Engineering Health and Safety Module and Case Studies

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Prepared for:

Minerva Canada
http://www.minervacanada.org

July 2004

PREFACE

Health and safety issues are important in engineering, management and other fields. Most professional engineering associations point out that health and safety are issues of utmost importance in engineering practice. For example, Professional Engineers Ontario (http://www.peo.on.ca) states in its Code of Ethics, “A practitioner shall … regard the practitioner's duty to public welfare as paramount.” The need for appropriate education and training in engineering health and safety is also widely recognized, and engineering programs usually must appropriately address health and safety to maintain accreditation. For instance, the Canadian Engineering Accreditation Board (http://www.ccpe.ca) includes in its curriculum-content criteria, “Appropriate exposure to … public and worker safety and health considerations … must be an integral component of the engineering curriculum.”

This document is an engineering-oriented module and set of case studies on health and safety, which helps convey the importance of these issues in a concise package. The material can be covered in a single lecture, or over an extended period. The materials herein are intended and structured for engineering students, but are also useful for others, e.g., students in other technical programs such as applied sciences and technology, students in management, business and other programs that interface with engineering, and students in company training programs.

This package contains case studies since they usually present a useful and interesting means of delivering education on health and safety to engineering students. Minerva Canada (http://www.minervacanada.org) and others have in the past developed several useful business- and engineering-oriented case studies on health and safety. The case studies presented here are fictitious, although they contain ideas based on actual incidents. Although the case studies are oriented towards engineering, they also incorporate management and business issues, since health and safety must be dealt with in an integrated and interdisciplinary manner. For example, criteria for business success, such as performance and profitability, must be considered in concert with health and safety. The case studies are not intended to be judgmental, but rather to provide a basis for discussion.

The author invites feedback and comments from interested parties and users, so that the module and accompanying case studies can be enhanced in the future.

Acknowledgements

The author is grateful to Minerva Canada for its support of the development of this module and the case studies. In addition, the author is thankful for the comments and suggestions made by several members of the Minerva Canada Board.

Particular thanks are due to David Meston, a member of Minerva Canada who provided invaluable advice.

Finally, the author is grateful to Dr. William Goodman, a faculty member in the School of Business and Information Technology at University of Ontario Institute of Technology, for reviewing this work. Beyond providing general useful suggestions, Dr. Goodman's review helped ensure that the material would find uses in areas beyond engineering where health and safety are important, such as business and management.

Basic Management Principles in Occupational Health and Safety

Occupational Health and Safety

Occupational health and safety is concerned with the identification, evaluation and control of hazards associated with the workplace. Companies and organizations often have occupational health and safety programs, the objectives of which are to reduce:

- occupational injuries, which include any harm from a workplace accident (e.g., fracture, cut, burn), and
- occupational illnesses, which include abnormal conditions caused by exposure to factors associated with the workplace.

Occupational health and safety are often grouped together, but they are not the same even though they are closely related. It is important to understand both. One way we can differentiate health and safety is as follows:

- Safety usually is concerned with situations that cause injury and deals with hazards that lead to severe and sudden outcomes.
- Health usually is concerned with situations that cause illness or disease and deals with adverse reactions to exposure over prolonged periods to hazards that are usually less severe, but still dangerous.

Of course, some situations can simultaneously lead to safety and health concerns.

Types of Workplace Hazards

The range of potential workplace hazards is large and includes the following types:

- mechanical
- fall-related
- lifting-related
- pressure
- sound, noise and vibration
- heat, cold and temperature
- fire
- explosion
- electrical
- chemical
- biological
- toxic, carcinogenic and otherwise harmful substances
- radiation
- automation
- ergonomic
- human and psychosocial factors (e.g., stress)

Some hazards do not clearly fall into one of the above types (e.g., the hazards associated with work in a confined space), while other hazards may fall into more than one type.

Stakeholders

The number of stakeholders affected by occupational health and safety is large and includes, among others, the following:

- employers
- employees
- government and other regulatory authorities
- compensation and insurance providers
- the public

In an organization, occupational health and safety involves everyone, from the chief executive officer to the worker. Employees and employers often are jointly responsible for occupational health and safety and employers are accountable for non-compliance.

Importance of Occupational Health and Safety

Some of the main reasons for being concerned about occupational health and safety include the following:

- Economics. The economic costs, both direct and indirect, of workplace accidents, injuries and illnesses are significant. Costs can be associated with the time lost from work, human pain and suffering, and the subsequent loss of moral and decline in worker efficiency and productivity.
- Legality. Occupational Health and Safety Acts provide workers with the right to a safe work environment. In protecting workers, employers must exercise due diligence, i.e., take reasonable precautions appropriate for the circumstances. The legal penalties that are possible for violations of health and safety legislation are significant and can include civil lawsuits and criminal prosecutions.
- Morality. It is generally accepted that employers have a moral responsibility to provide a safe working environment for their employees.

The field of occupational health and safety has been increasing in importance due to the consequences of occupational injuries and illnesses, and public expectations have increased for better occupational health and safety.

Role of Senior Management in Occupational Health and Safety

Senior management within a company plays a very important role in occupational health and safety. In particular, senior management is responsible for

- taking a leadership role in establishing occupational health and safety as a company priority and commitment,

- promoting a positive health and safety culture throughout the company,
- ensuring support for occupational health and safety initiatives is provided, and
- demonstrating and modeling good occupational health and safety practices.

Without a clear commitment to occupational health and safety by senior management, it is difficult for others in the company to feel that health and safety initiatives are appreciated or even desired. Employees will usually focus their efforts on other activities, and place a low priority on occupational health and safety, in instances where a lack of commitment seems to exist.

A commitment by and leadership from senior management is critical for engineers seeking excellence in health and safety that is sustainable over time. Without appropriate commitment and leadership, an engineer will normally only be able to go part way towards addressing occupational health and safety and, in the worst cases, may not even be able to initiate required measures.

Knowledge Needed to Address Occupational Health and Safety

In order to address occupational health and safety appropriately, a wide range of knowledge and skills are needed, including the following:

- A technical understanding of, and ability to assess, recognize and prevent, all types of workplace hazards and risk factors.
- Knowledge of relevant acts, standards, regulations, codes, laws and liability. These include occupational health and safety legislation, and Workplace Hazardous Materials Information System (WHMIS) legislation.
- Knowledge of workers compensation schemes and programs.
- Medical knowledge, including physiotherapy, psychology and health care.
- An ability to deal with and motivate people, communicate clearly, and develop and manage plans.

Workplace Qualities Needed for Successful Health and Safety Outcomes

There exist certain workplace qualities that are required for successfully addressing occupational health and safety. The Ontario Workplace Safety and Insurance Board workplace lists the following qualities as essential for successful health and safety outcomes:

- A positive health and safety culture, including strong active senior leadership and a workforce that is empowered to fulfill its responsibilities in keeping the workplace healthy and safe.
- An effective internal responsibility system that ensures all members of the workplace fulfill their health and safety responsibilities.
- An occupational health and safety management system that is geared towards control of risks.

Programs for Occupational Health and Safety

The information described in the previous two sections is used in creating programs for occupational health and safety. Such programs require the following:

- A leadership commitment to occupational health and safety.
- Consistent support of senior management in establishing and maintaining a health and safety culture in the company.
- Appropriate plans to deal with problems and emergencies.
- Promotion of health and safety throughout a company.
- Appropriate and relevant education and training in health and safety throughout a company.
- Clearly defined responsibilities relating to health and safety.
- Clearly defined authority to take action relating to health and safety.
- Appropriate procedures for reporting safety incidents.
- Procedures for investigating health and safety incidents and taking follow-up actions.
- Appropriate procedures for record keeping for all facets of health and safety.
- Establishment of on-site health and safety committees.

Activities in occupational health and safety programs can be broken down and categorized in several ways. One categorization considers three levels of intervention:

- Identification and removal of hazards and risk factors (e.g., adding safety devices to an existing process, designing systems and processes for health and safety, a task ideally done in the early stages of an engineering activity).
- Protection of workers from potential consequences of exposure hazards and risk factors (e.g., use of protective eyewear and clothing).
- Care of workers who have been harmed from exposure to workplace hazards or risk factors (e.g., use of treatment, rehabilitation and compensation programs).

Although they can be more costly to implement in the short term, interventions of the type in the first bullet are for several reasons usually preferable to and more successful than those in second bullet. One reason is that interventions of the type in the first bullet usually do not rely as much, if at all, on worker actions. Over the long term, if interventions of the type in the first bullet are designed appropriately into occupational health and safety systems, they can be as or more cost effective than those of the type in the second bullet. In general, there are many benefits to taking a “safety by design” approach, in which health and safety are treated from the start as primary factors in design activities (like manufacturability, maintainability, economic viability, etc.), rather than as an afterthought.

A second categorization of activities associated with occupational health and safety programs considers the following types of measures:

- Engineering and technical measures, which reduce exposure to workplace hazards through technical modifications (e.g., through redesigning the workplace, or providing protective equipment).

- Process measures, which reduce exposure to workplace hazards by modifying work processes (e.g., avoiding fatigue through breaks, avoiding lack of concentration, monotony and boredom through job rotation).
- Behavioural measures, which improve employee behaviour, attitudes, knowledge and skill of occupational health and safety (e.g., training, education to promote awareness).
- Administrative measures, which reduce exposure to workplace hazards by making administrative modifications (e.g., use of effective operating procedures, clear communications, occupational health and safety committees).

Various management system models for occupational health and safety exist and are becoming increasingly popular. Many of these incorporate Deming's Cycle of plan, do, check, act, or variations of it. Some examples:

- The occupational health and safety management systems of the British Standards Institution (BSI), specifically OSHAS 18001 (www.bsi-global.com/Corporate/18001.xalter). OHSAS 18001 is an assessment specification for occupational health and safety management systems that helps companies meet health and safety obligations efficiently. This model is similar to the International Standards Organization's ISO 9000 Quality Management Systems and ISO 14000 Environmental Management Systems.
- International Labour Organization's ILO OSH-2001 occupational safety and health management system guideline (www.ilo.org/public/english/protection/safework/managmnt/guide.htm). This guideline seeks to ensure organizations are able to tackle occupational safety and health challenges continuously and to build effective responses into dynamic management strategies.
- The Ontario Workplace Safety and Insurance Board Workwell model, which carries out health and safety audits (www.wsib.on.ca/wsib/wsibsite.nsf/public/Workwell).

Other management system models for occupational health and safety are in various stages of development by such organizations as the American National Standards Institute (ANSI), the U.S. National Safety Council (NSC) and the Canadian Standards Association (CSA).

Occupational Health and Safety Teams

No one person can reasonably be expected to have the requisite knowledge and skills to manage the health and safety tasks for a company alone. Hence, a team is usually assembled, from employees and – where necessary or desired – outside personnel. The team can include, or draw on the knowledge of engineers, scientists, technologists, technicians, workers, businesspeople, and managers. The team members each bring a different set of attributes and collectively are able to provide the knowledge and skills to manage the health and safety.

The health and safety team in a large company may include the following members:

- A representative of senior management
- Safety engineer
- Environmental engineer
- Industrial hygienist
- Health physicist

- Occupational health nurse
- Occupational physician

The health and safety manager is normally the key person in the team, and must coordinate the team's efforts and activities. The representative of senior management is instrumental in ensuring support for occupational health and safety initiatives is provided by senior management, and in demonstrating that senior management promotes a positive health and safety culture within the company.

Most health and safety legislation requires that joint health and safety committees be established, composed of representatives of both management and workers, to enhance workplace health and safety. Such committees carry out this function by identifying and evaluating potential hazards, recommending corrective action and following up on the implemented recommendations.

One of the duties of employers is to appoint persons as supervisors in the workplace who are competent in terms of occupational health and safety, where competent implies:

- qualified in terms of knowledge, training and experience, and
- familiar with relevant acts and regulations.

A supervisor is responsible for ensuring compliance with acts and regulations as well as the use of safe work practices, personal protective equipment and appropriate emergency procedures.

Ethical Dilemmas and Occupational Health and Safety

Ethical problems occur from time to time in engineering, and these often relate to health and safety of workers and/or the public. For example, an engineer may be faced with the choice of risking the health of workers on a project or delaying – or even stopping – the project to establish a proper safety procedures or to purchase and install appropriate safety equipment. The former action places workers in some degree of risk of harm, while the latter causes delays and increases costs for the employers or clients of the engineer. What level of risk severity and potential harm to workers is sufficient to overcome the losses to the client or employer that will result if the engineer delays or stops the project for a safety-related reason? Codes of ethics, as well as laws and regulations, are in place to guide engineers in ethical decision making and engineers are normally bound to observe these. But answers are sometimes not easily arrived at, as many situations fall into a grey area.

Engineering-Oriented Case Studies on Occupational Health and Safety

Case Study I

In the Canadian manufacturing plant of a global automotive company with headquarters in Canada, a large number of engineering activities are carried out in a wide range of areas. These activities include design, production of parts, assembly, testing, and quality assurance.

Many of the manufacturing processes in the plant are performed using automated technologies and equipment. People also perform some of the manufacturing tasks and the plant employs over 400 workers. The decision on whether people or machines will be used for a particular task is dependent on many factors, including costs, time, quality and worker health and safety.

The plant considered here produces a many parts for vehicles and assembles them. Among the parts produced are engine materials and parts, pumps, fans, some exterior parts, and electronics components. The plant normally operates three shifts per day and has production lines including machining equipment, conveyers and overhead cranes, punch presses, and paint-spray booths. The plant utilizes electricity and natural gas extensively.

A number of workers at the plant have over the last six months been subject to several different health problems. The following information has been received by the head engineer at the plant.

a) In an assembly area that was installed recently, workers have to bend to the ground throughout the day to attach several small parts onto a large and heavy vehicle component. Some workers have begun to develop lower back pain, likely due to the repetitive bending. The problem has become so severe for one of the workers that he has been told by his doctor to stay off work for two weeks so his back can recover. The manufacturing engineers who designed the assembly operation had wanted to use an automated system, but that option was deemed not to be economic. So they used a manual operation, but did not take into account industrial ergonomics, as they had no expertise in that discipline.

b) An increased incidence of respiratory illnesses has been reported over the last month by workers operating near the paint-spray booths. Many of the substances used in the booths (paints, solvents, etc.) are known to be causes of the observed respiratory illnesses. But the workers are not supposed to come into contact with any of the substances because the paint-spray booths are designed to ensure that all materials exit the plant through a high-capacity ventilation system and that no materials can leak back into the plant. No tests had been carried out on the ventilation system, or on the air quality around the paint-spray booths, so it is uncertain whether or not there have been any leaks into the plant from the paint-spray booths.

c) In an area of the plant where metal cutting occurs and workers use protective eyewear, workers have reported minor eye injuries. The area in question is one where it is common knowledge that the workers do not routinely use the protective eyewear. It is often observed to be hanging on nearby hooks or to be loosely hanging around the necks of workers. Workers complain that they find the protective eyewear uncomfortable and do not think it is needed or important. The plant manager knows of this behaviour but

overlooks it, since enforcing the use of the protective eyewear seems may make the workers unhappy and, consequently, less productive. That, he feels, could render the plant non-competitive.

Questions:

a) How would you go about investigating the causes of the observed health problems?
b) What are the unsafe conditions and acts in the plant?
c) Which of the unsafe conditions and acts identified in part b are (1) of a technical nature, or (2) related to human behaviour or management?
d) What are some steps can be taken to rectify the health problems observed?
e) Should the head engineer endeavour to rectify the health problems on her own, or should she report the problems to the plant manager beforehand? The head engineer is not sure if she will receive the support of the plant manager in rectifying the problems; what should she do if support is not provided?
f) Do you feel that some of the health problems that have occurred are due to worker health and safety being unduly compromised to allow the plant to be more productive or profitable?

Case Study II

Consider again the plant described in Case Study I. The head engineer at the plant wants to ensure that the plant provides a safe and healthy environment. So, she decides to ask an engineering health and safety consulting company to do a health and safety audit of the plant. The report provided by the consulting company lists the following safety problems:

a) An expert on fires and explosions notes that the extensive use of natural gas in the plant could lead to an explosion in the plant in some circumstances. The force of such an explosion could lead to severe injuries or deaths of workers and, possibly, cause the building to be damaged or to collapse. The potential for an explosion could develop if a sufficient natural gas leak occurs or the plant ventilation system fails to perform properly or certain controls or sensors fail. But, the expert further notes, there is insufficient information available on the concentration of natural gas in the plant air, as only one natural gas sensor is in place at the plant, but it is not located in the main area where an accumulation of natural gas is likely to occur. Thus, the potential for an explosion could exist, yet not be detected or acted upon. In addition, the expert is concerned because the natural gas sensor is connected neither to an automated shut-off system for the natural gas supply nor to an alarm, thus increasing the likelihood of an incident and its potential severity.
b) Although maintenance is supposed to be done quarterly on the natural gas lines and equipment, no evidence is found that maintenance has ever been performed since they were first installed four years ago. Such maintenance typically involves checking for and fixing gas leaks. Also, no training has been provided to workers on either understanding the potential for explosion, or the steps to take to avoid an explosion. In fact, most workers did not even realize the potential for an explosion existed. Furthermore, no written procedures relating explosions exist within the plant.

c) The plant contains toxic materials that can harm people and animals. The way this material is stored in the plant, it could, in the event of a plant explosion, be released and impact an area within one kilometer of the plant. Such an incident could lead to illnesses or deaths among members of the public and could harm animals in the environment.

Questions:

a) What are the unsafe conditions and acts in the plant?
b) What are some steps can be taken to rectify the noted safety concerns?
c) From point c) in the consulting company report, it is clear that the problem affects not just worker safety, but also the safety of the public and the environment. Should the difference in who or what is affected cause head engineer to modify her actions in addressing the problem? If so, how?
d) Can the head engineer choose to ignore or not act fully upon the safety concerns raised by the consulting company? If yes, in what instances and under what conditions?
e) If the head engineer at the plant decides that measures must be taken to protect health and safety, but the plant manager refuses to approve the measures, what are the obligations of the head engineer?
f) Do any of the problems cited demonstrate that it is best to address health and safety comprehensively in the early stages of an engineering activity, preferably within the design process and not as an afterthought? For instance, can you indicate some measures that will likely be more expensive to implement to fix the problem compared to the cost that would have been incurred during the design process to resolve the problem then?

Case Study III

Consider again the plant described in Case Studies I and II. The head engineer at the plant realizes that the company has a similar plant operating in a developing country with different – and usually less stringent – occupational health and safety requirements, standards and codes than Canada. The head engineer is certain that the same problems that have been identified in Case Studies I and II for the Canadian plant also exist in the company's foreign plant. The head engineer recommends to company management that the problems be fixed at the foreign plant, like they were for the Canadian plant. Company management refuses to authorize the work required to fix the safety problems in the foreign plant, and gives the following reasons:

a) The regulations and laws in the foreign country do not require the problems identified at the Canadian plant, should they exist in the foreign plant, to be rectified. The head engineer checks and learns that this is so, even though in Canada, where the company's headquarters are located and where the head engineer is licensed, the company has an obligation to rectify the situation.
b) The work required would not be economically feasible in the foreign plant.
c) Even if one agrees that the company should be obliged by the foreign country to rectify the safety issues in that plant, the problem is associated with the country's laws and regulations, and not the company's policies or decisions.

Questions:

a) As a licensed engineer in a Canadian province, the head engineer is obliged to adhere to the code of ethics for engineers in her province. Mindful of this obligation, what actions should she take – if any – regarding the companies refusal to fix the safety problems in the foreign plant?

b) Select a province or territory in Canada. What are the relevant clauses in the engineering code of ethics of that province or territory that provide guidance on how the head engineer should deal with the dilemma she faces?

c) Are all of the reasons cited by the company for not fixing the safety problems in the foreign plant valid? For instance, can you give a scenario in which doing the required work might be economic?

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