

**PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH
UNIVERSITY OF MOSTAGANEM
FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF PROCESS ENGINEERING**

« HSE and Industrial Installations »

- COURSE HANDOUT -

**Designed for Bachelor of Science (L2) and
Engineering Students in Process
Engineering**

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FOREWORD

This course handout is born from a deep conviction: the process engineer of the 21st century cannot merely be an excellent technician. They must be a responsible professional, fully aware of the implications of their choices on human safety, public health, and the preservation of our environment.

Specifically designed for Bachelor and Engineering students in Process Engineering at the University of Mostaganem, this document covers the syllabus of the **HSE and Industrial Installations** course. It has been written with a dual ambition: to provide the essential theoretical foundations for understanding industrial risks, while initiating students into a rigorous methodology of analysis and action, directly transferable to their future professional practice.

The pedagogical approach is deliberately progressive. The first chapter anchors the reflection at the heart of industrial activity, focusing on occupational risk assessment and control, as well as the methodical analysis of accidents. The second chapter broadens the perspective by addressing public health issues, environmental protection, and sustainable development, thereby recalling that an industrial installation is not an island, but a system in constant interaction with its human and ecological environment.

May this handout support every student in acquiring the essential skills for a responsible practice of the engineering profession, in service of the sustainable industrial development of our nation.

The Author

Abstract

This course handout, designed for L2 and engineering students in Process Engineering (University of Mostaganem), covers HSE (Health, Safety, Environment) fundamentals across two chapters. Chapter 1 establishes standardized safety terminology (hazard, risk, accident, incident), monitoring indicators (frequency rate, severity rate), the risk assessment methodology (identification, analysis, prioritization via criticality matrix), and Fault Tree Analysis. Chapter 2 broadens the scope to public health, housing hygiene, key environmental protection domains (water, air, soil, waste, noise), sustainable development, and institutional actors (WHO, ILO, UNEP). The goal is to train engineers who integrate HSE responsibility as an intrinsic part of process design, aiming for "zero accidents, zero occupational diseases, zero pollution."

Keywords

Industrial risk, Prevention, Health and safety, Fault tree analysis, Environmental protection, Sustainable development.

Résumé

Ce polycopié, destiné aux étudiants L2 et ingénieurs en Génie des Procédés (Université de Mostaganem), présente en deux chapitres les fondamentaux de la santé-sécurité-environnement (HSE). Le chapitre 1 pose le vocabulaire normalisé (danger, risque, accident, incident), les indicateurs de suivi (taux de fréquence, taux de gravité), la méthodologie d'évaluation des risques (identification, analyse, priorisation via matrice de criticité) et l'analyse par arbre des causes. Le chapitre 2 élargit la perspective vers la santé publique, l'hygiène de l'habitat, les grands domaines de la protection environnementale (eau, air, sol, déchets, bruit), le développement durable et les acteurs institutionnels (OMS, OIT, PNUE). L'objectif est de former des ingénieurs capables d'intégrer la responsabilité HSE comme dimension intrinsèque de la conception des procédés, visant le « zéro accident, zéro maladie professionnelle, zéro pollution ».

Mots-clés

Risque industriel, Prévention, Hygiène et sécurité, Arbre des causes, Protection de l'environnement.

ملخص

يقدم هذا المطبوع الموجّه لطلبة السنة الثانية والمهندسين في هندسة الطرائق (جامعة مستغانم) أسس الصحة والسلامة والبيئة (HSE) عبر فصلين. يرسّي الفصل الأول المصطلحات المعيارية للسلامة (الخطر، المخاطرة، الحادث، الحادث الوشيك)، مؤشرات المتابعة (معدل التكرار، معدل الخطورة)، منهجية تقييم المخاطر (التحديد، التحليل، الترتيب حسب الأولوية عبر مصفوفة الحرجية)، وتحليل شجرة الأعطال. أما الفصل الثاني فيوسّع النظرة نحو الصحة العمومية، نظافة السكن، المجالات الرئيسية لحماية البيئة (الماء، الهواء، التربة، النفايات، الضجيج)، التنمية المستدامة، والجهات المؤسساتية الفاعلة (منظمة الصحة العالمية، منظمة العمل الدولية، برنامج الأمم المتحدة للبيئة). الهدف هو تكوين مهندسين يدمجون المسؤولية HSE كبعد جوهري في تصميم العمليات، سعياً إلى "صفر حوادث، صفر أمراض مهنية، صفر تلوث".

كلمات مفتاحية

المخاطر الصناعية، الوقاية، الصحة والسلامة، تحليل شجرة الأعطال، حماية البيئة، التنمية المستدامة.

GENERAL INTRODUCTION

Industrial installations, at the very core of process engineering, handle hazardous substances on a daily basis, operate under extreme conditions, and generate emissions into the environment. This reality confers upon the engineer a responsibility that extends far beyond the technical framework of yield and quality. Risk management, health protection, and environmental preservation have become inseparable dimensions of the design and operation of any industrial installation.

This course, part of the Process Engineering curriculum at the University of Mostaganem under the title **HSE and Industrial Installations**, aims to equip students with the knowledge and tools enabling them to address these challenges in a structured and rigorous manner. Upon completion of this course, students will be able to:

- **Identify and assess risk:** Acquire an observational methodology to transition from the intuitive perception of a hazard to the objective assessment of a risk within an industrial installation.
- **Implement appropriate prevention methods:** Design and propose hierarchical control solutions, prioritizing collective protection and the elimination of hazards at the source.
- **Verify the implementation and effectiveness of control measures:** Develop a culture of monitoring and continuous improvement through the use of relevant indicators and the systematic analysis of events.

The pedagogical journey proposed in this handout is structured into two complementary chapters.

Chapter 1 lays the foundations of risk management. It clarifies the standardized vocabulary of safety, presents the key performance indicators for HSE monitoring, outlines the methodology for observing and analyzing a work situation, and details the fault tree analysis method, an essential tool for learning from failure and preventing accident recurrence.

Chapter 2 expands the focus. It explores the links between industrial activity and public health, addresses the fundamentals of housing hygiene, provides an overview of the main domains of environmental protection (water, air, soil, waste, noise), introduces the challenges of sustainable development, and presents the institutional actors involved in occupational health and safety.

Let us recall this quote from Albert Einstein, which must guide the engineer throughout their career: *"The concern for man and his safety must be the primary preoccupation of any technological endeavor. Never forget this when you are immersed in your sketches and equations."*

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INTRODUCTION TO RISK ASSESSMENT AND CONTROL, ACCIDENT ANALYSIS

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INTRODUCTION TO RISK ASSESSMENT AND CONTROL, ACCIDENT ANALYSIS

Chapter Objectives:

- Understand the fundamental concepts of hazard and risk.
- Acquire the standardized vocabulary of occupational safety.
- Apply an accident analysis method (Fault Tree Analysis).
- Master key safety performance indicators.

1.1 Understanding Basic Concepts (Hazard, Risk) and Identifying Prevention Actors

1.1.1 The HSE Approach:

Definition

Health, Safety, and Environment (HSE) constitutes a global and systemic management approach. Its objective is to create working conditions that preserve the physical and mental integrity of people, protect property and production assets, and minimize the impact of activities on the environment. For the process engineer, the HSE dimension is not an external constraint but an intrinsic component of process design and operation, as fundamental as yield or product quality. The ultimate goal is to strive for "zero accidents, zero occupational diseases, zero pollution."

1.1.2 Safety Terminology

Risk control relies on a common and rigorous language. The following definitions must be assimilated.

- **Hazard:** An intrinsic property of a substance, equipment, situation, or system capable of causing harm to people, property, or the environment. A hazard exists independently of any exposure.
- **Dangerous Situation:** A situation in which a person, property, or the environment is exposed to one or more hazards.
- **Hazardous Event (or Initiating Event):** The occurrence of a specific set of circumstances that transforms a dangerous situation into the materialization of harm.
- **Harm:** Physical injury, damage to the health of persons, or damage to property or the environment.

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- **Accident:** An unwanted, random, and unforeseen event, occurring in space and time, resulting from one or more causes, leading to harm to people, property, or the environment. An accident occurs because a dangerous situation existed for which the risk was not sufficiently controlled.
- **Incident (or Near-Miss):** An unwanted event that presents the same scenario as an accident but which, fortuitously, results in no human, material, or environmental harm. The incident is a valuable warning signal for prevention and should be systematically analyzed.
- **Risk:** The combination of the *probability* of occurrence of a hazardous event and the *severity* of its consequences. It is defined as the product of these two factors:

$$\text{Risk} = \text{Probability} \times \text{Severity}$$

The higher the probability and severity, the greater the risk.

- **Nuisance:** A set of elements that impair the quality of life without necessarily causing immediate harm (pollution, noise, odors).
- **Ergonomics:** The scientific discipline concerned with adapting work to the human being, by designing workstations, tools, and organizations to reduce physical and mental strain.
- **Adverse Health Effect:** Any change in body function or cell structure that can lead to disease or health problems. This includes bodily injury, occupational diseases, developmental effects (teratogenic, fetotoxic effects), hereditary genetic effects, reduced life expectancy, and alterations in mental state linked to stress or occupational exposures.

1.1.3 The Actors of Prevention

The prevention of occupational risks relies on a structured network of actors with responsibilities defined by regulations.

- **The Employer:** Bears the primary responsibility for the safety and health of workers. They have a duty of result, obliging them to take all necessary measures to prevent risks, inform and train staff, and implement an appropriate organizational structure.

- **The Worker (Employee):** Has the obligation to take care of their own safety and that of others. They must follow instructions, correctly use the protective equipment provided, and immediately report any dangerous situation.
- **The Occupational Health Service:** Composed of occupational physicians and nurses, its mission is exclusively preventive. It advises the employer and employees, conducts medical examinations, and contributes to the assessment of occupational risks.
- **The Health and Safety Committee / Works Council:** A staff representative body, it is consulted on all matters relating to health, safety, and working conditions.
- **External Bodies:** The Labor Inspectorate (enforcement), Social Security organizations (accident insurance, prevention advice), and specialized institutes (research, training) complete this framework.

1.2 Mastering Indicators Related to Occupational Accidents and Occupational Diseases

To manage safety performance, one must measure it. Statistical indicators enable the tracking of accident trends, comparison with industry benchmarks, and the effective targeting of prevention actions.

1.2.1 Indicators Related to Occupational Accidents

- **Frequency Rate (FR):** Measures the number of lost-time accidents for a given quantity of hours worked. It is typically expressed per one million hours worked.

$$\text{FR} = (\text{Number of Lost-Time Accidents} / \text{Total Hours Worked}) \times 1,000,000$$

- **Severity Rate (SR):** Measures the severity of accidents by relating the number of days lost due to temporary disability to the number of hours worked.

$$\text{SR} = (\text{Number of Lost Days} / \text{Total Hours Worked}) \times 1,000$$

- **Incidence Rate:** The number of lost-time accidents per 1,000 employees.
- **Global Severity Rate (GSR):** Incorporates both temporary lost days and permanent disabilities, the latter expressed as equivalent lost-day rates.

1.2.2 Indicators Related to Occupational Diseases

- **Prevalence Rate:** The number of recognized cases of occupational disease within a given population at a specific point in time.

- **Incidence Rate:** The number of new cases of occupational disease appearing over a given period.

These indicators have limitations due to under-reporting and the latency period of certain pathologies. They must be supplemented by more responsive, leading indicators such as the number of identified dangerous situations, the rate of completion of corrective actions, or the number of analyzed near-misses.

1.3 Observing and Analyzing Risks Associated with a Work Situation

The observation and analysis of risks are the core of the prevention process. They aim to identify the hazards present in a work situation and to assess the associated level of risk.

1.3.1 Different Types of Hazards

When observing a work situation, hazards must be systematically identified, classified into the following categories:

- **Biological:** Bacteria, viruses, fungi, parasites, etc.
- **Chemical:** Substances exhibiting hazardous physical (flammable, explosive), chemical (corrosive, oxidizing), or toxic (carcinogenic, mutagenic) properties.
- **Physical:** Ionizing and non-ionizing radiation, electromagnetic fields, extreme pressures (high pressure or vacuum), noise, vibration, thermal environments.
- **Ergonomic:** Repetitive movements, awkward postures, manual handling of loads, inadequate workstation layout.
- **Psychosocial:** Occupational stress, internal or external violence, harassment, excessive workload.
- **Safety-Related:** Risks of falls (slipping, tripping, falling from heights), mechanical risks (cutting, entanglement, crushing), inadequate machine guarding, non-compliant electrical installations.

1.3.2 Different Types of Risks

Beyond classification by hazard nature, several broad families of risk are distinguished:

- **Natural Risks:** Avalanches, forest fires, earthquakes, floods, storms, cyclones, volcanic eruptions.

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- **Technological Risks:** Industrial, nuclear, biological risks, dam failure.
- **Occupational Risks:** Risks linked to work activity and worker safety.
- **Collective Transport Risks:** Transport of people, transport of hazardous materials.
- **Everyday Life Risks:** Domestic accidents, road accidents.
- **Conflict-Related Risks:** Wars, terrorist attacks.

Within the scope of process engineering, the primary focus is on technological and occupational risks.

1.3.3 The Risk Assessment Process

Risk assessment is a structured process involving several steps:

Step 1: Hazard Identification

This involves identifying and characterizing all potential sources of harm in the work situation under consideration.

Step 2: Risk Analysis

For each identified hazard, the probability of occurrence of a hazardous event and the potential severity of the resulting harm are determined. Normal operating conditions, abnormal situations (shutdowns, breakdowns), and foreseeable emergency situations must be considered.

Step 3: Risk Evaluation and Prioritization

The risk level is determined by combining probability and severity. The criticality matrix is a simple and effective tool for this step.

[Insert Table 1: Probability × Severity Matrix here]

[Insert Table 2: Risk Rating and Associated Actions here]

The risk ratings, with their corresponding actions, are as follows:

- **Very High Risk (Immediate Danger):** Stop the process and implement immediate control measures.

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- **High Risk:** Conduct a thorough investigation and rapidly implement control measures.
- **Moderate Risk:** It is not necessary to stop the process, but a risk control plan must be developed and implemented as soon as possible.
- **Low Risk:** Regular monitoring is required, and maintenance of existing measures is sufficient.

Step 4: Determination of Control Measures

Step 5: Follow-up and Reassessment

Risk assessment is an iterative process. The effectiveness of the implemented measures must be verified, and the situation must be reassessed periodically or whenever a significant change occurs (new process, new equipment, organizational modification).

1.3.4 Prevention and Control Measures

Prevention consists of acting as far upstream as possible in the mechanism leading to harm. Prevention measures are organized around three complementary axes:

- **Organizational Measures:** Definition of written procedures, safety instructions, work organization (schedules, rotations), maintaining order and cleanliness (housekeeping), planning of maintenance operations.
- **Technical Measures (Collective Protection):** General and local exhaust ventilation (source capture), machine enclosures, emergency stop systems, automatic detection (fire, gas leak), acoustic insulation.
- **Human Measures:** Training and information for personnel exposed to hazards, safety awareness campaigns, provision and mandatory use of Personal Protective Equipment (PPE: helmets, gloves, safety glasses, safety shoes, respiratory protection). PPE constitutes the last line of defense when collective protections prove insufficient.

The Hierarchy of Prevention and Control Measures is as follows:

1. Identify Hazards.
2. Assess Risks.
3. Eliminate Hazards (where possible).

4. Reduce Risks through Collective Protection.
5. Protect Workers Individually (PPE).
6. Train and Inform.
7. Monitor and Review the effectiveness of measures taken.

1.4 Developing a Fault Tree Analysis

Fault Tree Analysis (FTA) is a method for the *a posteriori* analysis of an accident. It aims to obtain an objective description, reconstruct the accidental sequence, identify all factors and their causal relationships that contributed to its occurrence, and propose prevention measures to prevent its recurrence.

1.4.1 General Principles

Analysis using an FTA is based on three fundamental principles:

- **Do not judge; do not seek a culprit.** The objective is to understand, not to punish.
- **Work with facts.** Each element in the tree must be a concrete, observable, and indisputable fact, not an opinion or interpretation.
- **Search for root causes.** The analysis must not stop at the immediate causes but must trace the causal chain back to the underlying organizational failures.

1.4.2 Construction Methodology

Phase 1: Information Gathering

This phase is critical. It must be conducted as soon as possible after the accident to prevent loss of information. The goal is to collect all facts relating to the accident:

- Facts linked to the individual (action, gesture, position).
- Facts linked to the task (procedure, instructions, objectives).
- Facts linked to the equipment (condition, operation, guarding).
- Facts linked to the environment (noise, lighting, clutter, weather conditions).
- Facts linked to the organization (schedules, training, supervision, maintenance).

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The pitfalls to strictly avoid are: the immediate search for blame ("Whose fault is it?"), hasty solutions ("We should just..."), and *a priori* judgments ("It's obviously because...").

Phase 2: Building the Tree.

For each collected fact, the following three questions must be systematically asked:

1. **What was necessary** for this fact to occur?
2. **Is this condition necessary** for the production of this fact?
3. **Is this condition sufficient**, or were there other, equally necessary causes?

The construction starts from the ultimate harm (the accident) and moves chronologically upstream. Facts are linked together by logical connections:

- **Sequence (Succession):** A fact A is followed by a fact B.
- **Conjunction (Combination):** Several independent facts (A, B, C) are all necessary for a fact D to occur.

[Insert the schematic diagram of the Fault Tree with the standard sequence and conjunction symbols here]

Phase 3: Exploiting the Results

The completed tree highlights the root causes which, if corrected, can prevent the accident from recurring. The analysis must lead to a plan of prevention actions, complete with assigned responsibilities and implementation deadlines.

1.4.3 The Practice of Occupational Hygiene

Occupational hygiene follows a parallel and complementary approach, centered on medium- and long-term health risks. Its classical steps are:

1. **Identification** of hazardous agents present in the workplace.
2. **Assessment** of the degree of worker exposure to these agents.
3. **Prevention and Control** through strategies aimed at eliminating or reducing exposure to hazardous factors to acceptable levels.

The ideal approach is that of "**anticipatory and integrated preventive action**".

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Chapter Objectives:

- Understand the main issues in hygiene and public health related to industry.
- Acquire the fundamentals of housing hygiene.
- Know the key domains of environmental protection.
- Apprehend the principles and challenges of sustainable development.
- Identify the roles of national and international bodies in HSE.

2.1 Identifying the Main Aspects of Hygiene and Public Health

2.1.1 Definition and Scope of Public Health

Public health is a discipline aimed at improving the health status of a population through collective actions of prevention, health promotion, and the organization of care. It encompasses a state of complete physical, mental, and social well-being.

In the context of process engineering, the engineer must understand the interactions between industrial activities and the health of populations, whether workers (occupational health) or neighboring communities and consumers (public health).

2.1.2 The Determinants of Health

The health status of a population results from the interaction of four major groups of determinants:

- **Biological and Genetic Factors:** Age, sex, genetic heritage.
- **Environmental Factors:** Air quality, water quality, soil quality, exposure to chemicals, noise.
- **Behavioral and Lifestyle Factors:** Diet, physical activity, smoking, alcohol consumption.
- **Factors Related to the Health System:** Access to care, quality of health services.

The process engineer primarily intervenes on environmental determinants.

2.1.3 Occupational Health and Occupational Diseases

Occupational health is an essential component of public health. The main risks to occupational health are:

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- **Chemical Risks:** Exposure to CMR substances.
- **Physical Risks:** Noise, vibration, radiation, extreme temperatures.
- **Biological Risks:** Infectious agents.
- **Psychosocial Risks:** Stress, burnout, harassment, violence.

2.1.4 The Practice of Occupational Hygiene

Occupational Hygiene is the discipline dedicated to the identification, assessment, and control of hazardous agents in the workplace. Its classical steps are the identification of hazards, the assessment of exposure, and the implementation of prevention and control strategies. The ideal approach is that of "**anticipatory and integrated preventive action**".

2.2 Understanding the Concepts of Housing Hygiene

Housing hygiene concerns all the environmental and sanitary conditions of the living environment. The main health risks are indoor air quality, water quality, noise nuisances, waste management, and dampness/mold.

2.3 Knowing the Main Domains of Environmental Protection

2.3.1 Water: Protection of the entire water cycle.

2.3.2 Air: Reducing emissions of SO₂, NO_x, PM, VOCs, O₃, and GHGs.

2.3.3 Soil and Groundwater: Combating chronic and accidental pollution.

2.3.4 Waste: Following the treatment hierarchy (prevention, reuse, recycling, recovery, disposal).

2.3.5 Noise: Acting at the source, on the propagation path, and at the receiver.

2.4 Understanding the Challenges of Sustainable Development

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report, 1987). It rests on three pillars: economic, social, and environmental. The operational principles for the engineer include eco-design, circular economy, life cycle assessment (LCA), and green chemistry.

2.5 Identifying the Role and Mission of Various Organizations in Occupational Health and Safety and Public Health

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2.5.1 At the International Level: WHO, ILO, UNEP.

2.5.2 At the National Level: Ministry of Labor, Ministry of Health, Ministry of Environment, Social Security bodies.

2.5.3 At the Enterprise Level: Occupational Health Service, Health and Safety Committee, front-line management.

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GENERAL CONCLUSION

At the end of this two-chapter journey, one conviction should stand out for every student: Health, Safety, and Environment are not peripheral disciplines added as an afterthought to the design of an industrial installation. They constitute a fundamental dimension of the engineering art.

Chapter 1 has provided the tools to analyze risk at the closest level to the field. Chapter 2 has broadened this vision, exploring the links between the industrial installation, the health of populations, and the state of the natural environment.

This introduction to risk management and environmental protection constitutes a first step in the training curriculum at the University of Mostaganem. It has laid the foundations upon which more specialized courses will build. But beyond technical knowledge, it is an intellectual and ethical posture that the **HSE and Industrial Installations** course hopes to have helped forge: that of an engineer who, in every design or operational decision, systematically questions its consequences on people and the planet.

For it is by integrating this requirement of responsibility that the graduates of the University of Mostaganem will become not only competent and sought-after engineers, but also enlightened actors in the sustainable industrial development of Algeria tomorrow.