liquids

**Physical agents include environmental stresses such as:**

- noise
- ionizing and non ionizing radiation
- pressure extreme
- temperature extreme
- vibration

**NOTE:**

All of these stresses can have a profound effect on the body.

**Biological agents, which come from a variety of indoor and outdoor sources, include:**

- fungi
- pollen
- bacteria
- viruses
- parasites

**Routes of entry include:**

- Direct contact – animal to human transmission via a bite or scratch.
- Indirect contact- workplace becomes contaminated and the infectious material is transferred to a host.
- Vector –borne infection: infectious substances are mechanically or biological transmitted by a living vector (mosquitoes, ticks).
- Airborne Inhalation: infectious particles are inhaled, e.g., Mycobacterium Tuberculosis.

## ***Sampling Strategies***

In general, an acceptable strategy is one that:

- prioritizes needs,
- optimizes resources,
- is readily implemented, and
- is cost effective.

**Sampling strategies depend on whether the sampling is for chronic or for acute exposure. Types of samples include:**

### **◆ Area Samples**

They are useful for evaluating “What if” situations in which a contaminant is suspected but not known.

### **◆ Personal Samples**

Personal sampling on workers can be on individuals or group of workers who have been determined to have the potential for exposure to the contaminant of interest.

## **Sampling Period**

Once the sampling purpose and corresponding strategy have been decided, the sampling period must be selected. This time depends on three main factors:

- the length of the workday or the task being performed;
- the expected concentration; and
- the standard for comparing the data.

A work shift is generally defined as 8 hours. A Time Weighted Average (TWA) refers to concentration of airborne toxic materials, which have been weighted for a certain duration, usually 8 hours.

Other sample periods used to calculate concentrations are Short Term Exposure Limits (STELs). These refer to the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between one exposure episode and the next.

## ***Resources for monitoring hazards in the workplace***

Reference locations, containing information related to all aspects of exposure monitoring, assessment and analysis in the Oil and Gas industry are:

1. Occupational Exposure Sampling Strategy Manual,  
<http://www.cdc.gov/niosh/77-173.html>
2. The Industrial Environment – Its Evaluation and Control  
<http://www.cdc.gov/niosh/74-117.html>
3. Analyzing Workplace Exposure Using Direct Reading Instruments and Video  
Exposure Monitoring Techniques <http://www.cdc.gov/niosh/92-104.html>
4. National Institute for Occupational Safety and Health (NIOSH) Manual of  
Analytical Methods, 4<sup>th</sup> Edition  
<http://www.cdc.gov/niosh/nmam/nmammenu.html>

## ***Exposure Monitoring Program***

For an occupational exposure-monitoring program to be effective, it needs to include the following components:

### **Phase #1: Identify occupational health hazards**

#### **◆ Interviews**

Interview operations supervisors, engineers, and workers to learn about processes, inputs and outputs. Ask what job tasks are performed that expose workers to toxic and dangerous conditions.

#### **◆ Review plant diagrams and floor plans**

Learn how departments are laid out, and where process equipment and materials are situated.

#### **◆ Walk-through survey/preliminary survey**

These surveys allow the Industrial Hygiene (IH) personnel to observe different work areas and processes. Control measures are identified and observed for their effectiveness. Preliminary surveys can be conducted at work areas or process equipment that known to produce toxic emissions, to quantify the significance of each hazard.

#### **◆ Review chemical/material inventory lists**

An inventory list of chemicals and materials used in the process should be reviewed.

#### **◆ Review reported plant/industry accident and illness statistics**

If possible, review past plant/operations injury and illness statistics to determine if there are injury or accident trends related to work place exposure.

### **Phase #2: Prioritize the hazards by criteria that include:**

- known severity of toxic/harmful contaminants
- number of workers exposed to contaminants
- possibility of worker exposure
- suspected magnitude of emission from visual walk-through survey observations
- number of health illness complaints and concerns related to each hazardous discipline

### **Phase #3: Quantify hazards through sampling**

Collection and analysis of samples can reveal the actual exposure of workers, degree of regulatory compliance, and the effectiveness of engineering controls. For a sampling program to be effective, a comprehensive sampling strategy must be developed.

Sampling Methodology is very important and greatly depends on the type and physical state of the contaminant. The most accepted methodologies, in use throughout the world by the Oil and Gas industry, have been developed by National Institute For Occupational Safety and Health (NIOSH), and are available on the Internet web site <http://www.cdc.gov/niosh/nmam/nmammenu.html>

This site provides methodology not only for collecting the samples but also for analyzing them.

#### **Phase #4: Introduce hazard exposure controls**

The sampling program will indicate areas in which hazards are being controlled adequately and other areas in which the hazard levels are unacceptable. Once the excessive hazards have been revealed, controls will need to be introduced to reduce the hazards to acceptable levels.

The instructor will initiate an open classroom discussion on hazard control methodologies.

#### **Phase #5: Ongoing monitoring**

After the new controls have been introduced, an ongoing monitoring program will be required to assess the effectiveness of the controls. If the ongoing monitoring program reveals any deficiencies, the control measures will need to be adjusted. In this way, working conditions will be improved continually.

## **EXERCISE #1**

### ***Case Study***

#### **PART 1**

- Gas plant in Fox Creek producing 20, 000 cubic meters of gas a day.
- Plant has 4 operators, 3 maintenance workers and 2 instrumentation technicians.
- Chemicals of interest from your preliminary survey indicated were: Benzene, N-Hexane, and THC (Total Hydrocarbon).
- Other concerns were welding, nuisance and respirable dust from sand blasting.
- The weather on the day of your visit is sunny with a mild wind.
- The plant's workload is considered average.

Given this scenario, and assuming an unlimited budget, outline your sampling strategies and give your reasons.

#### **PART 2**

##### **Lab costs for analyses are:**

- Aromatics \$100.00/sample
- Nuisance dust/respirable dust is: \$150.00/sample
- Welding fumes is: \$200.00/sample.

##### **Equipment rental costs:**

- Pumps: \$35.00/pump
- Calibrator (Dry Cal): \$25.00/day.
- Filters cassettes: \$15.00/cassette.
- Charcoal tubes package of ten: \$200.00/package.
- Direct read instruments: \$150.00/day.

Given a budget of \$5,000.00 for doing a sampling survey, outline a sampling survey for the gas plant in Fox Creek, and explain your reasons.

## SAMPLING INSTRUMENTATION AND ANALYTICAL METHODS – NIOSH

### *Active sampling*

Active sampling is the procedure for collecting the contaminant of interest from the air by using a filter assembly or tube that contains the appropriate adsorbent material, such as charcoal. Once the sample is collected, it must be analyzed to determine the content of the compound or contaminant of interest. The National Institute for Occupational Safety and Health (NIOSH) has assessed and standardized methodologies for analysis. They are described in NIOSH's Manual of Analytical Methods, 4<sup>th</sup> Edition

<http://www.cdc.gov/niosh/nmam/nmammenu.html>

#### ◆ **Active sampling equipment**

- **Detector tubes:** This is an inexpensive method that is less accurate than some other methods. It is used for grab sampling for instantaneous measurements (e.g., confined spaces).
- **Long-service detector tubes (continuous):** These operate on the same principle as regular detector tubes, but are designed to be used over a full work shift.
- **Electronic Monitors:** They can produce instantaneous results on digital displays or signal an alarm when an occupational limit is exceeded.
- **Sorbent Tubes:** Used for sampling organic vapours. The sorbent materials used include charcoal, silica gel, and porous polymer trade brands.
- **Bubblers:** Used for sampling sulphur dioxide and formaldehyde.
- **Gas Bags:** Can produce (don't you mean MEASURE) Short Term Exposure Limits (STELs). Gas bags are made from several materials, including Mylar, Saran, Teflon, Polyethylene, etc.

## ***Units of Measurement***

The units used for Industrial Hygiene data are based on a decimal system of weights and measures founded on the “kilogram” and the “meter.” This system is known universally as the Metric System.

The “meter” is the basic metric unit of length, and the “kilogram” is the basic unit of weight. These units can be kept in perspective by remembering the following:

One (1) meter = 39.4 inches and one (1) kilogram is = 2.2 pounds.

Metric units most commonly encountered in industrial hygiene work include “cubic centimeter”, “liter”, and “cubic meter” for reporting volumes, and milligrams for reporting weight.

### **ABBREVIATIONS FOR UNITS OF MEASUREMENT**

<b>Unit of volume</b>	<b>Abbreviation</b>
Cubic centimeter	cc (or cm <sup>3</sup> )
Liter	L
Cubic meter	m <sup>3</sup>
<b>Unit of weight</b>	<b>Abbreviation</b>
Microgram	ug
Milligram	mg
Gram	g

## Conversion Factors

Often it is necessary to convert from one unit of measurement to another.

<b>Units of Volume</b>	<b>To</b>	<b>Multiply by</b>
L	cc	1000
m <sup>3</sup>	cc	1000000
m <sup>3</sup>	L	1000

---

<b>To convert from</b>	<b>To</b>	<b>Divide by</b>
cc	L	1000
cc	m <sup>3</sup>	1000000
L	m <sup>3</sup>	1000

---

<b>Units of Weight</b>	<b>To</b>	<b>Multiply by</b>
mg	ug	1000
g	ug	1000000
g	mg	1000

---

<b>To convert from</b>	<b>To</b>	<b>Divide by</b>
ug	mg	1000
ug	g	1000000
mg	g	1000

**EXAMPLE:**

A sample volume is calculated to be 946 L and the lab reported the net amount (weight) of contaminant to be 0.0017g.

- Convert the sample volume to  $m^3$ .
- Convert the net amount of contaminant to mg.
- Calculate concentration in  $mg/m^3$ .

**SOLUTION:**

- $946 \text{ L} \text{ divided by } 1000 \text{ L}/m^3 = 0.946 \text{ m}^3$
- $0.0017 \text{ g} \times 1000 \text{ mg/g} = 1.7 \text{ mg}$
- $1.7 \text{ mg}/0.946 \text{ m}^3 = 1.8 \text{ mg}/m^3$

**Airborne Concentrations – Corrected to Standard Temperature and Pressure (STP)**

Airborne Concentration refers to the net amount of contaminant per specific volume of contaminated air. This term can be expressed mathematically by the following general equation.

$$\text{AIRBORNE CONCENTRATION} = \frac{\text{net amount of contaminant}}{\text{air sample volume.}}$$

**Units of Airborne Contaminant Concentrations**

Most commonly used in Industrial Hygiene work for expressing airborne contaminant concentrations.

- **$mg/m^3$** : A weight to volume ratio expressed as milligrams of contaminant per cubic meter of air.
- **ppm (parts per million)**: A volume to volume ratio expressed as parts of contaminant per million parts of air.
- **Fibre/cc (fibres per cubic centimeter)**: A special designation for asbestos and other fibrous materials expressed as the number of fibers of a specific length per cubic centimeter of air.

**NOTE:**

Note mg/m<sup>3</sup> and ppm are not linearly interchangeable but can be converted using the following formula:

$$\text{ppm} = \frac{(X) (24.45)}{(M.W.) (V)}$$

**Where X** = net amount of contaminant collected via air sampling, in mg

**M.W.** = molecular weight of the contaminant, g/mole

**V** = sample volume, m<sup>3</sup>

**NOTE:**

The above formula equation is *only* for sample air volumes at standard conditions of 25<sup>0</sup>C and 760 mm Hg.

**Corrected Sample Volume to Standard Temperature and Pressure (STP)**

The volume occupied by a constant number of molecules of a gas or vapour will expand with an increase in temperature and/or a decrease in barometric pressure, and vice versa.

When calculating the airborne concentration of gases or vapours, the sample volume should be corrected to a standard temperature and pressure (STP) of 25<sup>0</sup>C (degrees centigrade) and 760 mm Hg (millimeters of mercury), respectively. Calculating corrected volumes, absolute temperature, usually expressed in degrees Kelvin (<sup>0</sup>K) should be used in place of the centigrade scale, while barometric pressure is usually expressed in millimeters of mercury (mm Hg).

**FORMULA:**

$$V_s = \frac{P_a V_a (T_s + 273)}{P_s (T_a + 273)} = \frac{P_a V_a \times 298}{P_s (T_a + 273)}$$

**WHERE:**

- $V_s$  = sample volume at STP, in cc, L or  $m^3$
- $P_a$  = actual barometric pressure during sampling period, mm Hg
- $V_a$  = actual sample volume, in cc, L or  $m^3$
- $T_a$  = actual temperature during sampling period, in  $^{\circ}C$ ; ( $^{\circ}C + 273 = ^{\circ}K$ )
- $P_s$  = standard pressure, defined to be 760 mm Hg.
- $T_s$  = standard temperature, defined to be  $25^{\circ}C$ ; ( $25^{\circ}C + 273 = 298^{\circ}K$ )

Temperature is sometimes expressed in Fahrenheit ( $^{\circ}F$ ) and should be converted to  $^{\circ}C$  as follows:

$$^{\circ}C = \frac{(^{\circ}F - 32)}{(1.8)}$$

**EXAMPLE:**

Convert a sample volume of 41000 cc to STP, given the following sampling conditions:

- $T_a = 97^{\circ}F$
- $P_a = 741.7$  mm Hg

◆ **First Convert  $97^{\circ}F$  to  $^{\circ}C$ :**

$$\frac{(97^{\circ}F - 32)}{(1.8)} = 36.1^{\circ}C.$$

◆ **Next convert 41 000 cc to STP**

$$\frac{(741.7 \text{ mm Hg}) (41000 \text{ cc}) (25^{\circ}C + 273)}{(760 \text{ mm Hg}) (36.1^{\circ}C + 273)} = 38576 \text{ cc or } 38.6 \text{ L}$$

### ***Time Weighted Average Concentrations (TWA)***

In a typical work environment, an employee's exposure level to a particular contaminant may vary several times during the work shift (due to changes in job assignment, workload, ventilation conditions, processes, etc). It is desirable to know the extent of concentration changes during the full work shift. Now, in addition to having two or more short-term average concentrations, the time-weighted average concentration (TWA) for the entire shift can be calculated by integrating the short-term concentration values over the total time base of the sampling period, as follows:

- $$\text{TWA} = \frac{(C_1T_1 + C_2T_2 \dots C_n T_n)}{(T_1 + T_2 + \dots T_n)}$$

#### **WHERE:**

C<sub>n</sub> = concentration calculated from each short – term sample

T<sub>n</sub> = Length of sampling period for each short – term sample

#### **NOTE:**

T<sub>1</sub> + T<sub>2</sub> + ..... T<sub>n</sub>

Should be equal to eight (8) hours, or as close as possible.

#### **EXAMPLE:**

Two filters are used to sample an airborne nuisance dust. The results of sampling for 210 minutes and 270 minutes with the filters are 12.0 mg/m<sup>3</sup> and 7.4 mg/m<sup>3</sup> respectively.

Calculate the TWA.

$$\frac{(12.0 \text{ mg/m}^3) (210 \text{ min}) + (7.4 \text{ mg/m}^3) (270 \text{ min})}{(210 \text{ min} + 270 \text{ min})} = 9.4 \text{ mg/m}^3$$

## ***Noise: Principles and Monitoring Strategies***

The word noise is often used to mean “sound that is unwanted by the listener” because it is unpleasant. Noise interferes with the perception of wanted sound and is likely to be physiologically harmful.

Sound is usually applied to the form of energy that produces a sensation perceived by the sense of hearing in humans, while vibration usually refers to the non audible acoustic phenomena that are recognized by the tactile experienced of touch or feeling.

### ◆ **Noise: Concepts**

- **Sound waves:** Are a particular form of a general class of waves known as elastic waves. Sound waves only can occur in media that have the properties of mass (inertia) and elasticity. Because air possesses both inertia and elasticity, a sound wave can be propagated in air.
- **Frequency:** The number of times per second that a point on the sound source is displaced from its position of equilibrium, rebounds through the equilibrium position to a maximum displacement opposite in direction to the initial displacement, and then returns to its equilibrium position.
- **Wavelength:** The distance measured between two analogous points on two successive parts of a wave. Wavelength is the distance that a sound wave travels in one cycle.
- **Sound Pressure Level (SPL):** The level, decibels, of a sound is 20 times the logarithm to the base 10 of the ratio of the pressure of this sound to the reference pressure. This reference pressure must be explicitly stated.
- **Decibels (dB):** A unit used to express sound power level (L<sub>w</sub>). Sound power is the total acoustic output of a sound source in watts (W). By definition, sound power level, in decibels, is:  $L_w = 10 \log W/W_o$  where W is the sound power of the source and W<sub>o</sub> is the reference sound power.
- **Sound Pressure Weighting:** A weighting scheme to address frequencies in the same way as the human ear.

- A weighting scale was designed to approximate the equal loudness curves at low sound pressure levels (resembles the human ear).
- B weighting scale was designed for medium sound pressure levels, and
- C weighting scale was designed for high levels.

As a result of its simplicity, the A weighting scale has been adopted as the measurement for assessing noise exposure by the American Conference of Governmental Industrial Hygienists. (ACGIH).

### ***Monitoring Strategies***

**Sound measurements fall into two broad categories:**

#### **◆ Source Measurements**

These involve the collection of acoustical data for the purpose of determining the characteristics of noise radiated by a source.

#### **◆ Ambient noise measurements**

These range from studying a single sound level to making a detailed analysis showing hundreds of components of complex vibrations.

**Equipment used to conduct surveys can be one of the following:**

- sound level meters
- dosimeters

**NOTE:** The choice of equipment used depends on the information required.

#### **◆ Sound level meters**

Range in cost and sensitivity, and fall into the following types:

- Type I is the most sensitive in terms of microphones;
- Type II is less sensitive and
- Type O is the most sensitive and is used readily in laboratory settings.
- Type I, II are most commonly used in the field.
- Octave band analyzers are also used in the surveys of noise to determine where the noise energy lies in the frequency spectrum. They are useful when engineering controls of noise problems are planned, because industrial noise is

make up of various sound intensities at various frequencies. The identification of pure tone components, when present, is an extremely useful diagnostic tool for finding and quieting the noise source and assessing hearing protection.

◆ **Noise dosimeters**

Provide noise exposure profiles of workers during their work shifts.

### ***Preliminary Noise Surveys***

A hearing conservation program should start with a preliminary plant-wide noise survey using appropriate sound level measuring equipment to locate operations or areas where workers may be exposed to hazardous noise levels.

A noise survey should be carried out in a work area in which it is difficult to communicate in normal tones, or if, after working in an environment, the worker's hearing changes so that speech and other sounds are muffled for several hours, or if a worker develops ringing in the ears.

A preliminary noise survey normally does not define the noise environment in depth, and therefore should not be used to determine employee exposure time and other details.

**A preliminary survey simply supplies sufficient data that can be used to determine if a potential noise problem exists and to give some indication of its extent.**

### ***Detailed Noise Surveys***

From the preliminary noise surveys, it is relatively easy to determine specific locations that require more detailed study and attention. A detailed noise study should then be made at each of these locations to determine the employee's Time Weighted Average (TWA) exposure. The purpose of a detailed noise survey is to:

- obtain specific information on the noise levels existing at each employee's work station;
- develop guidelines for establishing engineering and /or administrative controls;
- define areas in which hearing protection is required; and

- determine those work areas where audiometric testing of employees is desirable and /or required.

**In addition, detailed noise survey data can be used to:**

- develop engineering control policies;
- procedures; and
- determine whether or not specific company, state, or federal requirements have been met.

## TECHNIQUES FOR CALIBRATING IH EQUIPMENT

### *Techniques for Calibrating IH Equipment*

In order to determine air concentration of chemical contaminants, it is necessary to measure accurately the amount of contaminant per unit volume of air.

By regularly calibrating equipment, sampling errors may be reduced, thus increasing confidence in obtained values. The frequencies of calibration depend on the use and care of the instruments.

All instruments should be calibrated as soon as they are received from the manufacturer, and before and after field use.

#### ◆ **Calibration Standards**

When calibrating air-sampling instruments used for monitoring chemical agents, calibration standards are distinguished as either primary or secondary. Usually, instruments for measuring physical agents are purchased complete with their own calibration devices.

#### ◆ **Primary Standard**

Primary Standards are defined as direct measurements of volume based on the physical dimensions of enclosed spaces. These measurements are not altered by changes in temperature or atmospheric pressures.

A common primary standard used by Industrial Hygienists is the “bubble meter”, which is connected to the sampling pump with tubing. The sampling media, with which the pump is to be calibrated, is placed in-line between the pump and the burette.

A soap bubble, formed in the bottom end of the burette, is pulled up by the sampling pump. The flow rate of the sampling pump, in conjunction with a particular collection medium, can be determined by timing the movement of the bubble from one marking to another (a known volume).



**DryCal DC-Lite Primary Standard Flow Meter**

### ***Secondary Standard***

Secondary Standards base their calibration upon primary standards, and may be affected by temperature or atmospheric changes. Their accuracy may also be altered by mishandling. Therefore, care must be taken when operating or transporting calibration devices. In order to assure valid reference measurements, secondary standards must be recalibrated periodically.

The rotameter is an example of a commonly used secondary standard in industrial hygiene. It consists of a free moving float within a vertically tapered tube. Air moving up the tube causes the float to rise in proportion to the amount of airflow. The height of the float (usually determined at the maximum diameter of the float) indicates flow rate and can be measured on a scale attached to the tube.

## ***Instrumentation For Monitoring Chemical, Biological & Physical Agents***

There are a large number of instruments available to the Industrial Hygienist to do the monitoring for the above agents. Here are a few actual instruments that can be rented to do the surveys:

### ◆ **Chemical:**

- Gastec 830 Hand pump
- Drager Accuro hand pump
- SKC 224-PCXR4 sampling pump
- MSA Escort ELF sampling pump
- GAST High flow sampling pump

### ◆ **Physical:**

- Quest 2900 Sound Level Meter
- Quest Q 300 Noise Dosimeters
- Bruel & Kjaer 2238 Mediator Sound Level Meter
- Ludlum 3-97 NORM meter
- Light meter
- Quest Questemp 15 Heat stress monitor

### ◆ **Biological:**

- RCS Microbial Sampling pump
- AGAR Strips for RCS (Rose Bengal)

**All of the instruments used for practical demonstrations in the Industrial Hygiene portion of this training have been provided by:**

**Mr. Kae Schummoogum, P. Eng.  
Enviro Rentals  
Calgary, Canada  
Telephone (403) 276-2532**

**Enviro Rentals sells and rents industrial hygiene equipment worldwide.**

## ***Calibration of Noise Equipment***

Due to the technological diversity of sound measuring equipment, it is recommended that the user follow the manufacturer's calibration procedures.

- In all cases, it is important to calibrate before and after use.
- Battery life should also be checked routinely.
- Because of extreme sensitivity, noise equipment should always be handled with extra care.
- It is recommended that all noise equipment be returned to the manufacturer for recalibration preferably on an annual basis.

## ***Other Recommended Equipment that can be used***

There are other instruments and equipment that can be used to provide monitoring data for the agents already mentioned. They include:

- Alnor Balometer Jr. – Airflow measurements for Ventilation.
- Enviro HW 4000-4 H<sub>2</sub>S monitor
- RKI Eagle LEL PPM Hydrocarbon Monitor
- Photovac 2020 Photoionisation detector
- Ultra Rae Benzene Detector
- Tracer Micro ELF Magnetic Field Meter.
- Passive Badges – 3M 3500 Models.
- Impingers
- Charcoal tubes.
- Filters, Matched Weight, PVC
- Silica Gel
- Cyclones
- Gas Bags
- Etc.

## **EXERCISE #2**

### **◆ Calibrate these sampling pumps to a flow rate of:**

- 1 L/ minute
- 500 ml/minute
- 50 ml/minute

### **◆ Calibrate these noise dosimeters to the following parameters:**

- Response rate SLOW
- Filter A WEIGHTING
- Exchange Rate 3 dB
- Cut offs 80, 90 dB
- Ceiling 115 dB
- Dose Criteria 85 dB
- Dose Criteria Length 8hr

Calibrate this Sound Level Meter according to the manual. Calibrate the other equipment present according to its manual.

# VENTILATION

## *Purpose of Ventilation*

In order to limit the potential of employee exposure to airborne contaminants and to comply with applicable governmental regulation, it is necessary to keep employee exposures below required levels. Well-designed ventilation systems help to prevent or control:

- fire and explosions
- heat and humidity for comfort/health
- noxious odors
- exposure to airborne contaminants

## *Definitions*

### **Some common terms to note:**

- Face Velocity: Linear flow rate of air across the opening or face of a hood.
- Static Pressure: The potential pressure exerted in all directions by air at rest.
- Slot Velocity: Linear flow rate of air through a slot.

## *Principles of Air Flow:*

The flow of air between two points is due to the occurrence of pressure differences between the two points. This pressure difference causes air to flow from the high pressure zone to the low pressure zone. The basic air formula to derive quantity of air flow is stated as:

$$Q = VA$$

### **WHERE:**

Q = Volumetric Flow rate, cubic feet per minute (cfm)

V = Air velocity, linear feet per minute (fpm)

A = cross sectional area through which air flows, squared (ft<sup>2</sup>)

This basic relationship describes the flow of air under all conditions.

## ***Types of Ventilation Systems***

### **◆ Dilution Ventilation (General):**

Process by which outside, uncontaminated air is mixed with inside air for comfort and contaminant control. An example of comfort control, hot, moist air may be replaced with cooler, dryer air from an outside source. Because this type of ventilation disperses, but does not substantially remove airborne contaminants, dilution ventilation has a limited efficiency in contaminant control.

This system should only be used when the contaminant(s) present is of known low toxicity and the contaminant sources are at constant locations having a uniform rate of generation. Even if the above criteria are met, this type of ventilation may be successful in controlling organic vapors but is seldom effective in controlling fume and other particulate air contaminants.

### **◆ Local Exhaust Ventilation:**

A local exhaust ventilation system is designed to control airborne contaminant levels by capturing the contaminant(s) at or near the source. This system usually contains a hood and ductwork, leading to an air cleaning device for air pollution control, before it is finally exhausted to the outside.

If the system is designed properly, contaminants can be controlled at their source of origin to minimize the potential of employee overexposure. However, because this system relies on mechanical removal methods, periodic, routine maintenance is essential.

## ***Ventilation Tests:***

**The value of obtaining ventilation test data is noted in the following applications:**

- To record the initial performance of the system and determine if it is functioning in accordance with specifications.
- To determine the degree of compliance with applicable code or trade association standards.
- To determine whether the system has sufficient capacity for additional ductwork or other alternations.
- To obtain data through periodic checks to determine whether maintenance or repair is necessary.
- To provide data to assist the design of future systems.

### **Initial Testing:**

If a new system evaluation must be conducted, ensure that the industrial hygienist is consulted along with other personal responsible for the ventilation systems.

### **Periodic Testing:**

Periodic testing should also be made to determine the performance of the system. If there have been no alterations to the system, this can be done manually by close visual inspection and face velocity measurements (hoods). All periodic measurements can also be made continuously by means of an operating console or other remote readout system.

If the system is not working properly, the following should be performed:

Inspect the system for physical damage and/or component malfunction. This can be achieved by checking all motors; belts for slippage, breaks or tears; fans for accumulated dust, bent or missing blades; and ducts for obstructions, cracks or dents.

For hoods, face velocity measurements should be taken and compared with previous values. Determine if fan is rotating in proper direction.

### ***Instrumentation Applications:***

Initial information required to assess ventilation system performance includes the measurements of air volume in cfm's. This determination should be performed prior to initial start-up and periodically thereafter. Common used instruments are of the velocity –measuring type rather than quantity meters. Therefore, it is necessary to obtain both the average air velocity through an opening or duct and the net cross-sectional area at the point of measurement. The quantity of air can then be determined from the equation:  
 $Q = VA.$

#### **◆ Regulations:**

All ventilation systems should conform to applicable standards or recommended guidelines. Industry standards are usually developed by consulting with a specialist, a leader in Industry Ventilation, Mr. D. Jeff Burton. PE, CSP, CIH. He is the prime consultant to industry when ventilation matters occur. His books have become industry standards for Industrial Ventilation. Some of his sources include:

Industrial Ventilation Workbook, Fourth Edition. ISBN 1-883992-04-4

IAQ and HVAC Workbook ISBN 1-883992-16-8

Or visit his web site at [www.eburton.com](http://www.eburton.com)

# ILLUMINATION

## *Illumination Principles*

Adequate, well balanced levels of illumination are essential in establishing safe, comfortable working conditions. While there is no evidence that poor lighting will cause eye defects, proper illumination levels have been shown to promote efficient work performance, reduce accidents and improve morale and housekeeping.

## *Lighting Terminology:*

**Luminous Intensity/Candle Power:** Luminous intensity, sometimes referred to as candle power, indicates the quantity of light a source emits in a given direction. The unit of luminous intensity is the candela.

**Lumen:** The lumen(lm) is the unit of light output from a light source.

**Illumination Level:** The amount or quantity of light falling on a surface is referred to as the illumination level and is measured in foot candles (fc). In metric units, illumination is measured in lux.

**Luminance:** The measure of the amount of light emitted or reflected from a certain area of a surface is known as luminance or photometric brightness. It is measured in foot lamberts (fl) when the area of surface is in square feet.

**Reflectance:** The measure of how much light is reflected from a surface is reflectance. It is the ratio of the luminance of a surface to the illumination on the surface(reflectance= $\frac{\text{luminance}}{\text{illumination}}$ ).

**Lamp:** A lamp is a man-made lighting device.

**Luminaire:** A luminaire is a complete lighting device consisting of one or more lamps together along with dedicated accessories.

### ***Electric Light Sources:***

The two main sources of illumination are daylight and electric light. Since daylight is obviously not always available, electric light sources must be provided. Some electric light sources used in industry:

- **Incandescent Lamp:** Consists of a tungsten filament inside a partially evacuated glass globe. Resistance to electrical current causes the filament to become heated and emit light.
- **Mercury Vapor Lamp:** Light is produced by an electric current passing through mercury vapor.
- **Metal Halide Lamp:** Provide color rendering that is superior to the presently available phosphor coated mercury vapor lamps. The metal halide lamps contain various metal halides in addition to mercury vapor that are partially vaporized and then dissociated into halogen and metal. As the two become cooled off, they recombine and continue the cycle.
- **High Pressure Sodium Lamps:** Light is produced by electricity passing through sodium vapor. Xenon is the starting gas in the arc tube where light is produced.

### **Maintenance:**

Not only should the lighting be properly designed and coordinated with its environment, but it also should be maintained on a regular basis.

- Six causes of light loss that must be accurately assessed:
  - temperature
  - voltage
  - deterioration of luminaries
  - lamp lumen depreciation
  - lamp burnouts
  - dust accumulation

### ***Illumination Requirements for Industry:***

There is no existing standard governing illumination levels. Industry has an obligation to provide adequate, safe lighting in its work environment. Brightness ratios, glare and intensity are the three qualities of light taken into consideration by the Illumination Engineering Society Of North America. IES Lighting Handbook. 1987. This book provides recommended illumination levels depending on task.

### ***Light Surveys:***

In evaluating the lighting in any environment it is important to know how to make a meaningful survey. This requires understanding the instrumentation as well as survey methods.

**Instrumentation:** Illumination (light) meters contain a light sensitive cell, which is activated when struck by radiant energy. The electrical output of the cell is converted to a meter readout in foot candles (illumination level).

### **Survey Methods:**

In measuring illumination, several things should be taken into consideration when using the aforementioned instrumentation.

- The operator of the instrument should avoid casting a shadow on the light sensitive cell while taking light readings.
- The measuring instrument should be on a horizontal or vertical plane at an appropriate height, depending upon the task/area being evaluated.
- Mercury or fluorescent lamps should be lit at least an hour prior to measuring their output.
- Illumination measurements of a specific task should be taken with the employee in the normal working position.
- Lights, shields, fixtures, lamps etc. should be clean.

**When making a light survey the following information is important to record:**

- Description of the area and its dimension, color, reflectances and conditions of room surfaces.
- Description of general and supplementary lighting systems, quantity, condition, wattage, spacing and lamp types.
- Description of instrumentation used.
- Illumination measurements.

## SAMPLING DOCUMENTATION

### *Sampling Documentation*

**After a sample has been taken, it is important that it be labeled properly for:**

- Cross –reference to the documentation sheet containing descriptive information of the location, employee, sampling conditions, and methods used for sampling.
- Identification of the analysis for a particular sample by the laboratory.

Labeling provides one method of identifying the sample in the “chain of custody” between the person taking the sample, the shipper and the laboratory. Documentation of the “chain of Custody” is extremely important for legal purposes in documenting the integrity of the sample results. If a number of samples are collected, each sample must contain its own label and be identified by its own sample number.

### *Handling and Shipping*

Because many air contaminants react or change their characteristics when exposed to sunlight, or temperature changes, etc., care should be taken when handling samples to protect them from these environmental factors.

Upon completing monitoring work, all industrial hygiene samples should be promptly processed. If shipping is delayed, hydrocarbon samples should be stored in a cool, dark environment.

In the case of impingers or bubbler samples (fragile), excessive sunlight and/or heat may affect not only the collected contaminant but also the reagent. The laboratory supplying the reagent media or doing the analysis should be consulted prior to sampling to determine specific storage-handling requirements.

In Canada the shipping requirements have changed according to Transportation of Dangerous Goods (TDG) for samples. Since August 15, 2002, TDG has gone through a change called TDG Clear Language and in its mandate for samples collected in the field

for analysis is exempt from the regulations, provided that samples are less than 10 kg in total weight. It is important that the samples are shipped in containers that meet the needs of the transportation of these samples safely. The samples need to be marked “test samples” to indicate that they indeed are samples to be analyzed. Refer to TDG regulations (Clear Language Edition), Part 1 (General) Section. 1.19 subsections (1), (2).

International, various federal agencies have regulations concerning shipment of toxic or hazardous materials, which must be followed when shipping samples. Please consult with the authorities in your area for proper protocol.

### ***Record Keeping***

It is very important that all records concerning Industrial Hygiene data be kept on file and confidential. Data from these measurements are on workers' exposures and therefore are restricted. Employees who participated in the sampling survey need to be notified by the person who sampled them or a manager of the department. Questions concerning the results need to be addressed, and concerns from the data collected need to be handled promptly.

## HEALTH MONITORING

### *Health Monitoring/Health Surveillance in the workplace*

Prevention of occupational illness and disease in a workplace can involve more than just monitoring the work environment for chemical or physical contaminants (industrial hygiene). Health monitoring, consisting of medical screening and medical surveillance, can be used to determine the current health of the exposed workforce and to aid the health and safety professional/department in the prevention and control of occupational health hazards.

#### ◆ **Medical Screening:**

Used interchangeably with medical surveillance. Similar to medical surveillance, screening refers to the application of medical tests and procedures to identify illnesses or disorders. However, the difference lies in the fact that screening is used to test health status of workers in relation to known or potential health risks, or health/physical requirements (e.g. motor skills or drug use, handling heavy equipment in populated areas). Results from medical screening can also be used as a health baseline for orientated workers. After periodic tests the workers' health status can be compared to the original screening results to determine if the workers' health has changed as a result of workplace exposure.

#### ◆ **Medical Surveillance:**

Involves subjecting individual workers, who may be at risk for occupational illness, to medical tests and procedures. These are conducted periodically over time of employment (e.g. annually) to determine if occupational illness/disorders may be present, or if workers are over-exposed to workplace contaminants/toxins.

#### ◆ **Occupational Hazard Surveillance:**

monitoring of exposure to chemicals and other toxic agents in the workplace (usually using industrial hygiene techniques).

## ***Effectiveness of Treatment***

### **Benefits to Management**

Health monitoring (medical & Surveillance screening) when used in the workplace can be very beneficial to the company that implements these programs if used appropriately. Health monitoring can be used to detect overexposure to toxic agents (e.g. phenol in blood can indicate high exposure to benzene, and skin dermatitis can indicate dermal exposure to crude oil), then it should only be used as a supportive tool to environmental exposure monitoring.

**Secondly, if used to detect disease/illness among asymptomatic person then two key factors need to be addressed:**

- Tests must be accurate and specific enough to detect illness related to specific workplace exposure; and
- There are advantages of detecting the illness/disorder that is being tested for, such as the illness of detected early can be treated or symptoms alleviated with therapeutic intervention.

**True motivation and advantages for employers having a health-monitoring program are:**

- to comply with mandatory government regulations.
- to maintain a healthy work force through detection and treatment of non-occupational disorders.
- to ensure that workers are fit to perform the tasks of the job.
- to conduct epidemiological surveillance to detect patterns of exposure and diseases.

### **Benefits to Workers**

Detecting an illness is important so that treatment can be given early and the worker's health can be maintained. This has obvious benefits to the worker himself and to his family. This also saves the employer, the industry and the health care system from further losses and expenses.

For example, a worker might experience a Noise Induced Hearing Loss (NIHL). If the problem is noticed early enough, and the worker is removed from the noisy environment, his hearing can be saved. This preserves the worker's quality of life, helps to keep him at maximum productivity for the company, and helps to prevent him from becoming a burden to the health care system.

### ***Effectiveness of Controls***

Test results that indicate high or overexposure to workplace contaminants/toxins or show a presence of workplace related diseases might indicate that workplace controls that are in place are not effective. Engineering controls (e.g., local ventilation), administrative controls (e.g. job procedures) or personal protective equipment (PPE) could be either ineffective due to inadequate design, equipment failure, or failure to follow safe work practices.

### **EXERCISE #3**

Review a light meter and conduct a light survey at office.