

MODULE 3: Communication and Terminology for the Workplace

TOPIC 6: Engineering Concepts and Health and Safety Issues

LEARNING OUTCOMES:

By the end of this lesson, participants will be able to:

- ◆ relate engineering concepts to health and safety issues within their own discipline and in general engineering practice
- ◆ have knowledge of terminology related to health and safety in the engineering workplace

TOPIC	SKILLS	CLB COMPETENCE AREA	COMPETENCIES	PRE-TASKS	TASK	POST-TASK
<ul style="list-style-type: none"> ◆ Engineering Concepts and Health and Safety Issues 	<ul style="list-style-type: none"> ◆ Reading ◆ Speaking 	<ul style="list-style-type: none"> ◆ unformatted text ◆ exchanging information 	<ul style="list-style-type: none"> ◆ analyze engineering concepts in terms of health and safety issues ◆ scan for specific information ◆ apply new terminology related to health and safety when providing information related to prior work experience 	<ul style="list-style-type: none"> ◆ read an article on health and safety and engineering ◆ extract information from a text ◆ categorize safety topics by discipline ◆ identify generic engineering concepts ◆ match health and safety issues appropriate to generic engineering concepts 	<ul style="list-style-type: none"> ◆ categorize engineering concepts by discipline ◆ list related health and safety issue ◆ discuss application or approach of health and safety in previous work experience 	<ul style="list-style-type: none"> ◆ extend knowledge of discipline specific health and safety issues

Facilitator's Guide for Module 3**Topic 6: Engineering Concepts and Health and Safety Issues****FACILITATOR PREPARATION*****Content***

In order to prepare for this lesson, the facilitator should be familiar with engineering concepts and related health and safety concerns. It is also important to be very familiar with the article used as an introduction.

Delivery

Copies should be made of the following handouts:

- ◆ Handout 1 P.Engs. and Workplace Safety
- ◆ Handout 2 Engineering Concepts Categorization Activity
- ◆ Handout 3 Generic Engineering Concepts and Health & Safety Issues
- ◆ Handout 4A-D Discipline-specific Health & Safety Issues
- ◆ Handout 5 Summary Chart

Terminology List (optional)

Prepare a list on chart paper of engineering health and safety issues (see Facilitator's Notes, Pre-Task 2).

Methodology***Introduction***

- (10 minutes)** 1. Review briefly the WHMIS lesson from the previous session, stressing that WHMIS is legally required for all employees, but that engineers have specific health and safety concerns related to their professional practice.

2. Facilitate a class discussion by asking participants how they applied health and safety rules in their last job as part of their professional responsibilities.

Pre-Tasks

- (30 minutes)** 1. Explain to the class that there have been some changes in the role of public health and safety within the engineering profession. Distribute Handout 1. Pair the participants and assign one of the following questions to each pair.

- ◆ How is the Ministry of Labour changing its role in health and safety?
- ◆ What are the implications for private-sector engineers?

Have them scan for this information as they are reading. Participants should try and determine the meaning of unfamiliar vocabulary using context clues and try to use this vocabulary when answering the above questions. To conclude this activity, discuss the role of the PEO as mentioned in the article.

- (20 minutes)** 2. Brainstorm as a whole class some safety “topics” that would be applicable to engineers (e.g., fire safety, radiation control, chemical-process safety). Group participants according to discipline and have them list on chart paper safety topics that are applicable to their discipline. After ten minutes show the following list of safety topics (on chart paper) and have participants expand their list:

Safety Topics

- ◆ Ergonomics / Biomechanics
- ◆ Materials Handling and Warehousing
- ◆ Machine Safety, Controls, and Displays
- ◆ Electrical Safety and Lockout
- ◆ Mechanical Handling Systems
- ◆ Automated Systems and Robotics
- ◆ Slips and Falls
- ◆ Confined Spaces
- ◆ Industrial Hygiene

- ◆ Chemical Process Safety
- ◆ Hand and Power Tools
- ◆ Personal Protective Equipment
- ◆ Fire Protection
- ◆ Life Safety
- ◆ Construction Safety
- ◆ Transportation Safety
- ◆ System Safety Techniques
- ◆ Product Safety

Remind the participants that they should be prepared to explain the reasons for their choices. Have the groups share their lists; they should justify their answers and provide examples (i.e., “_____ is important because...”).

- (10 minutes)** 3. Participants should now work in mixed-discipline groups. Mention that industrial engineers and mechanical engineers have the most to do with health and safety. Distribute Handout 2, a list of engineering concepts with which participants will be very familiar.

Explain that some of these concepts are generic and others are discipline specific. Have participants identify the generic concepts and make a list on the board.

- (10 minutes)** 4. Distribute Handout 3 and have the participants work in pairs to match generic engineering concepts with related health and safety issues. Take up as a whole class.

Task

- (10 minutes)** 1. Regroup participants by disciplines. Refer participants back to the list of engineering concepts in Handout 2 and have them circle the concepts that are relevant to their discipline.

- (15 minutes)** 2. After deciding which concepts are relevant to their discipline, have participants discuss what specific health and safety issues would be related to each concept that they selected. Give the participants fifteen minutes to discuss and share knowledge gained from prior work experience and training.

Post-Tasks

- (20 minutes)**
1. Distribute Handouts 4A, B, C, D to participants in the appropriate discipline groups. Explain that this is a matching activity that is similar to the previous one but related to their discipline. Have the participants share their answers within their group. The Chemical Engineering handout is not extensive. Have this group review the WHMIS / MSDS post-task activity, since it would be relevant to them. Encourage them to discuss the health and safety issues they dealt with in their previous engineering workplaces, using the terminology covered in this lesson and the previous one.
 2. Distribute Handout 5, which provides a summary of the information presented in this lesson

Handout 1

PLATFORM

P.Engs and Workplace Safety

Nadia Elgohary, M.Eng., P.Eng.

Recent changes by the Ontario Ministry of Labour demonstrate how government is shifting responsibility to the engineering profession for areas of public health, safety and welfare it once regulated directly, says this labour ministry engineer. To protect the public and themselves, professional engineers must become more aware of and prepare for their new responsibilities.

The provincial government is moving toward deregulation as a means of creating a competitive marketplace in which business can thrive. Yet the government must still maintain its commitment to protect the public's health and safety. This means placing more responsibilities on professional engineers and industry to achieve higher safety standards and greater public protection.

The Ministry of Labour, for example, has changed the way it does business; its new mission statements says its new role is to set, communicate and enforce workplace parties to become more self-reliant in achieving those standards. This internal responsibility system will form the foundation of Ontario's approach to health and safety.

The ministry will no longer be in the business of preventing illness and injury. Prevention will be shifted to professional engineers, the Workers' compensation board, and such government and safety Association of Ontario.

Accordingly, the ministry announced in April 1996 that it was downsizing an refocusing its professional services. At that time, the ministry's engineering complement comprised 33 engineering consultants working for the construction,

industrial and mining programs. Their duties included:

- ◆ predevelopment reviews of drawings, as required by the Occupational Health and Safety Act;
- ◆ issuing permits for such things as explosives magazines and lifting and hoisting devices in mines;
- ◆ reviewing the structural adequacy of arenas;
- ◆ reviewing notifications, structural designs, new machinery and equipment, and new processes;
- ◆ consulting with workplace parties, and
- ◆ investigating with inspectors.

In June, the ministry reduced its engineering complement by more than half. Those professional engineers left will now focus on enforcement, engineering support for field staff, and policy and standards setting.

Thus, labour ministry engineers will no longer be responsible for review of drawings and engineering consultations for the following sections of Regulation 213/91: forms and form/false work, scaffoldings, fall protection systems, suspended work platforms, multi-point suspended work platforms, excavation support systems, excavation slopes, support systems for repairs of underground pipes, shafts support systems, tunnels support systems, window cleaning anchor systems and layout and procedures for confined space entry. Similarly, they will no longer conduct predevelopment drawing reviews for industrial establishments legislated by the Occupational Health and Safety Act, nor will they review the structural adequacy of arenas. Also eliminated will be mine predevelopment drawing reviews, and licensing for explosives magazines and lifting and hoisting devices in mines.

To ensure that someone provides these necessary safety engineering services, existing legislation will be changed to require owners and employers to obtain the services of professional engineers.

This shift of responsibilities will present a major challenge for private sector engineers, who will have to become knowledgeable of all relevant safety legislation to

avoid increasing their liability exposure. Remember, there will no longer be government professionals to double check safety engineering work.

To meet this challenge:

- ◆ PEO must make Ontario engineers aware of the implications of the transfer of responsibilities from government engineers to the private sector, and must put in place a method to demonstrate to the government and the public its members' competence and accountability for this work;
- ◆ Organizations that employ engineers must ensure that their engineers have the necessary safety training;
- ◆ Industry, when seeking safety engineering services, must employ only professional engineers who are qualified and experienced in safety engineering, and
- ◆ Professional engineers must seek training on safety legislation and other specialized safety topics.

The Ministry of Labour has given Ontario engineers a tremendous opportunity to become recognized by the public as the group primarily responsible for ensuring workplace health and safety. But with this opportunity comes new responsibilities and new risks. If the Ontario public is to be protected and industry is to reap the benefits of an accident and injury free workplace, the engineering profession must recognize and prepare itself to accept its new responsibilities. □

Nadia Elgohary, M.Eng., P.Eng., has over 25 years' experience in construction consulting, the last 15 as a safety engineering consultant with the labour ministry.

Platform is a forum for opinion on current engineering issues. Ideas expressed do not necessarily reflect PEO opinion or policy, nor does the association assume responsibility for the opinions expressed.

Source: *Engineering Dimensions*, 1996.

Handout 2

Engineering Concepts Categorization Activity

- ◆ Control systems
- ◆ Statics and Dynamics
- ◆ Automation
- ◆ Mechanics and Kinetics
- ◆ Fluid and Gas Dynamics
- ◆ Professional and Engineering Ethics
- ◆ Thermodynamics
- ◆ Electrical Theory and Systems
- ◆ Electronic Data Processing
- ◆ Strength of Materials
- ◆ Layout and Facility Planning
- ◆ Information Management
- ◆ Process Design and Analysis
- ◆ Engineering Economics
- ◆ Productivity
- ◆ Product Design
- ◆ Customer Relations
- ◆ Simulation and Modelling
- ◆ Quality
- ◆ Engineering and Project Management
- ◆ Emerging Technologies

Handout 3

Generic Engineering Concepts and Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Engineering Economics

a)

- Federal Safety standards
- Familiarity with industry and consensus standards
- Risk management, insurance, and liability

2) Engineering and Project Management

b)

- Risk assessment
- Job safety analysis
- Epidemiological analysis of new materials and substances

3) Information Management

c)

- Establishment of safety programs and work teams
- Pre-operations safety planning
- Measuring safety performance
- Development of effective oral/written safety reports to

4) Simulation and Modelling

d)

- Product safety in acquisition and installation of new process equipment
- Toxics use reduction
- Formalized process hazard analysis

5) Customer Relations

e)

- Safety assessment and inspection techniques
- Warnings and hazard communication
- Incident investigation and

6) Emerging Technologies

f)

- Handling complaints from public/users
- Responding to accidents/incidents
- Written communications (warnings, instructions, etc.)

7) Professional and Engineering Ethics

g)

- Process hazard analysis (what-if, use of checklists, etc.)
- Material process flow analysis
- Ergonomics task assessment and use of anthropometric data

8) Process Design and Analysis

h)

- Risk assessment
- Cost/benefit analysis
- Cost justification of safety projects

FACILITATOR'S NOTES

Answer Key to Handout 3

All Disciplines

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Engineering Economics	h	a)	<ul style="list-style-type: none"> ▪ Federal Safety standards ▪ Familiarity with industry and consensus standards ▪ Risk management, insurance, and liability
2) Engineering and Project Management	c	b)	<ul style="list-style-type: none"> ▪ Risk assessment ▪ Job safety analysis ▪ Epidemiological analysis of new materials and substances
3) Information Management	e	c)	<ul style="list-style-type: none"> ▪ Establishment of safety programs and work teams ▪ Pre-operations safety planning ▪ Measuring safety performance ▪ Development of effective oral/written safety reports to
4) Simulation and Modelling	g	d)	<ul style="list-style-type: none"> ▪ Product safety in acquisition and installation of new process equipment ▪ Toxics use reduction ▪ Formalized process hazard analysis
5) Customer Relations	f	e)	<ul style="list-style-type: none"> ▪ Safety assessment and inspection techniques ▪ Warnings and hazard communication ▪ Incident investigation and
6) Emerging Technologies	b	f)	<ul style="list-style-type: none"> ▪ Handling complaints from public/users ▪ Responding to accidents/incidents ▪ Written communications (warnings, instructions, etc.)
7) Professional and Engineering Ethics	a	g)	<ul style="list-style-type: none"> ▪ Process hazard analysis (what-if, use of checklists, etc.) ▪ Material process flow analysis ▪ Ergonomics task assessment and use of anthropometric data
8) Process Design and Analysis	d	h)	<ul style="list-style-type: none"> ▪ Risk assessment ▪ Cost/benefit analysis ▪ Cost justification of safety projects

Handout 4A

Industrial Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Mechanics and Kinetics

a)

- Fire safety in building design
- Storage and transport of corrosive and reactive substances
- Selection and testing of personal protective equipment (hard hats, safety shoes, etc.)

2) Control Systems

b)

- Ergonomic design of workplaces
- Minimization of materials handling
- Facility traffic flow and vehicle safety
- Design for fire prevention and protection
- Life safety and evacuation planning

3) Automation

c)

- Selection and use of controls
- Human error
- Layout and positioning of controls

4) Layout and Facility Planning

d)

- Slip and fall protection
- Properties of floor surfaces and optimal coefficients of friction
- Bio-mechanical assessment of musculoskeletal system
- Health hazards of segmental and whole-body vibration

5) Productivity

e)

- Robotics safety
- Use of automation in the prevention of materials handling hazards
- Assessment of human tolerance for speed

6) Strength of Materials

f)

- Work physiology and fatigue
- Detrimental effect of shift work/overtime
- Optimization of ambient environmental conditions (e.g., lighting, temperature, etc.)

FACILITATOR'S NOTES

Answer Key to Handout 4A

Industrial Engineering

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Mechanics and Kinetics

d

a)

- Fire safety in building design
- Storage and transport of corrosive and reactive substances
- Selection and testing of personal protective equipment (hard hats, safety shoes, etc.)

2) Control Systems

c

b)

- Ergonomic design of workplaces
- Minimization of materials handling
- Facility traffic flow and vehicle safety
- Design for fire prevention and protection
- Life safety and evacuation planning

3) Automation

e

c)

- Selection and use of controls
- Human error
- Layout and positioning of controls

4) Layout and Facility Planning

b

d)

- Slip and fall protection
- Properties of floor surfaces and optimal coefficients of friction
- Bio-mechanical assessment of musculoskeletal system
- Health hazards of segmental and whole-body vibration

5) Productivity

f

e)

- Robotics safety
- Use of automation in the prevention of materials handling hazards
- Assessment of human tolerance for speed

6) Strength of Materials

a

f)

- Work physiology and fatigue
- Detrimental effect of shift work/overtime
- Optimization of ambient environmental conditions (e.g., lighting, temperature, etc.)

Handout 4B

Chemical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Product Design

a)

- Product hazard assessment and control
- Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)

2) Quality

b)

- Detection and analysis of defects and system features
- Hazard identification techniques
- System safety analyses (e.g., FMEA, Fault Tree)

Refer back to the WHMIS lesson and read and discuss in your group the MSDS form.

FACILITATOR'S NOTES

Answer Key to Handout 4B

Chemical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Product Design

a

a)

- Product hazard assessment and control
- Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)

2) Quality

b

b)

- Detection and analysis of defects and system features
- Hazard identification techniques
- System safety analyses (e.g., FMEA, Fault Tree)

Refer back to the WHMIS lesson and read and discuss in your group the MSDS form.

Handout 4C

Mechanical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1. Statics and Dynamics

a)

- Detection and analysis of defects and system features
- Hazard identification techniques
- System safety analyses (e.g., FMEA, Fault Tree)

2. Fluid and Gas Dynamics

b)

- Control of explosions and other unintended releases of energy
- Safe use of compressed gases
- Safety of boilers and pressure vessels

3. Thermodynamics

c)

- Ventilation of air contaminants
- Design and hydrostatic testing of sprinkler systems
- Safety properties of cryogenic fluids

4. Product Design

d)

- Calculation of safety factors and performance limits
- Rated capacities of hoists, cranes, scaffolding, storage racks, etc.
- Floor loading

5. Quality

e)

- Product hazard assessment and control
- Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)

FACILITATOR'S NOTES

Answer Key to Handout 4C

Mechanical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1. Statics and Dynamics	d	a)	<ul style="list-style-type: none"> ▪ Detection and analysis of defects and system features ▪ Hazard identification techniques ▪ System safety analyses (e.g., FMEA, Fault Tree)
2. Fluid and Gas Dynamics	c	b)	<ul style="list-style-type: none"> ▪ Control of explosions and other unintended releases of energy ▪ Safe use of compressed gases ▪ Safety of boilers and pressure vessels
3. Thermodynamics	d	c)	<ul style="list-style-type: none"> ▪ Ventilation of air contaminants ▪ Design and hydrostatic testing of sprinkler systems ▪ Safety properties of cryogenic fluids
4. Product Design	e	d)	<ul style="list-style-type: none"> ▪ Calculation of safety factors and performance limits ▪ Rated capacities of hoists, cranes, scaffolding, storage racks, etc. ▪ Floor loading
5. Quality	a	e)	<ul style="list-style-type: none"> ▪ Product hazard assessment and control ▪ Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)

Handout 4D

Electrical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Electrical Theory and Systems

a)

- Safety data storage and retrieval
- Software safety
- Hazards of computers and VDTs

2) Product Design

b)

- Product hazard assessment and control
- Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)

3) Electronic Data Processing

c)

- Protective and system grounding
- Lockout/tagout. Zero energy state
- Prevention of fires and electrical shock

4) Quality

d)

- Detection and analysis of defects and system features
- Hazard identification techniques
- System safety analyses (e.g., FMEA, Fault Tree)

FACILITATOR'S NOTES

Answer Key to Handout 4D

Electrical Engineering Health & Safety Issues

Match the engineering concepts on the left with appropriate health and safety issues on the right.

1) Electrical Theory and Systems	c	a)	<ul style="list-style-type: none"> ▪ Safety data storage and retrieval ▪ Software safety ▪ Hazards of computers and VDTs
2) Product Design	b	b)	<ul style="list-style-type: none"> ▪ Product hazard assessment and control ▪ Product life-cycle analysis (e.g., installation, repair, maintenance, disposal)
3) Electronic Data Processing	a	c)	<ul style="list-style-type: none"> ▪ Protective and system grounding ▪ Lockout/tagout. Zero energy state ▪ Prevention of fires and electrical shock
4) Quality	d	d)	<ul style="list-style-type: none"> ▪ Detection and analysis of defects and system features ▪ Hazard identification techniques ▪ System safety analyses (e.g., FMEA, Fault Tree)

Handout 5- Summary Chart

Engineering Concepts	Safety and Health Examples
Statics and Dynamics	<ul style="list-style-type: none"> • Calculation of safety factors and performance limits • Rated capacities of hoists, cranes, scaffolding, storage racks, etc. • floor loading
Mechanics and Kinetics	<ul style="list-style-type: none"> • Slip and fall protection • Properties of floor surfaces and optimal coefficients of friction • Biomechanical assessment of musculoskeletal system • Health hazards of segmental and whole-body vibration
Fluid and Gas Dynamics	<ul style="list-style-type: none"> • Ventilation of air contaminants • design and hydrostatic testing of sprinkler systems • Safety properties of cryogenic fluids
Thermodynamics	<ul style="list-style-type: none"> • Control of explosions and other unintended releases of energy • Safe use of compressed gases • Safety of boilers and pressure vessels
Electrical Theory and Systems	<ul style="list-style-type: none"> • Protective and system grounding • Lockout/tagout – Zero energy state • Prevention of fires and electrical shock
Strength of Materials	<ul style="list-style-type: none"> • Fire safety in building design • Storage and transport of corrosive and reactive substances • Selection and testing of personal protective equipment (hard hats, safety shoes, etc.)
Information Management	<ul style="list-style-type: none"> • Safety assessment and inspection techniques • Warnings and hazard communication • Incident investigation and recordkeeping
Engineering Economics	<ul style="list-style-type: none"> • Risk assessing • Cost/benefit analysis • Cost justification of safety projects
Engineering and Project Mgmt.	<ul style="list-style-type: none"> • Establishment of safety programs and work teams • Pre-operations safety planning • Measuring safety performance • Development of effective oral/written safety reports to management
Quality	<ul style="list-style-type: none"> • Detection and analysis of defects and system failures • Hazard identification techniques • System safety analyses (e.g., FMEA, Fault Tree)
Simulation and Modeling	<ul style="list-style-type: none"> • Process Hazard analysis (“what-if”, use of checklists, etc.) • Material Process flow analysis • Ergonomics task assessment and use of anthropometric data

Engineering Concepts	Safety and Health Examples
Productivity	<ul style="list-style-type: none"> • Work physiology and fatigue • Detrimental effect of shift work/overtime • Optimization of ambient environmental conditions (e.g., lighting, temperature, etc.)
Product Design	<ul style="list-style-type: none"> • Product hazard assessment and control • Product life-cycle analysis (e.g., installation, repair, maintenance, disposal) • Use of CPSC, ASTM and other safety-related standards.
Customer Relations	<ul style="list-style-type: none"> • Handling complaints from public/users. • Responding to accidents/incidents • Written communications (warnings, instructions, etc.)
Emerging Technologies	<ul style="list-style-type: none"> • Risk assessment • Job safety analysis • Epidemiological analysis of new materials and substances
Process Design and Analysis	<ul style="list-style-type: none"> • Product safety in acquisition and installation of new process equipment • Toxics use reduction • Formalized process hazard analysis
Layout and Facility Planning	<ul style="list-style-type: none"> • Ergonomic design of workplaces • Minimization of materials handling • Facility traffic flow and vehicle safety • Design for fire prevention and protection • Life safety and evacuation planning
Electronic Data Processing	<ul style="list-style-type: none"> • Safety data storage and retrieval • Software safety • Hazards of computers and VDTs
Professional and Engineering Ethics	<ul style="list-style-type: none"> • Federal/state safety standards • Familiarity with industry and consensus standards • Risk management, insurance and liability
Automation	<ul style="list-style-type: none"> • Robotics safety • Use of automation in the prevention of materials handling hazards • Assessment of human tolerance for speed
Control Systems	<ul style="list-style-type: none"> • Selection and use of control • Human error • Layout and positioning of controls

Source: Dembe, A.E. (1996). "The Future of Safety and Health in Engineering Education." *Journal of Engineering Education*: 85.

Terminology List

Pre-Task 1

- ◆ deregulation
- ◆ a means of
- ◆ downsizing
- ◆ shift
- ◆ competence and accountability
- ◆ to reap benefits
- ◆ notifications

Generic Health and Safety Terminology

- | | |
|---------------------------------------|----------------------------------|
| ◆ safety standards | ◆ risk management |
| ◆ industry and consensus standards | ◆ risk assessment |
| ◆ liability | ◆ job-safety analysis |
| ◆ epidemiological analysis | ◆ work term |
| ◆ safety performance | ◆ material process flow analysis |
| ◆ formalized process hazards analyses | ◆ ergonomics task assessment |
| ◆ anthropometric data | |