Health and Safety Essentials

Lecture 15 - Risk Assessment Methodologies

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Undergraduate Diploma in
Occupational Health and Safety

Recap last week's topic

Kahoot Quiz:

https://play.kahoot.it/v2/*?quizId=e1dd446f-34ce-4e92-a1c1-98e573a63acd

Objectives of the Lecture

By the end of this lecture, you will be able to:

- ✓ Understand the principles and importance of risk assessment.
- ✓ Differentiate between various risk assessment methodologies.
- ✓ Apply a selected methodology to a case study.

History of Risk Assessment

- Probabilistic risk assessment as we know it today had its root in the insurance (actuarial) discipline at the end of the nineteenth century.

- The Swedish actuary **Filip Lundberg** is considered to be the founder of mathematical risk theory. His first mathematical model for nonlife insurance was presented already in **1909.**

- Was largely ignored till the Swedish professor **Harald Cramér** in **1930** developed his insurance risk theory based on Lundberg's approach.

What is Risk Assessment?

EU-OSHA Definition

- Risk assessment is the process of evaluating risks to workers' safety and health from workplace hazards. It is a systematic examination of all aspects of work that considers:

  - what could cause injury or harm;
  - whether the hazards could be eliminated and, if not;
  - what preventive or protective measures are, or should be, in place to control the risks.

https://oira.osha.europa.eu/en/what-is-risk-assessment

Other definitions

- **Hazards**
  - A hazard can be anything - whether work materials, equipment, work methods or practices - that has the potential to cause harm.

- **Risks**
  - A risk is the chance, high or low, that somebody may be harmed by the hazard.

Why is Risk Assessment Important?

- ✅ Prevents workplace injuries and illnesses.
  ✅ Ensures legal compliance (EU & UK).
  ✅ Improves workplace safety culture.
  ✅ Supports effective risk management.

- 💬 **Discussion Question:**
  Why is risk assessment a core element of OHS?

Legal Frameworks

📜 EU & Maltese Legislation:

- Framework Directive 89/391/EEC (Employers must conduct risk assessments).
- Maltese OHS Act (CAP. 646) (Transposes EU laws).

📜 UK Legislation:

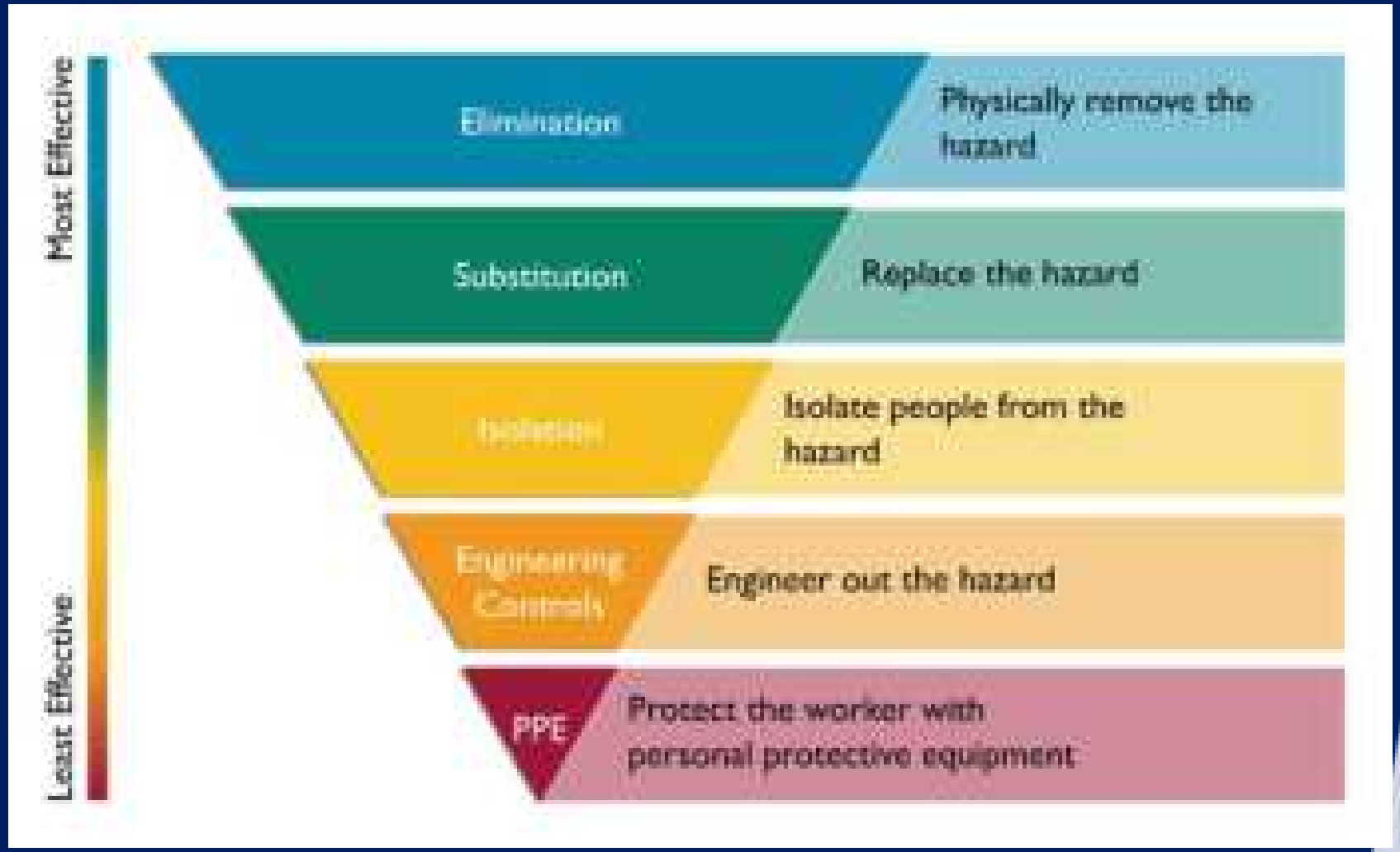
- Health and Safety at Work Act 1974 (General duty to assess risks).
- Management of Health and Safety at Work Regulations 1999 (Formalises risk assessment requirements).

The Five Steps to Risk Assessment

- **Step 1:** Identify hazards.
- **Step 2:** Decide who might be harmed and how.
- **Step 3:** Evaluate risks and decide on precautions.
- **Step 4:** Record findings and implement them.
- **Step 5:** Review and update as necessary.

- 🗣️ **Interactive Poll:**
  Which step do you think is most challenging?

Hierarchy of Control Measures



Types of Risk Assessment Methodologies

📌 **1. Qualitative Risk Assessment**
✓ Simple & descriptive
✓ Uses **risk matrices**

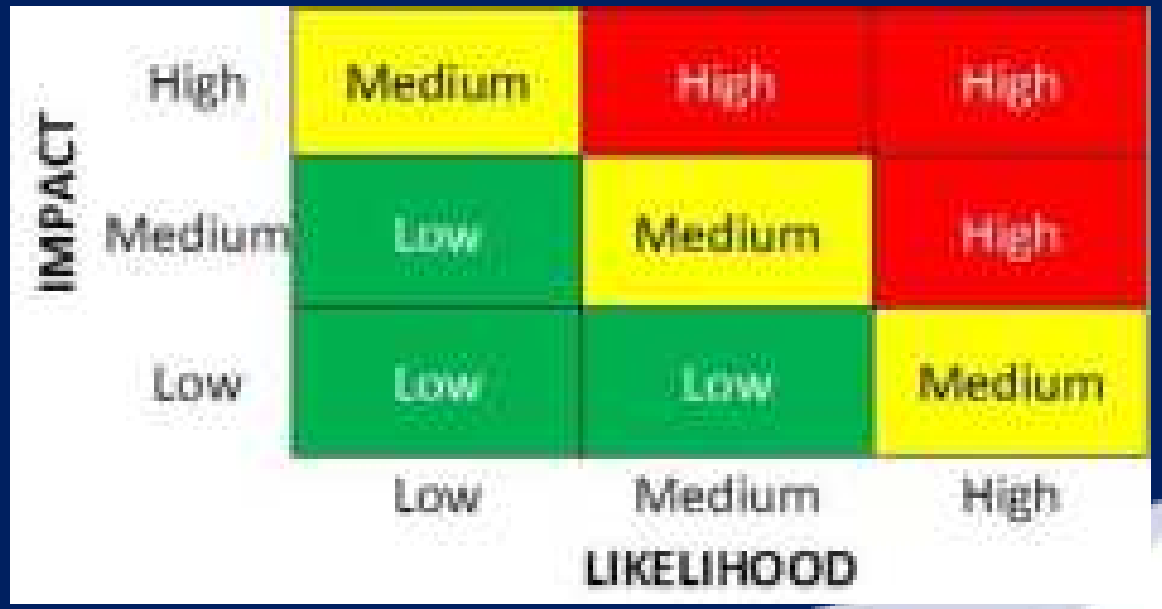
📌 **2. Semi-Quantitative Risk Assessment**
✓ Uses **numeric scoring**
✓ More precise ranking of risks

📌 **3. Quantitative Risk Assessment (QRA)**
✓ Uses **data & statistics**
✓ Often applied in high-risk industries

📌 **4. Specialised Techniques**
✓ **Job Safety Analysis (JSA)** – Task-based
✓ **Hazard and Operability Study (HAZOP)** – Process-based
✓ **Failure Modes and Effects Analysis (FMEA)** – System-based

Qualitative Risk Assessment Example

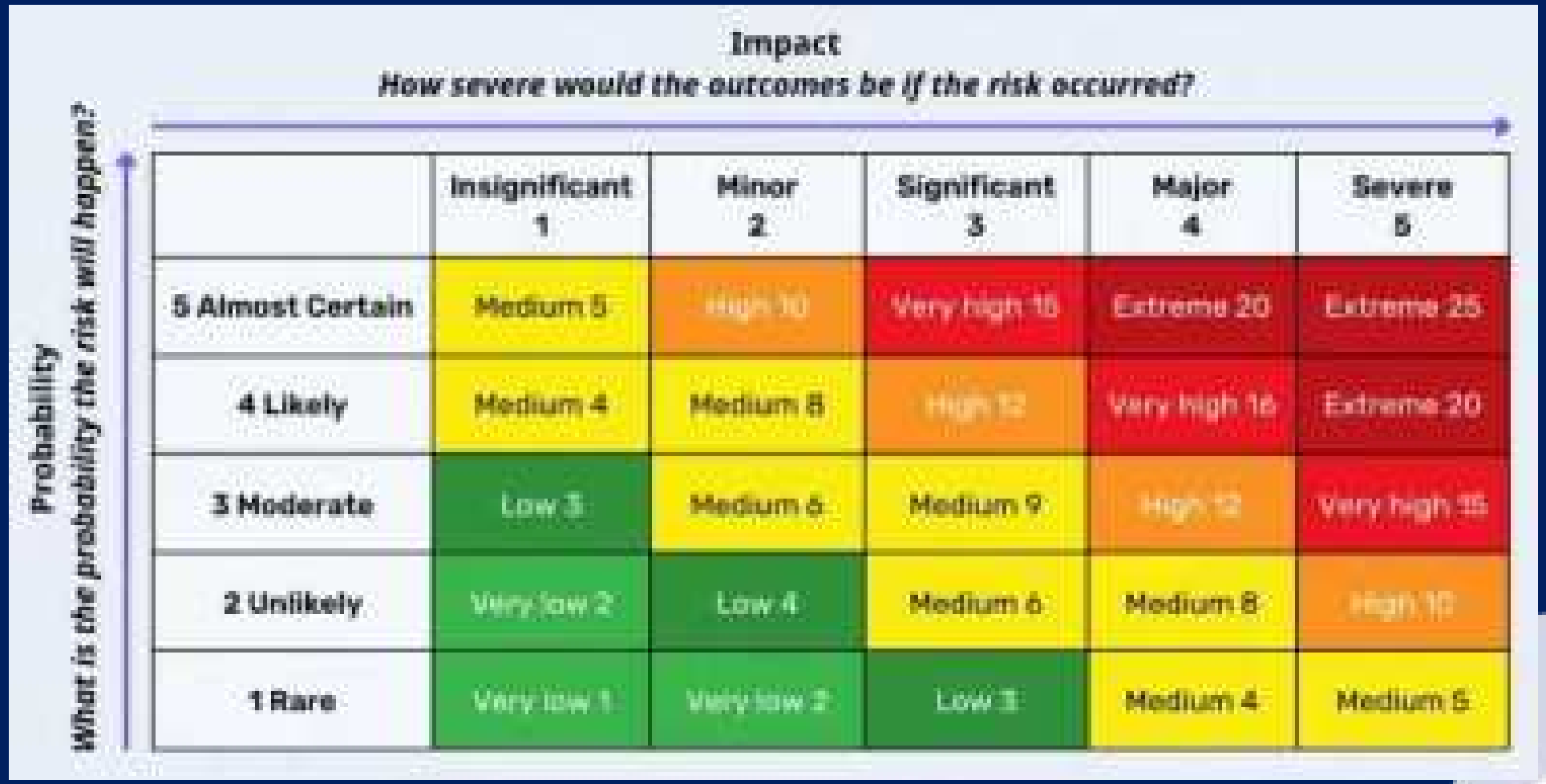
- 🟩 **Low Risk:** No action needed.
  🟨 **Medium Risk:** Control measures required.
  🟥 **High Risk:** Immediate action required.
- 📌 **Example:**
  A wet floor in a supermarket. **Likelihood:** High. **Severity:** Low/Medium. **Risk Level:** Medium.



Semi-Quantitative Risk Assessment

-  Uses **numerical scales** to score risks.
  Example Calculation:
- Likelihood = **4** (Likely)
- Severity = **3** (Serious injury)
- Risk Score = **4 × 3 = 12** (Medium-High Risk)

5×5 Risk Matrix Example



Probability

Also called likelihood, the Probability (x-axis) pertains to the extent of how likely it is for the risk to occur. The 5 risk rating levels under this component are as follows:

- Rare – unlikely to happen and/or have minor or negligible consequences
- Unlikely – possible to happen and/or to have moderate consequences
- Moderate – likely to happen and/or to have serious consequences
- Likely – almost sure to happen and/or to have major consequences
- Almost certain – sure to happen and/or have major consequences

Impact

Also called severity or consequences, the Impact (y-axis) aims to determine the level of effects that the hazard can cause to workplace health and safety.

5×5 risk matrix can be tailored to the needs of an organisation - the following represent the general terms used to describe the 5 levels to determine the risk's impact:

- Insignificant – won't cause serious injuries or illnesses
- Minor – can cause injuries or illnesses, only to a mild extent
- Significant – can cause injuries or illnesses that may require medical attention but limited treatment
- Major – can cause irreversible injuries or illnesses that require constant medical attention
- Severe – can result in fatality
- Each risk box represents the rating of a risk that is calculated based on its particular levels of probability and impact. In most cases, the 5×5 risk matrix uses numeric values to better represent the risk ratings.

Calculating Risks – 5x5 Matrix

Probability x Impact = Risk Level

The first step is to assign a numeric value from 1 to 5, 1 being the lowest, for each of the categories under Probability and Impact. Then, use the formula of multiplying the value of the Probability to the value of Impact to determine the Risk Level.

- **1-4: Acceptable** – no further action may be needed and maintaining control measures is encouraged
- **5-9: Adequate** – may be considered for further analysis
- **10-16: Tolerable** – must be reviewed in a timely manner to carry out improvement strategies
- **17-25: Unacceptable** – must implement cease in activities and endorse for immediate action

Quantitative Risk Assessments (QRA)

- ✓ Used for **measuring workplace hazards** with **scientific data**.
- ✓ Applies **approved monitoring equipment** to assess **actual exposure levels**.
- ✓ Ensures compliance with **EU & UK OHS regulations**.
- ✓ Helps determine **effective control measures** to prevent harm.

📌 **Examples Covered in This Session:**

1. **Noise Exposure (Surveys & Dosimetry)**
2. **Airborne Contaminants (Gas, Vapour, Fumes)**
3. **Dust & Particulate Matter (PM Monitoring)**
4. **Chemical Risk Assessment (Biological & Modelling)**
5. **Radiation Monitoring (Ionising & Non-Ionising)**
6. **Heat Stress Monitoring (WBGT Index)**
7. **Ergonomic Assessments (Manual Handling & Posture Analysis)**

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What Type of Risk Assessment Is This?

🧯 Scenario: A petrochemical plant models gas leak risks using a Monte Carlo Simulation to predict thousands of possible exposure scenarios. The results show a probability distribution of explosion risk levels.

ⓘ Start presenting to display the poll results on this slide.

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What Type of Risk Assessment Is This?

🚧 Scenario: A safety officer conducts a visual inspection of a construction site and rates hazards as Low, Medium, or High based on expert judgment. No numerical calculations are used.

ⓘ Start presenting to display the poll results on this slide.

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What Type of Risk Assessment Is This?

📢 Scenario: A factory conducts a noise exposure assessment using measured decibel levels (dB). The data is entered into a risk matrix, which assigns a score based on likelihood and severity.

ⓘ Start presenting to display the poll results on this slide.

Break

QRA - Monte Carlo Simulation

✓ A **mathematical technique** that models **uncertainty** in risk assessment.
✓ Uses **random sampling** to simulate multiple **possible outcomes**.
✓ Helps **quantify risk levels** by considering **variable inputs**.
✓ Applied in **safety, finance, engineering, and environmental health**.

📌 **OHS Application:**

- Predicting **accident probabilities** in high-risk industries.
- Estimating **exposure to hazardous substances**.
- Assessing **failure rates of safety systems**.

How Monte Carlo Works in Risk Assessment

📌 **Step 1:** Identify **input variables** (e.g., exposure levels, failure rates, accident probabilities).
📌 **Step 2:** Assign **probability distributions** (normal, uniform, log-normal, etc.).
📌 **Step 3:** Run **thousands of simulations** with random values.
📌 **Step 4:** Analyse results to find the **most probable risk level**.

🔹 **Unlike a single risk score, Monte Carlo gives a range of possible outcomes.**

Specialised Techniques

- ✓ **Job Safety Analysis (JSA)** – Task-based
- ✓ **Hazard and Operability Study (HAZOP)** – Process-based
- ✓ **Failure Modes and Effects Analysis (FMEA)** – System-based

Job Safety Analysis (JSA)

- ✓ **Breaks tasks into steps.**
- ✓ Identifies hazards at each step.
- ✓ Proposes control measures.
- 📌 **Example Task:** Steel Fabrication Workshop

Step 1: Break Task into Steps

1. **Preparation** – Gathering materials, setting up tools and workspace.
2. **Cutting steel beams** – Using a cutting torch or angle grinder.
3. **Welding joints** – Fusing steel components together.
4. **Inspection & Cleanup** – Checking weld quality, removing debris.

Then continue with the rest of the steps: ID Hazards, Evaluate etc…

HAZOP (Hazard and Operability Study)

📌 **Objective:** Identify **process hazards and operability issues** in complex systems like **chemical plants, manufacturing, and oil & gas operations**.

📌 **How HAZOP Works:**
✓ **Systematically examines each process step** for potential deviations.
✓ Uses **guidewords** (e.g., "More," "Less," "No," "As well as") to analyse possible failures.
✓ Involves a **multidisciplinary team** (engineers, OHS professionals, operators).

📌 **HAZOP Process Steps:**

1. **Define the system/process** – e.g., a **steam boiler system** in a factory.
2. **Break it into sections** – (e.g., water feed, heating, steam output).
3. **Apply guidewords to each section** – e.g., "No Flow" → Water pump failure.
4. **Identify causes & consequences** – No water flow → Boiler overheating → Explosion risk.
5. **Recommend controls** – Redundant pumps, automatic shutdowns.

HAZOP (Hazard and Operability Study)

📌 Example – HAZOP on a Chemical Mixing Tank:

Guideword	Deviation	Possible Cause	Consequence	Control Measure
More	Overpressure	Blocked outlet valve	Tank rupture	Pressure relief valve
Less	Low Flow	Pump failure	Incomplete mixing	Pump redundancy
No	No Flow	Valve left closed	Process stop	Operator checklist

📌 Applications:

✓ **Used in high-risk industries** (oil refineries, pharmaceutical manufacturing).

✓ **Best for processes where failures can have catastrophic consequences.**

FMEA (Failure Modes and Effects Analysis)

📌 **Objective:** Systematically **identify potential failure modes** in a system, product, or process and **prioritise them** based on risk.

📌 **How FMEA Works:**

✓ Identifies **all possible ways a system/process can fail**.

✓ Assesses the **severity, likelihood, and detectability** of each failure.

✓ Calculates a **Risk Priority Number (RPN)** to prioritise actions.

FMEA (Failure Modes and Effects Analysis)

📌 **FMEA Process Steps:**

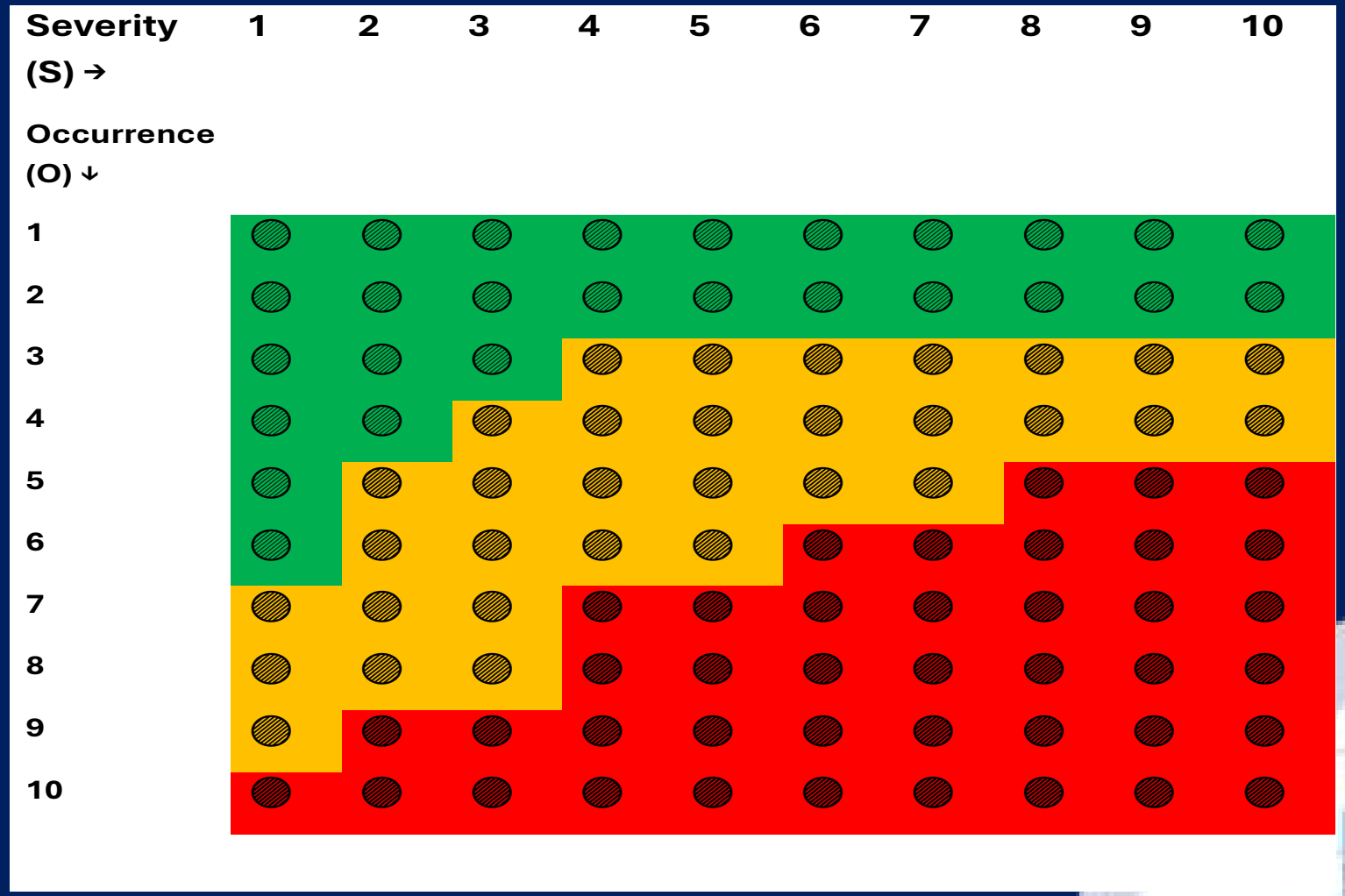
1. **List all process steps/equipment components** – e.g., **hydraulic press operation**.
2. **Identify failure modes** – e.g., "Hydraulic pressure loss".
3. **Determine effects of failure** – e.g., "Production stoppage, safety hazard".
4. **Assign scores for:**
   - ✓ **Severity (S)** (1–10) → Impact of failure.
   - ✓ **Occurrence (O)** (1–10) → Likelihood of failure.
   - ✓ **Detection (D)** (1–10) → Likelihood of detecting failure before impact.
5. **Calculate Risk Priority Number (RPN):**

RPN = S × O × D

6. **Prioritise actions for high-RPN failures**.

FMEA (Failure Modes and Effects Analysis)

Risk Matrix example:



FMEA (Failure Modes and Effects Analysis)

Classification Table example:

RPN Range	Risk Level	Action Required
RPN > 200	🔴 High Risk	Immediate corrective action required.
RPN 80–200	🟠 Moderate Risk	Risk reduction measures recommended.
RPN < 80	🟢 Low Risk	Monitor & maintain controls.

FMEA (Failure Modes and Effects Analysis)

📌 Example – FMEA on a Hydraulic Press Machine:

Failure Mode	Effect	Severity (S)	Occurrence (O)	Detection (D)	RPN (S × O × D)	Control Measures
Hydraulic failure	Loss of pressure → Machine stops	8	6	5	240	Preventive maintenance
Sensor failure	No emergency stop activation	10	3	4	120	Regular sensor testing

📌 Applications:

✓ Used in **manufacturing, aerospace, healthcare, and automotive industries.**
✓ Helps **prioritise risk mitigation efforts** for **high-failure-risk components.**

Comparison – HAZOP vs. FMEA

- 📌 **When to Use?**
  ✓ **HAZOP** → When analysing complex **process operations** (e.g., refineries, water treatment).
  ✓ **FMEA** → When assessing **equipment reliability & failure risks** (e.g., factory machines, medical devices).

Method	Type	Best For	Strengths	Weaknesses
HAZOP	Qualitative/Semi-Quantitative	Process hazard identification (chemical, energy systems)	Systematic & structured, ideal for continuous processes	Time-consuming, requires expert team
FMEA	Semi-Quantitative/Quantitative	Component & system failure analysis (machines, production lines)	Assigns numerical risk scores, prioritises actions	May not consider unexpected failure interactions

Reviewing & Updating Risk Assessments

🔄 Risk assessments must be **regularly reviewed** to remain effective.

✅ **When to review?**

- After an **incident or near miss**.
- When **work conditions change**.
- If **new hazards emerge**.

Breakout Activity

🔹 **Scenario:** A factory with moving machinery and chemical storage.

🔹 **Task:**

- Choose an appropriate risk assessment methodology.
- Justify your choice.
- Suggest basic controls.

⏳ **Time:** 10 minutes (Breakout Rooms)

Summary & Key Takeaways

- ✓ Risk assessment is **critical for workplace safety**.
- ✓ EU & UK laws **require systematic risk assessments**.
- ✓ Different methodologies **suit different situations**.
- ✓ Risk assessments must be **regularly reviewed**.

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