Managing Physical Hazards

Lecture Title:
Measurement & Monitoring Techniques for Physical Hazards

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Date: 9th March 2025

21 ACADEMY

Undergraduate Diploma in
Occupational Health and Safety

Welcome and Objectives

Students learn the essential measurement and monitoring techniques used for physical hazards.

The lecture covers instruments such as sound-level meters, noise dosimeters, vibration meters, WBGT devices, light meters, and radiation detectors. Concepts include measurement strategies, sampling periods, calibration, common errors, and interpreting exposure metrics. This foundational technical session prepares students for the hazard-specific lectures that follow.

Welcome, Module Roadmap & Transition from Risk Management

Lecture 1 — Introduction to Physical Hazards & Regulatory Frameworks

Lecture 2 — Measurement & Monitoring Techniques for Physical Hazards

Lecture 3 — Noise & Vibration Hazards: Exposure, Measurement & Control

Lecture 4 — Physical Hazard Control Strategies: Engineering, Administrative & PPE

Lecture 5 — Thermal Hazards: Heat Stress, Cold Stress, and Thermal Comfort

Lecture 6 — Radiation Hazards: Ionising and Non-Ionising

Lecture 7 — Lighting, Visibility, and Workplace Ergonomics

Lecture 8 — Machinery, Mechanical Hazards & Machine Safeguarding

Lecture 9 — Workplace Environment Hazards: Slips, Trips, Falls, and Confined Spaces

Lecture 10 — Integrated Physical Hazard Management & Continuous Improvement

This module focuses on physical agents and their technical, physiological, and legal considerations

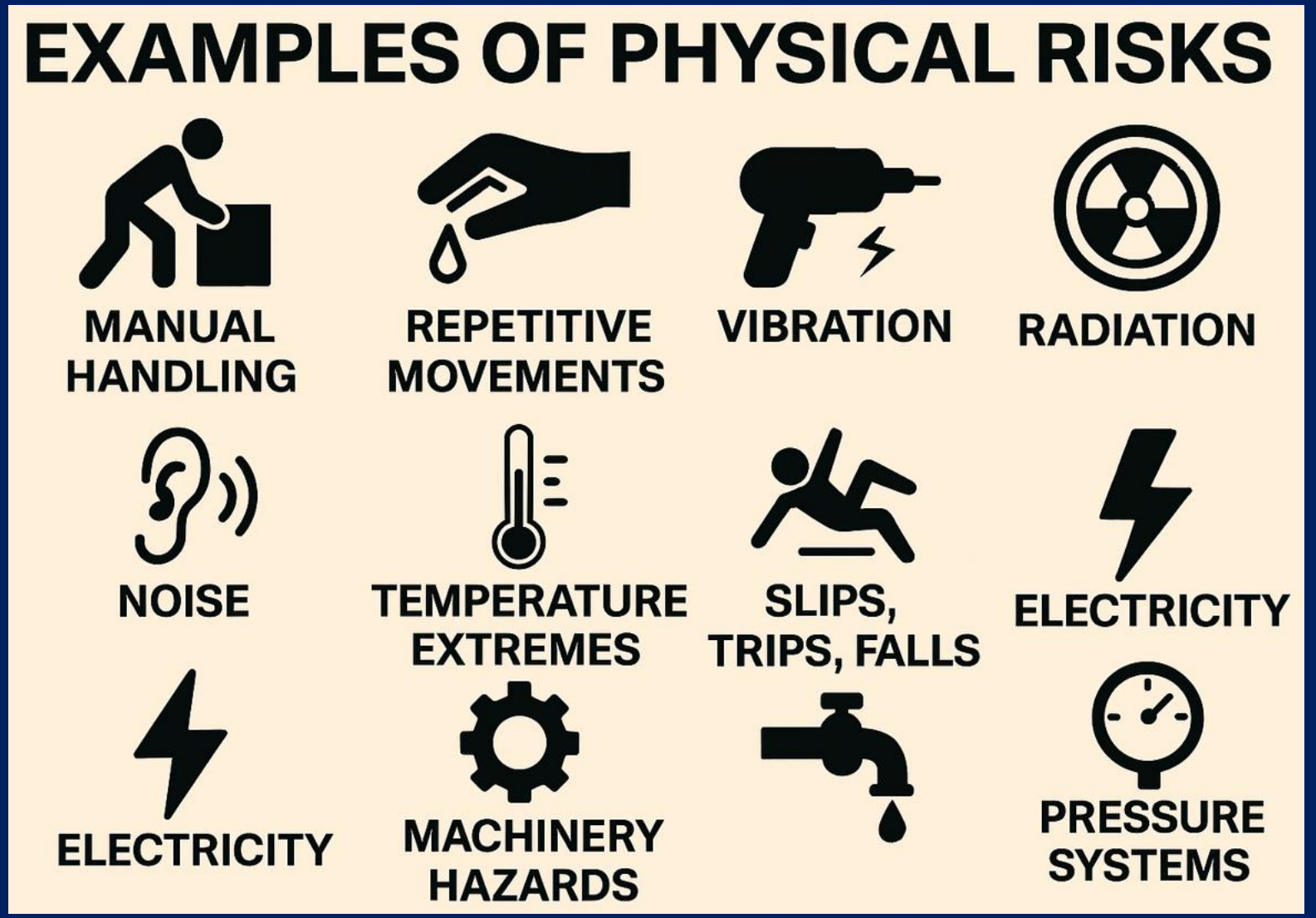
Part 1:
Introduction & Foundations

Part 1 — Introduction & Foundations

Recap of Lecture 1

What are physical hazards?

Physical hazards are environmental and workplace factors that can cause harm without necessarily touching the worker. They include noise, vibration, heat and cold stress, radiation, poor lighting, pressure extremes, and mechanical energy.


EXAMPLES OF PHYSICAL RISKS
MANUAL HANDLING
REPETITIVE MOVEMENTS
VIBRATION
RADIATION
NOISE
TEMPERATURE EXTREMES
SLIPS, TRIPS, FALLS
ELECTRICITY
ELECTRICITY
MACHINERY HAZARDS
PRESSURE SYSTEMS

Part 1 — Introduction & Foundations

Recap of Lecture 1

Why measure and monitor Physical Hazards?

1. To understand actual worker exposure rather than relying on assumptions.
2. To identify high-risk jobs, tasks, equipment, or locations.To verify whether controls are effective (engineering, admin, PPE).
3. To ensure compliance with exposure limits and prevent long-term health effects.
4. To gather objective data that supports risk assessments and control decisions.

Part 1 — Introduction & Foundations

Recap of Lecture 1

Connection to Risk Assessment Principles

1. Measurement provides the data needed to quantify risk.
2. It supports the identification of hazards, evaluation of likelihood, and severity of harm.
3. Measured exposure levels help determine whether existing controls are adequate.
4. Results guide the application of the Hierarchy of Controls.
5. Monitoring ensures risks remain controlled over time and detects any changes in conditions.

Part 1 — Introduction & Foundations

Objectives of Measurement

1. **Compliance**: Meet legislative and internal exposure limits
2. **Exposure Assessment**: Understand true worker exposure
3. **Risk Prioritization**: Identify high-risk tasks and groups
4. Compliance ensures we meet national and EU requirements.

Measurement vs Monitoring vs Exposure Assessment

1. **Measurement**: One-off data collection at a point in time
2. **Monitoring**: Repeated or continuous measurement over time
3. **Exposure Assessment**: Interpretation of measurement data to evaluate risk

Key Concepts in Measuring Physical Hazards

1. **Spot measurements –** Quick checks for screening
2. **Continuous monitoring –** Ongoing measurement for changing conditions
3. **Personal vs area monitoring –** Worker vs environment exposure
4. **Direct-reading instruments vs integrated sampling devices**

Expanded Key Concepts

1. **Spot Measurements:** Instant readings; good for quick assessments
2. **Continuous Monitoring:** Ideal for heat stress, noise, radiation
3. **Personal Monitoring:** Worker-mounted devices
4. **Area Monitoring:** Fixed position for environmental conditions
5. **Direct-Reading**: Immediate hazard levels
6. **Integrated Sampling:** Lab analysis for cumulative exposure

Part 2:
Principles of Measurement & Monitoring

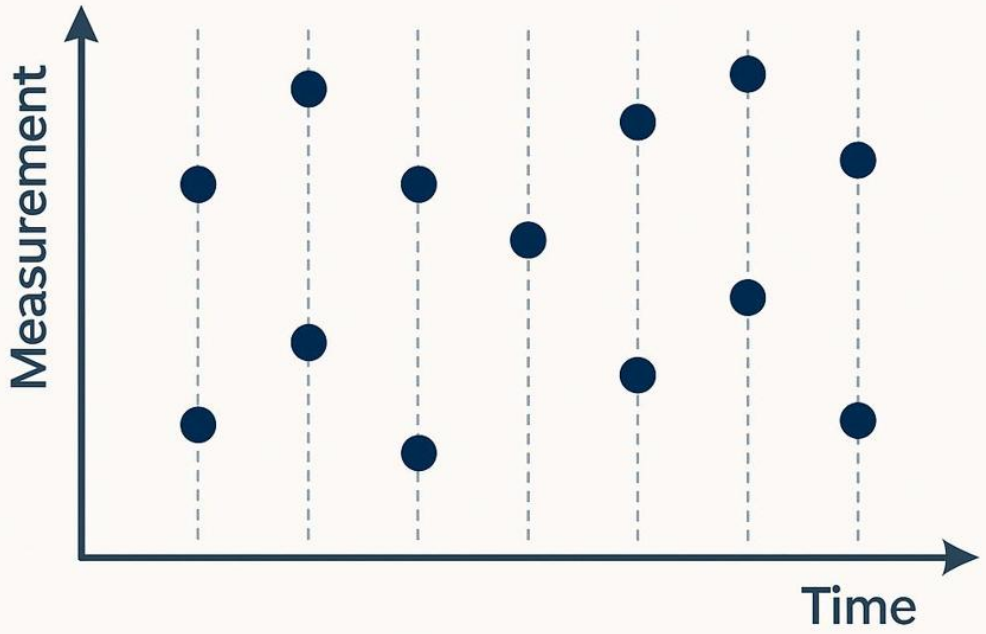
Measurement Strategies - Overview

1. Different strategies are used to ensure exposure measurements are representative.
2. Strategy depends on the hazard, work pattern, and purpose of assessment.

Measurement Strategies - Random Sampling

1. Measurements taken at unpredictable times
2. Reduces bias or behaviour changes
3. Useful when exposure varies throughout the day

Measurement Strategies – Random Sampling

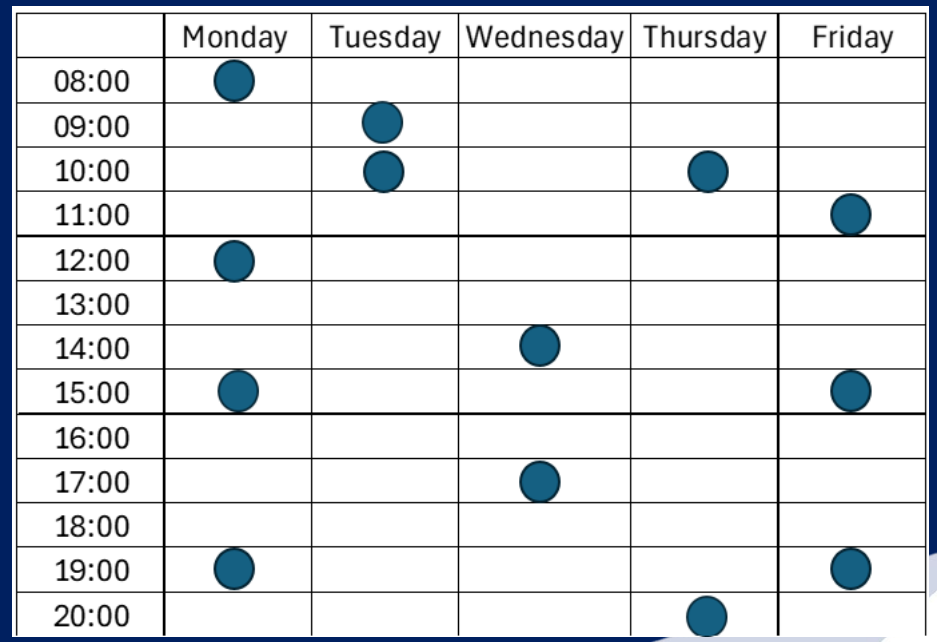


Random sampling provides an unbiased snapshot of real-world exposure by collecting data at unpredictable intervals.

Random sampling helps ensure that exposure measurements truly represent real working conditions because measurements are taken at unpredictable times, preventing workers from changing their behaviour during data collection.

Measurement Strategies - Scheduled / Periodic Sampling

1. Measurements taken on a fixed schedule
2. Tracks long-term trends
3. Useful for stable, predictable hazards



Measurement Strategies - Worst-Case Task-Based Sampling

1. Focus on tasks expected to have highest exposure
2. Ensures conservative assessment

Measurement Strategies - Full-Shift Monitoring

1. Measures exposure over an entire 8-hour shift
2. Provides Time-Weighted Average (TWA)
3. Best for noise, vibration, continuous hazards

Measurement Strategies - Task-Specific Monitoring

1. Measures exposure during individual tasks
2. Identifies high-exposure jobs
3. Supports control evaluation

Measurement Strategies - Representative Worker Selection

1. Select workers whose exposure represents the group
2. Often those with the highest foreseeable exposure
3. Supports Similar Exposure Group (SEG) assessment

Sampling Periods & Data Quality - Overview

1. Understanding how sampling duration affects exposure results
2. Selecting appropriate sampling intervals
3. Ensuring accuracy, reliability, and representativeness of data

Sampling Periods & Data Quality - Key Exposure Metrics

1. Time-Weighted Average (TWA)
2. Short-Term Exposure Limit (STEL)
3. Peak / Ceiling Values
4. Essential for comparing exposure results against regulatory limits

Sampling Periods & Data Quality - Time-Weighted Average (TWA)

1. Represents average exposure over a standard period (typically 8 hours)
2. Used to assess long-term or cumulative exposures
3. Most applicable to hazards such as noise, dust, vibration, and heat
4. Allows comparison against occupational exposure limits (OELs)

Part 2 — Principles of Measurement & Monitoring

Sampling Periods & Data Quality - STEL & Ceiling Measurements

1. STEL: Short Term Exposure Limit Average exposure over a short period (usually 15 minutes)
2. Relevant for substances causing acute effects (e.g., solvents, irritant gases)
3. Ceiling / limit value: Must never be exceeded at any point
4. Critical for hazards with immediate health impacts

Part 2 — Principles of Measurement & Monitoring

Sampling Periods & Data Quality - Duration & Representativeness

1. Ensure sampling covers the full range of tasks and exposures
2. Short samples risk underestimating high-exposure tasks
3. Match sampling duration to:
   - Full-shift monitoring
   - Task-specific operations
   - Worst-case scenarios
4. Avoid gaps in data that distort exposure profiles

Part 2 — Principles of Measurement & Monitoring

Calibration & Instrument Verification - Data Quality Considerations

1. Verify calibration of all instruments before and after sampling
2. Ensure correct placement of sensors (personal vs area monitoring)
3. Check for environmental conditions that may distort readings
4. Document task conditions, worker activities, and anomalies
5. Use appropriate units and maintain traceable records

Part 2 — Principles of Measurement & Monitoring

Calibration & Instrument Verification - Pre-Use Calibration (“Field Calibration”)

1. Quick check before starting measurements
2. Confirms instrument response to known standard
3. Detects gross errors (damaged sensor, low battery, blocked inlet)
4. Examples: acoustic calibrator for SLMs

Part 2 — Principles of Measurement & Monitoring

Calibration & Instrument Verification - Post-Use Checks

1. Verifies stability of the instrument after measurement
2. Confirms drift stayed within acceptable limits
3. If outside tolerance → data may be invalid
4. Essential for long-duration or unattended monitoring

Principles of Measurement & Monitoring

Calibration & Instrument Verification – Manufacturer Documentation & Traceability

1. Calibration certificates with dates & tolerances
2. Sensor expiry dates and replacement intervals
3. Recommended calibration frequency
4. Traceability to national standards (example: UKAS, NIST)
5. Required for audits, legal compliance, and investigations

Part 3:

Measurement Instruments for Physical Hazards

Noise Measurement

Instruments

Sound Level Meters (Class 1 vs Class 2)

Noise Dosimeters (personal monitoring)

Key Concepts

1. A-weighting vs C-weighting
2. Fast/slow response settings
3. LAeq, Lmax, Peak (C), Dose %
4. Calculating noise exposure (Lep,d)

Common errors:

1. Measuring too close to reflective surface
2. Shielding microphone with body
3. Wind noise

Sound Level Meter

Dosimeter

Vibration Measurement

Instruments

Hand-Arm Vibration meters

Whole-Body Vibration platforms

Key Concepts

1. m/s^2 RMS
2. Vector sum (x, y, z axis)
3. Influence of grip, posture, tool condition

Hand-Arm Vibration meters

Whole-Body Vibration platforms

Thermal Environment Measurement (WBGT)

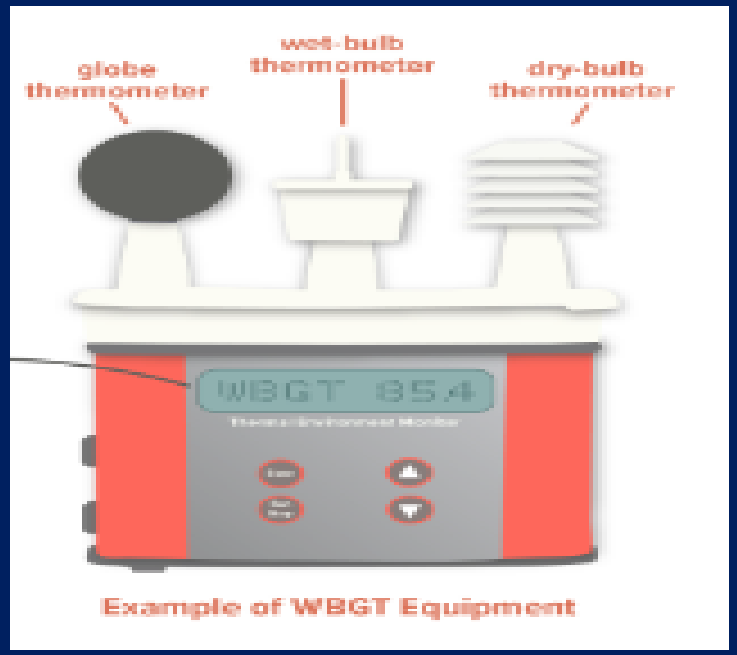
Instruments

WBGT meters (indoor/outdoor with solar load)

Infrared thermometers (surface temperature)

Key Concepts

1. Natural wet bulb, dry bulb, globe temperature
2. Calculation of WBGT indoors/outdoors
3. Limitations: clothing correction factors, low airflow conditions



Wet Bulb Globe Temperatures (WBGT) meters

Infrared thermometers

Lighting Measurement

Instruments

Lux meters

Key Concepts

1. Lux levels for different tasks
2. Uniformity ratio
3. Direct glare vs reflected glare
4. Daylight influence

1872
Lux
POWER
200
2,000
HOLD
20,000
200,000
LX-101A LUX METER

BENETECH
METER
GM1010
Features:
Measuring range :
0 – 200000Lux / 0 – 18500Fc
Automatic measurement function
LUX/FC Unit selection function
Data rise and fall time is short
After 5 minute Auto power off
MAX/MIN measurements
Low battery indication
Backlight function
Power supply:
6F22 9V battery
MAX
GM1010
Digital Lux Meter
DIGITAL LUX METER

Lux Meters

Ionising & Non-ionising Radiation Measurement

Instruments

Geiger-Müller counters

Dosimetry badges (TLD, film)

EMF meters for non-ionising radiation

Key Concepts

1. Count rate vs dose rate
2. Penetration differences: alpha, beta, gamma
3. Shielding impact
4. Time–Distance–Shielding principles
5. EMF frequency ranges and typical workplace exposures

Geiger-Müller counters

Dosimetry badges (TLD, film)

EMF meters

Part 4:
Interpreting Results & Exposure Metrics

Understanding Exposure Metrics

1. TWA, STEL, peak exposures
2. Logarithmic scales (noise)
3. RMS vibration measurement
4. Dose calculation examples

Common Errors & How to Avoid Them

1. Miscalibration
2. Incorrect sampling location
3. Influence of PPE during measurement
4. Environmental interference

1. What is the main purpose of measuring physical hazards in the workplace?
2. What's the difference between "measurement" and "monitoring"?
3. Why can't we rely only on visual inspection to assess physical hazards?
4. What is the advantage of personal monitoring compared to area monitoring?

5. Why do we use A weighting for workplace noise measurements?
6. Why is it important to measure both peak and average noise levels?
7. Why is random sampling sometimes used in exposure monitoring?
8. When would worst case sampling be more appropriate than random sampling?

9. What does TWA (Time Weighted Average) represent?
10. Why are pre use calibration checks essential before starting measurements?
11. Why must noise dosimeters be placed on the shoulder near the ear?

12. Why do we measure vibration in three axes (x, y, z)?

13. Why is it important to keep good records of all measurements taken in the workplace?

14. Why is WBGT preferred over simple temperature measurements for heat stress assessment?

15. Why do lighting assessments consider uniformity, not only lux levels?

16. Why are EMF exposures measured in frequency-specific ranges?

17. What is one common mistake that leads to unreliable measurements?

Next: Lecture 3: Noise & Vibration Hazards: Exposure, Measurement & Control

A combined deep-dive into noise and vibration as key occupational hazards.

Covers sound physics, vibration transmission, exposure metrics (LEX,8h & A(8)), health effects (NIHL & HAVS/WBV), EU directives 2003/10/EC and 2002/44/EC, measurement techniques, audiometry, and engineering/administrative control strategies for both hazards.