CHE 517: Industrial Hazard and Air Pollution

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Industrial Hazard

- Hazard is a physical situation with a potential for human injury, damage to property and environment or some combination of these.
- Hazards may be natural or technological.
- Natural hazards: earthquake, floods, drought, landslides
- On the other hand, technological hazards are the threats to people and life-support systems that arise from the mass production and transportation of goods and services.
- Industrial hazard is a type of technological hazard

Approach to Hazard Classification

- starr’s (1969) division based on involuntary or voluntary exposure
- Row’s (1977) scheme based on general risk factors
- Slovic (1987) for example, uses the public perception of risks to develop the categories of risky technologies
- Another approach is to use the broad-based activities or technologies that cause or create environmental risks
- low probability/high-consequence events and high-probability/low-consequence events.

One of the most sophisticated schemes was developed by Hohenemser, Kates and Slovic (1983) that describe the seven-class taxonomy on a three-fold scale of severity based on 12 attributes or descriptors of the risk

Classification of Technological Hazard

S/N	Class	Example
1	Multiple extreme hazards	Nuclear war, radiation
2	Extreme hazards	
3	a) Intentional biocides	Antibiotics, vaccines
4	b) Persistent teratogens	Uranium mining, rubber manufacture.
5	c) Rare catastrophes	LNG explosion, air plane crashes.
6	d) Common killers	Auto crashes, coal mining (black lung).
7	e) Diffuse global threats	Fossil fuel, ozone depletion.
8	Hazards	Food activities, appliances.

Sources and Types of Industrial Hazard

- **Fire**
  - **Flame Jets**
  - **Vapour or Dust Cloud Fires**
  - **Liquid Pool Fires**
  - **Fire involving Flammable Solids**
  - **Fire involving Ordinary Combustibles**
- **Explosion**

An explosion is a sudden increase in volume and release of energy in a violent manner, with the generation of high temperatures and the release of gases. An explosion cause pressure waves in the local medium in which it occurs. Explosion may be natural or artificial.

  - **Container or Tank Over Pressurization Explosions:** These events are a result of excessive pressure within a sealed tank or container and are deemed non-thermals.
  - **Dust Explosion:** An explosion which results from the ignition of a mixture of finely divided combustible solids and air.
  - **Gas or Vapour Explosion:** Like airborne dusts, a gas or vapour within flammable or explosive limit concentrations may cause a deflagration, explosion or detonation upon ignition.
  - **Condensed Phase Explosion:** When the substance that explodes or detonates is a liquid or a solid, the event is often called a condensed phase explosion or detonation.
  - Boiling Liquid Expanding Vapour Explosion (BLEVE): BLEVE occurs from the sudden release of a large mass of pressurized liquid to the atmosphere resulting from an external flame impinging on the shell of a vessel above the liquid levels, and weakening the shell cause sudden rupture.

- Toxic Release
  - **Type of Toxic Effects:** Most toxic substances can be classified as irritants, asphyxiants and narcotics, systemic poisons, sensitizers, carcinogens, mutagens, and/or tetragenic substances. Irritants are substances with the ability to cause inflammation or chemical burns of the eyes, skin, nose, throat, lungs and other tissues of the body, which may come in direct contact.
  - **Instantaneous Vs. Continuous Discharges:** For the most common methods available for the assessment of vapour/gas dispersion hazards, it is required that discharges of vapour or gases into the atmosphere be classified as either being instantaneous or continuous in duration. Instantaneous discharges are those that take place over the course of few seconds or a minute or so and then stop for all intents and purposes. The result of such a discharge is typically a puff of vapour or gas or a distinct cloud. On the other hand, continuous discharges take place over a longer periods of time and procedure long stretched-out plumes of gas or vapour such as those typically seen from continuously operating smokestacks. These represents the two extremes by which contaminate emissions may be characterized.
  - **Toxic Release Parameters:**

Numerous factors influence the size and shape of downwind hazard zones resulting from vapour or gas discharges into the atmosphere. The factors are as below:

- **Toxic or flammable Limit Selection on Hazard Zone Size:** The concentration of an airborne contaminant decreases with increasing distance along the downwind direction of the cloud or plume path as well as in the crosswind direction.
- **Discharge Rates and Amounts:** In case of instantaneous release, the total amount (i.e. weight) of vapour or gas released to the atmosphere has an impact on the size and shape of downwind hazard zone.
- **Atmospheric Stability Conditions:** The time of a day, the strength of sunlight in the area, the extent of cloud cover and the wind velocity will play an important role in determining the level of turbulence in the atmosphere and thereby the distances downwind over which airborne contaminants will remain hazardous.
- **Gas or Vapour Buoyancy:** The overall behaviour of a cloud or plume can be very different than that of a neutrally or positively buoyant cloud or plume and the shape and dimensions of the cloud or plume can be strongly influenced by the duration of the discharge, prevailing atmospheric stability conditions and prevailing wind velocities.
- **Source Elevation**
- **Physical State of Contaminants**

INDUSTRIAL HAZARD RISK ASSESSMENT

- Risk Assessment in its broad definition is a structured procedure that evaluate qualitatively and/or quantitatively the level of risk imposed by the hazard sources identified within the installation.
- Industrial hazard risk assessment at hazardous industrial facilities is an integral part of industrial safety management. In other words, risk assessment is a systematic procedure for describing and quantifying the risk associated with hazardous substance, processes, actions or events.
- The main goals of risk assessment at hazardous industrial facilities are to provide information related to industrial safety, most hazardous points in terms of safety and reasonable recommendations to reduce the risk

The risk assessment process includes the following major phases

- Hazard Identification: Location, identification and characterization of potential source and accident site within the jurisdiction or locality concerned in the process is referred to as hazard identification.
- Probability Analysis: Evaluation of the likelihood of individual accident in a process is called probability analysis.
- Consequence Analysis: Evaluation of the consequences and impact associated with the occurrence of postulated accident scenarios in a process is referred to as consequence analysis.
- Risk Analysis: Combination of results from the accident probability and consequence analysis efforts to provide a measure of overall risk associated with the specific activity or activities being studied in a process referred to as risk analysis.

- The scope of Risk Assessment and of all the methods that have been developed for this is recognized as: “to improve the safety of the hazardous installations and to minimize the risk imposed on the surrounding population”.

Methods for Industrial Hazard Risk Assessment

- Rapid Ranking Method
- Qualitative Method
- Quantitative Method
- Semi-Quantitative method.

Effects of Air Pollution

- If present in small concentrations in human blood, carbon monoxide may cause reduction in oxygen-carrying capacity of the blood which may lead to death.
- atmospheric sulphur dioxide concentration is not detectable by odour but its adverse effects on health, vegetation and buildings can be readily observed. In the atmosphere, it reacts with water during rainfall to form sulphuric acid which is experienced as acid rain whenever it is present in high concentration.
- In addition, SO_2 acts as precursor to formation of other pollutants, like particulate matter. If present in small concentration in human blood, it also causes reduction in oxygen-carrying capacity of the blood which may eventually lead to death.

- Oxides of nitrogen may worsen asthma and possibly increase susceptibility to other infections while its environmental effects may include acid rain formation as well as being precursors to ground level ozone
- Impacts of the secondary air pollutants depend among other factors on the primary species interacting for their production and the resulting products. Adverse respiratory effects can occur due to their impacts on human and some of the products may be toxic.
- The presence of sulphate may influence emission of methane in peat sites thus creating further air pollution problems.
- acid rain continues to threaten sensitive aquatic and terrestrial ecosystems in some countries of the world
- groundwater can be acidified down to pH 4.4 due to its impact (Sox), an indication that agriculture in such an environment may be negatively affected

- Sulphuric acid, its major constituent, may impact negatively on historical buildings and it may decrease cement strength as well as affecting stone monuments made of marble and limestone.
- Ozone is a strong photochemical oxidant; its elevated concentrations in ambient air cause serious health problems and damage to ecosystems, agricultural crops and materials
  - decrease in pulmonary function in children, adolescents and young adults
- exposure of ecosystems and agricultural crops to certain level of ozone can result in visible foliar injury and in reductions to crop yield and seed production
- materials such as natural and synthetic rubbers, coating and textiles can also be affected by ozone while its synergistic effects in combination with the acidifying components SO_2 and NO_2 have been reported to lead to increased corrosion on building materials like steel, zinc, copper, aluminium and bronze.

Table 1: Threshold Values for Ozone Concentration

Threshold for:	Concentration (µg/m^3)	Averaging Period (h)
Health protection	110	8
Vegetation protection	200	1
	65	24
Informing the population	180	1
Warning the population	360	1

- Particulate (PM)contribute to both light scattering and absorption of radiation with consequential visibility and climate effects (PM do reduce visibility).
- They produce brighter clouds that are less efficient at releasing precipitation. These in turn may lead to large reductions in the amount of solar irradiance reaching Earth's surface, a corresponding increase in solar heating of the atmosphere, changes in the atmospheric temperature structure, suppression of rainfall, and less efficient removal of pollutants
- PM other impacts may include health which is chronic mortality in adult and infant; asthma and other lower respiratory symptoms; and chronic bronchitis.

Air Pollution Control

- Air pollution control can be divided into three broad categories including:
  - process change/raw material change;
  - abatement of pollution after formation; and
  - dispersion of pollutants.
- Process Change: Adoption of process change in the control of air pollution may include process route change, process raw material change, or process equipment re-design. It may also be a combination of any of these.
- Abatement of pollution after formation: this approach involves the use of air pollution control equipment. The equipment will depend on
  - the sources of air pollutants,
  - type of air pollutants and
  - the targeted reduction level among other factors.
  - They may be mechanical collectors, electrostatic precipitators, baghouses, venture scrubbers, combustion equipment (flares, incinerators) absorption and adsorption equipment.

- Dispersion of Pollutants: Due to possible reduction in air pollutant levels that can be achieved through dilution, pollutants can be dispersed via stack away from point of origin to mix with more air. However, effort have to be made to ensure that the desired concentration is achieved by using stack of appropriate dimensions with correct exit velocity.

To ascertain that polluters control their air pollutants to save level, there are usually regulatory agencies put in place. In Nigeria:

  - the Federal Environmental Protection Agency set up in 1988 which metamorphosed into
  - Federal Ministry of Environment in 1999 and now being repackaged as
  - the National Environmental Standards and Regulation Enforcement Agency (NESREA).

Usually, these bodies set up the General Air Quality which are

1. Air Quality standards (AQS) and
2. the Emission standards.

The Air Quality Standards are set to protect living organisms like plants, animals and human beings while the Emission Standards prescribe how much of pollutant each industry can emit into the environment(note Compliance monitoring). Usually, for this system to work.

- The air quality standards prescribe the permissible levels of contaminants (or pollutants) covered in the standards.
- There are 2 types – Primary and Secondary Air Quality Standards.
  - The primary AQS are set to protect human health but not necessary to prevent other known effects while
  - the secondary Air Quality Standards are set to prevent all other effects

Table 2: Nigeria Ambient Air Quality Standards

Pollutants	Time of Average	
Particulates	Daily average of hourly Values 1 hour	250 µg/m^3 *600 µg/m^3
Sulphur oxides (Sulphur dioxide)	Daily average of hourly Values 1 hour	0.01 ppm (26 µg/m^3) 0.1 ppm (µg/m^3)
Non-methane Hydrocarbon	Daily average of 3-hourly values	160 µg/m^3
Carbon monoxide	Daily average of hourly Values 8-hourly average	10 ppm (11.4 µg/m^3) 20 ppm (22.8 µg/m^3)
Nitrogen oxides (Nitrogen dioxide)	Daily average of hourly Values (range)	0.04 – 0.06 ppm (75.0 µg/m^3 – 113 µg/m^3)
Photochemical oxidant	Hourly values	0.06 ppm

Table 3: Air Pollution Episodes

Location	Excess Deaths	Illness	Causative Agents
Meuse Valley, Belgium December 1930	63	6000	Probably SO_2 and oxidation products with particulates from industry – steel and zinc.
Donora, Pennsylvania October 1948	20	7000	Not proven: particulates and oxides of sulphur, probably from industry – steel and zinc, temperature inversion
Poza Rica, Mexico 1950	22	320	H_2S escape from pipeline
London, England December 1952 January 1956 December 1957 January 1959 December 1962 December 1967	4000 1000 750 200 – 250 700 800 – 1000	Increased - - - - -	Not proven: particulates and oxides of sulphur, probably from household coal-burning; fog - - - - -
New York November 1953 October 1957 January - February 1963 November 1966	 165 130 200 – 400 152168	 - - - -	 Increased pollution Increased pollution SO_2 unusually high (15 ppm maximum) Increased pollution and inversion
New Orleans, Louisiana October 1955 1958	 2 -	 350 150	 Unknown Believed related to smouldering city dump
Seveso and Meda, Italy July 1976	Unknown Long-term	200+	Dioxin, an accidental contaminant formed in the manufacture of 2,4,5-trichlorophenol and hexachlorophenol – a bactericide
Bhopal, India December 1985	2000 - 5000	8000 disabled, 200,000 injured	Leak of methyl isocyanate from pesticide factory
Chernobyl, Soviet Union April 1986	31 on site, more than 300 total	130,000 evacuated; 6000 workers	Nuclear power plant accidental release, explosion and fire