

Risk Management in Practice

Lecture 7 : Managing Risk Exposure to Hazardous Substances and Physical Agents

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**Undergraduate Diploma in
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Lecture Aim

The aim of this lecture is to equip students with a clear understanding of how hazardous substances and physical agents enter the body and how exposure can be effectively reduced through informed planning and control strategies. Students will examine key exposure pathways (inhalation, dermal contact, and ingestion), and explore how workplace design, safe handling practices, and process modifications can minimise risk. The lecture also introduces major physical agents, including noise, vibration, radiation, and temperature extremes in detail, and their effects on worker health, safety and performance. Emphasis is placed on interpreting exposure limits, applying regulatory standards, and using monitoring and assessment methods to identify risks, ensure compliance, and support proactive workplace health and safety management.



Lecture Objective

1. Identify and explain the main exposure pathways for hazardous substances, including inhalation, dermal contact, and ingestion.
2. Describe common physical agents (noise, vibration, radiation, and temperature extremes) and assess their potential impacts on worker health and performance.
3. Interpret occupational exposure limits and apply relevant regulatory standards and workplace guidelines.
4. Evaluate exposure monitoring and assessment methods, such as air sampling, noise measurement, and health surveillance.
5. Plan and recommend effective control strategies to reduce hazardous exposures and improve workplace health and safety.



Hazardous Substances?

- **Definition of hazardous substances**

Hazardous substances include chemicals, biological agents, dusts, fumes, and vapours capable of causing harm.

- **Common workplace sources**

Found in manufacturing, healthcare, laboratories, construction, agriculture, and cleaning activities across workplaces.

- **Chemical hazards**

Chemicals may be toxic, corrosive, flammable, or reactive, posing immediate or long-term health risks.

- **Biological agents**

Bacteria, viruses, fungi, and bloodborne pathogens can cause infections, allergies, or serious occupational diseases.

- **Dusts and fumes**

Generated during cutting, grinding, welding, or combustion, easily inhaled and damaging respiratory systems.

- **Importance of understanding exposure**

Understanding exposure routes enables effective controls, prevents illness, improves safety, and ensures regulatory compliance.



Forms Hazardous Substances?

- **Dusts** – Fine solid particles generated from cutting, grinding, drilling, or sanding materials.
- **Fumes** – Very fine airborne particles formed when metals are heated, welded, or vaporised.
- **Vapours** – Gaseous form of substances normally liquid or solid at room temperature.
- **Gases** – Substances that exist in gaseous state, such as carbon monoxide or chlorine.
- **Mists** – Liquid droplets suspended in air, often from spraying, mixing, or machining fluids.
- **Smoke** – Airborne particles and gases produced by combustion or burning materials.



Hazardous Substances Enter the Body?

Inhalation

Inhalation is the most common route of exposure in workplaces where hazardous substances are present in the air. Dusts, fumes, vapours, mists, and gases can be breathed into the lungs during normal work activities. Once inhaled, these substances may irritate the respiratory system or pass into the bloodstream, causing both short-term effects such as coughing or dizziness and long-term illnesses including asthma, lung disease, or cancer.

Dermal Contact

Dermal exposure occurs when hazardous substances come into contact with the skin. Liquids, solids, and contaminated surfaces can allow chemicals to be absorbed through the skin or cause irritation, burns, or allergic reactions. Some substances can enter the bloodstream through intact skin, leading to systemic health effects. Prolonged or repeated contact increases the risk, particularly when protective clothing or hygiene practices are inadequate.



Hazardous Substances Enter the Body (2)?

- **Ingestion**

Ingestion, happens when hazardous substances are swallowed, often unintentionally. This can occur through contaminated hands, food, drinks, or cigarettes in the workplace. Poor hygiene practices, such as not washing hands before eating, significantly increase the risk. Once ingested, hazardous substances can affect the digestive system and may be absorbed into the bloodstream, causing poisoning, organ damage, or long-term health problems.

- **Eye Contact**

Eye exposure occurs when hazardous substances splash, spray, or become airborne and contact the eyes. Dusts, vapours, and liquid chemicals can irritate or damage eye tissues, leading to redness, pain, or vision impairment. In severe cases, corrosive substances may cause permanent eye injury or blindness. Eyes also provide a pathway for chemicals to enter the bloodstream, making proper eye protection essential.



Inhalation Exposure?

- Inhalation occurs when airborne hazardous substances are breathed into the lungs during work activities.
- Common inhaled contaminants include dusts, fumes, vapours, mists, and gases generated by processes or materials.
- Small particles can penetrate deep into the lungs, reaching the alveoli where gas exchange occurs.
- Once in the lungs, substances may cause irritation, inflammation, or damage to respiratory tissues.
- Some inhaled hazards pass from the lungs into the bloodstream, leading to systemic toxicity.
- Short-term effects may include coughing, wheezing, dizziness, headaches, or shortness of breath.
- Long-term exposure can result in chronic respiratory diseases such as asthma, bronchitis, or lung cancer



Inhalation Exposure (Control Measures)?

- **Elimination** – Remove hazardous substances or processes that generate airborne contaminants where possible.
- **Substitution** – Replace hazardous materials with less toxic or low-dust, low-vapour alternatives.
- **Engineering controls** – Use local exhaust ventilation, general ventilation, or enclosed systems to capture contaminants at source.
- **Isolation** – Separate workers from hazardous processes using barriers, distance, or remote operation.
- **Administrative controls** – Implement safe work procedures, job rotation, exposure time limits, and training.
- **Housekeeping** – Regular cleaning to prevent dust build-up and re-suspension into the air.
- **Monitoring and Assessment** – Conduct air sampling to ensure exposure levels remain below occupational limits.
- **Personal protective equipment (PPE)** – Provide and correctly use suitable respiratory protective equipment when other controls are insufficient.



Dermal Exposure?

- Dermal exposure occurs when hazardous substances come into direct contact with the skin.
- Chemicals, liquids, solids, and contaminated surfaces are common sources of skin exposure.
- Some substances can be absorbed through intact skin and enter the bloodstream.
- Skin contact may cause irritation, burns, dermatitis, or allergic reactions.
- Repeated or prolonged exposure increases the risk of chronic skin conditions.
- Cuts, abrasions, or damaged skin increase absorption and severity of effects.
- Inadequate hygiene and poor handling practices contribute to dermal exposure.
- Protective clothing, gloves, and good hygiene practices reduce dermal exposure risks.



Dermal Exposure (Control Measures)?

- **Elimination** – Remove hazardous substances or tasks that involve direct skin contact where possible.
- **Substitution** – Replace harmful chemicals with less toxic or skin-friendly alternatives.
- **Engineering controls** – Use enclosed systems, splash guards, and automated processes to prevent contact.
- **Administrative controls** – Develop safe work procedures, training, and clear handling instructions.
- **Personal protective equipment (PPE)** – Provide suitable gloves, protective clothing, and aprons appropriate to the substance.
- **Hygiene practices** – Ensure handwashing facilities, skin cleaning, and prohibition of eating or drinking in work areas.
- **Storage and labelling** – Correctly label and store substances to prevent accidental contact or spills.
- **Health surveillance** – Monitor skin health to identify early signs of dermatitis or chemical exposure.



Ingestion Exposure?

- Ingestion is the entry of chemical substances into the body through the mouth in an occupational setting.
- It occurs when chemicals are swallowed intentionally or unintentionally during work activities.
- Chemicals can enter the mouth via contaminated hands, food, drinks, cigarettes, or chewing gum.
- Splashing of liquid chemicals or settled dusts and powders can also be accidentally swallowed.
- Once ingested, the chemical passes through the digestive system and is absorbed into the bloodstream.
- Absorbed chemicals may be processed by the liver and distributed to other organs.
- Ingestion can lead to acute effects such as nausea, vomiting, abdominal pain, or poisoning.
- Long-term ingestion exposure may result in chronic health effects, including organ damage or systemic toxicity.



Ingestion Exposure (Control Measures)?

- Prohibit **eating, drinking, smoking, or chewing gum** in areas where chemicals are used or stored.
- Provide and enforce **proper handwashing facilities** before meals, breaks, and after handling chemicals.
- Ensure **good housekeeping** to prevent chemical contamination of surfaces and work areas.
- Use **clearly labeled containers** and never store chemicals in food or drink containers.
- Require appropriate **personal protective equipment (PPE)** such as gloves to prevent hand contamination.
- Implement **safe work procedures** for handling, mixing, and disposing of chemicals.
- Provide **training and awareness programs** on ingestion hazards and safe hygiene practices.
- Maintain **clean, designated eating areas** separate from chemical handling zones.



Eye Exposure?

- In Occupational Health and Safety (OHS), eye exposure occurs when hazardous substances enter the eyes through chemical splashes, mists, vapours, or airborne particles during work activities. This can happen while mixing chemicals, pouring liquids, grinding materials, or working in dusty environments where particles become airborne. The eyes are highly sensitive, and even brief exposure can cause immediate irritation, redness, watering, and pain. More serious exposures may result in chemical burns, corneal damage, blurred vision, or permanent vision loss, depending on the substance and duration of contact. In OHS, eye exposure is considered a significant risk because eye injuries can occur suddenly and may lead to long-term impairment, reduced work ability, or disability if not properly managed.



Factors Influencing Exposure?

Common Factors Influencing Exposure

1. Source characteristics

1. Concentration or intensity
2. Toxicity or infectivity
3. Duration and frequency of release

2. Pathway of exposure

1. Inhalation, ingestion, skin contact, injection
2. Environmental transport (air, water, soil, surfaces)

3. Duration & frequency

1. Acute vs. chronic exposure
2. Continuous vs. intermittent contact

4. Distance & proximity

- How close the individual is to the source
- Enclosed vs. open spaces



Factors Influencing Exposure (2)?

Common Factors Influencing Exposure

5. Individual characteristics

- Age, sex, body weight
- Health status (e.g., lung disease, immunity)
- Behaviour (hand hygiene, smoking, PPE use)

6. Environmental conditions

- Ventilation
- Temperature and humidity
- Weather (wind, rainfall)

7. Protective measures

- Use of personal protective equipment (PPE)
- Engineering controls (filters, shields)
- Safety practices



Workplace Design and Exposure ?

1. Proper ventilation systems dilute airborne contaminants, reducing inhalation risks and improving overall workplace air quality.
2. Effective workplace layout minimizes worker proximity to hazards, controlling exposure through spacing and directional workflow.
3. Isolation of hazardous processes prevents contaminant spread, protecting workers by separating dangerous operations physically effectively.
4. Use of fume hoods captures toxic vapors at source, significantly lowering inhalation exposure levels workplace.
5. Enclosed processes limit direct contact with harmful agents, enhancing safety and reducing accidental releases incidents.
6. Well-designed workstations support safe movements, reducing ergonomic strain and unintended contact with hazards during tasks.



Safe Handling Techniques to Reduce Exposure ?

1. **Use appropriate personal protective equipment** such as gloves, goggles, respirators, and protective clothing.
2. **Follow proper labeling and storage procedures** to prevent accidental misuse or chemical mixing.
3. **Handle chemicals in well-ventilated areas** to reduce inhalation of harmful vapors or fumes.
4. **Use engineering controls** like fume hoods, closed systems, and local exhaust ventilation.
5. **Avoid direct contact** by using tools, pumps, or dispensers instead of manual pouring.
6. **Wash hands and exposed skin immediately** after handling chemicals and before eating or drinking.
7. **Dispose of chemical waste safely** according to established safety guidelines and regulations.



Process Modification ?

Process modification, including automation, plays a crucial role in reducing worker contact with hazardous chemicals in the workplace. By redesigning processes to minimize manual handling, automation limits direct exposure during mixing, transferring, or packaging operations. Automated systems such as robotic arms, closed-loop dispensing units, and remote-controlled equipment reduce the need for workers to be physically present near chemical sources. Process modifications may also include substituting safer materials, reducing quantities used, and enclosing operations. These changes not only lower the risk of inhalation, skin contact, and accidental spills but also improve consistency, productivity, and overall workplace safety while supporting compliance with occupational health and safety regulations.



Chemical Agents & Impacts ?

Health Effects

- Respiratory problems (asthma, bronchitis, lung disease)
- Skin irritation and dermatitis
- Eye irritation or damage
- Poisoning and toxic effects
- Allergic reactions and sensitisation
- Damage to organs (liver, kidneys, nervous system) Reproductive and developmental effects
- Cancer from long-term exposure to carcinogens



Occupational Exposure Limit (OEL) Chemicals

- **Occupational Exposure Limit (OEL)** refers to the **maximum allowable concentration** of a **hazardous substance** in workplace air to which workers may be exposed **without adverse health effects**. OELs are established by regulatory or professional bodies to protect workers' health and are usually expressed as **time-weighted averages (TWA)**, **short-term exposure limits (STEL)**, or **ceiling limits (C)**. Employers use OELs to assess risks, design control measures, and ensure compliance with occupational safety regulations.
- **Types of OEL**
- **TWA (Time-Weighted Average):** Average exposure over 8 hours.
- **STEL:** Maximum exposure allowed for a short period (usually 15 minutes).
- **Ceiling Limit:** Concentration that should never be exceeded.
- **Examples of OELs**
- **Carbon monoxide:** 25 ppm (8-hour TWA)
- **Benzene:** 1 ppm (8-hour TWA)
- **Ammonia:** 25 ppm (TWA), 35 ppm (STEL)
- **Silica (respirable):** 0.05 mg/m³ (TWA)
- **Hydrogen sulfide:** 10 ppm (8- hour TWA)



Monitoring & Assessment Chemical Agents

1 Identify Chemicals of Concern

Determine which chemical agents are present using Safety Data Sheets (SDS) or workplace inventories.

2 Select Sampling Method

Choose between **air sampling** (for inhalation exposure) and **surface sampling** (for skin contact or contamination assessment).

3 Prepare Sampling Equipment

Use calibrated pumps, filters, sorbent tubes for air sampling.

Use swabs, wipes, or adhesive pads for surface sampling.

4 Conduct Sampling

Collect air samples in workers' breathing zones or area samples.

Collect surface samples from workbenches, machinery, and high-contact areas.

5 Analyse Samples

Send collected samples to a laboratory or use on-site analysis methods to quantify chemical concentrations.

Compare results with occupational exposure limits (OELs) or regulatory standards.

6 Record, Review, and Take Action

Document sampling results and trends.

Implement or adjust control measures (ventilation, PPE, cleaning) based on findings.



Occupational Exposure Limit (OEL) Physical Agents

- **Occupational Exposure Limits (OELs) for physical agents** are **recommended or legally enforced limits** on the intensity, duration, or magnitude of exposure to physical hazards in the workplace. Their purpose is to **prevent adverse health effects and performance impairment** among workers. Unlike chemical OELs (usually concentration-based), physical agent OELs are often expressed in **decibels (dB), meters per second squared (m/s^2), degrees Celsius, or radiation dose units**.
- **Explanation with Examples**
- **Noise:**
OELs limit sound levels to prevent hearing loss.
Example: 85 dB(A) as an 8-hour Time-Weighted Average (TWA). Higher noise levels require shorter exposure times.
- **Vibration:**
Limits protect against hand–arm vibration syndrome and whole-body disorders.
Example: Hand–arm vibration exposure action value of 2.5 m/s^2 over an 8-hour period.
- **Radiation:**
OELs restrict ionizing and non-ionizing radiation doses to reduce cancer and tissue damage risks.
Example: 20 mSv per year averaged over five years for occupational ionizing radiation exposure.

Monitoring & Assessment Physical Agents Agents

1 Identify Physical Hazards

- Determine which physical agents are present: noise, vibration, temperature extremes, radiation, or lighting issues.
- Consider areas and tasks where workers are most exposed.

2 Select Monitoring Methods

- Noise: use sound level meters or dosimeters.
- Vibration: use accelerometers or hand-arm vibration meters.
- Temperature: use thermometers, data loggers, or thermographic cameras.

3 Plan Sampling Strategy

- Decide on locations, duration, and timing of measurements
- Include representative worker activities and work shifts.



Monitoring & Assessment Physical Agents Agents

4 Conduct Measurements

- Perform personal monitoring (on workers) and area monitoring (environmental levels).
- Record peak, average, and exposure duration for each agent.

5 Analyse and Compare Data

- Compare results with occupational exposure limits (OELs), action levels, or standards for noise, vibration, and heat/cold stress.
- Identify areas or tasks exceeding safe limits.

6 Control Measures and Review

- Implement engineering, administrative, or PPE controls to reduce exposure.
- Maintain records, periodically review measurements, and update safety plans.



Health Surveillance

- Health surveillance for chemical and physical agents in the workplace is a critical process aimed at protecting employees from harmful exposures. It involves systematic monitoring of workers' health through medical examinations, biological sampling, and exposure assessments. By identifying early signs of illness related to chemicals, dust, fumes, or radiation, employers can implement preventive measures, reduce risks, and ensure compliance with occupational safety regulations. Regular surveillance helps maintain a safe working environment and promotes long-term employee well-being.
- Effective health surveillance also focuses on physical agents, such as noise, vibration, and temperature extremes, which can impact worker health over time. Monitoring exposure levels, providing protective equipment, and conducting routine health checks allow for early detection of conditions like hearing loss, musculoskeletal disorders, or heat stress.
- Combined with proper training and workplace adjustments, these measures reduce occupational hazards, ensuring workers remain healthy while performing their duties efficiently.



Health Surveillance Examples

- **1. Chemical Agents:**
 - **Biological monitoring:** Measuring levels of lead, mercury, or solvents in blood or urine.
 - **Lung function tests:** For workers exposed to dust, fumes, or asbestos.
 - **Skin checks:** For dermatitis from contact with irritant chemicals.
 - **Regular medical check-ups:** Detect early signs of organ toxicity from long-term chemical exposure.
- **2. Physical Agents:**
 - **Hearing tests (audiometry):** For employees exposed to high noise levels.
 - **Vision tests:** For workers using bright lights, lasers, or screens.
 - **Musculoskeletal assessments:** For repetitive motion or heavy lifting tasks.
 - **Thermal stress monitoring:** For exposure to extreme heat or cold.





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