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SCI S409 Safety and Reliability for Science and Technology (Free Courseware)

香港公開大學
THE OPEN UNIVERSITY OF HONG KONG

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Chapter 1 Risk assessment

1.1 About this module

Welcome to this free courseware module 'Risk assessment'!

This module is taken from the OUHK course *SCI S409 Safety and Reliability for Science and Technology (http://www.ouhk.edu.hk/wcsprd/Satellite?pagename=OUHK/tcGenericPage2010&c=C_ETPU&cid=191154132200&lang=eng&pri=0)*,a five-credit, higher level course that is a core course for the BSc (Hons) in Applied Science (Biology and Chemistry) and BSc / BSc (Hons) in Product Design and Technology degree programme offered by the School of Science and Technology (http://www.ouhk.edu.hk/wcsprd/Satellite?pagename=OUHK/tcSubWeb&l=C_ST&lid=191133000200&lang=eng) of the OUHK. The overall aims of this course are to introduce students to the principles and practices of safety and reliability in sciences.

SCI S409 is mainly presented in printed format and comprises ten study units. Each unit contains study content, activities, self-tests, assigned readings, etc for students' self-learning. This module (The materials for this module, taken from the print-based course SCI S409, have been specially adapted to make them more suitable for studying online. In addition to this topic on 'Risk Assessment', which is an extract from Unit 5 of the course, the original Unit 1 also includes the topics 'Safety analysis' and 'Software safety analysis'.) retains most of these elements, so you can have a taste of what an OUHK course is like. Please note that no credits can be earned on completion of this module. If you would like to pursue it further, you are welcome to enrol in *SCI S409 Safety and Reliability for Science and Technology (http://www.ouhk.edu.hk/wcsprd/Satellite?pagename=OUHK/tcGenericPage2010&c=C_ETPU&cid=191154132200&lang=eng&pri=0)*.

This module will take you about **four hours** to complete, including the time for completing the activities and self-tests (but not including the time for assigned readings).

Good luck, and enjoy your study!

1.2 Introduction

Safety and reliability are two important aspects of science and technology. They are highly related, and they complement each other, i.e. they provide each other with more information than could be obtained individually. When safety and reliability are performed in collaboration, better and more efficient products can be produced. In

this module, we focus on one important aspect of safety, i.e. risk assessment. This module will explain what risk assessments are, and how they are conducted.

1.3 Risk assessment

As you learned in the previous section, risk assessment (http://en.wikipedia.org/wiki/Risk_assessment) is a key element in a safety analysis (http://en.wikipedia.org/wiki/Safety_engineering). As explained in Harms-Ringdahl (2001) (Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.), the general aim of a risk assessment is to provide a basis for deciding whether a system is acceptable as it is, or whether changes are necessary. Before we start to discuss risk assessment, however, you should watch another online video that briefly explains what risk assessment is (Activity 1 (Page 2)) .

Risk assessment can be done quantitatively or qualitatively.

- Quantitative risk assessment: Quantitative risk assessment requires calculations of two components of risk: the magnitude of the consequence (impact) of occurrence, and the probability of occurrence.
- Qualitative risk assessments: Qualitative risk assessments are descriptive, rather than measurable as in quantitative risk assessment.

1.3.1 Activity 1

Visit YouTube and watch a short video on 'Risk assessment':

http://www.youtube.com/watch?v=jZlu-O1s9So (http://www.youtube.com/watch?v=jZlu-O1s9So%20http://www.youtube.com/watch?v=jZlu-O1s9So)

This video list steps in conducting a risk assessment. Details of the steps in conducting a risk assessment will be discussed later in this unit.

1.4 Quantitative assessments

In science and technology areas, particularly in occupational health and safety (http://en.wikipedia.org/wiki/Occupational_health) applications, risk assessments are usually done quantitatively, or by presenting quantitative results qualitatively.

Under quantitative approach to risk assessment, risk is defined as the probability of a hazard resulting in an adverse event, multiplied by the severity of the event (i.e. risk estimation). The quantitative measure of risks can then be used to judge whether or not a hazard is acceptable (i.e. risk evaluation). Under the IEC (http://www.iec.ch/

standardsdev/resources/) 1995 standard, this procedure is called probabilistic safety analysis or probabilistic risk analysis (http://en.wikipedia.org/wiki/Probabilistic_risk_assessment). Figure 1.1 will briefly explain the procedure of a safety analysis.

Procedure of a safety analysis

Click this link to watch the video:
http://www.opentextbooks.org.hk/system/files/resource/10/10660/10666/media/Procedure%20of%20a%20safety%20analysis.mp4

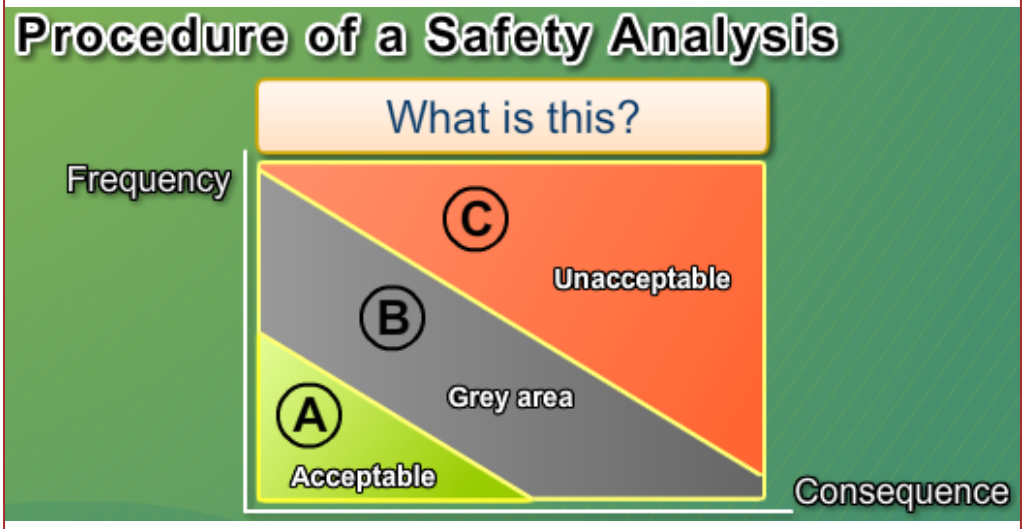


Fig. 1.1: Procedure of a safety analysis

Figure 1.1:

- shows the relationship between frequency of occurrence, the size of consequences or impacts, and limits of acceptance.
- is a procedure commonly used in risk evaluation.

Acceptable	• Risk is acceptable in Zone A • Both the probability of occurrence and the consequence are small
Grey area	• Should a risk that falls into Zone B be accepted or rejected? • You can find out the answer by studying Reading 1.
Unacceptable	• Risk is clearly unacceptable in Zone C • Both the probability of occurrence is high and the consequence is large

A risk estimation involves a number of analyses, including the following:

- **Frequency analysis**
  This estimates the probability of occurrence.
- **Consequence analysis**
  This estimates the level of consequence.
- **Risk calculations**
  This determines the quantitative measure of risks.
- **Uncertainty analysis**
  This determines the variation or imprecision in the model results.
- **Sensitivity analysis**
  This determines the changes in response of a model to changes in individual model parameters.

Instead of presenting the results as pure quantitative (i.e., numerical) estimates, qualitative descriptions are commonly used to represent these quantitative results. In practice, the results of quantitative studies are reported in narrative form punctuated by illustrative numerical examples like Table 1.1 and Table 1.2, which show examples of the classifications of consequences and probabilities under occupational safety applications.

Code	Category
0	Not harmful or trivial
1	Short period of sick leave
2	Long period of sick leave
3	Disablement
4	Fatality
5	Several fatalities, major disaster

Table 1.1: Example of the classification of consequences

Source: Harms-Ringdahl 2001 (Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.), Table 4.1, p. 48

Code	Category	Probability*
0	Very unlikely	1 in a 1000 years
1	Unlikely	1 in a 100 years
2	Rather unlikely	1 in 10 years
3	Rather likely	Once a year
4	Likely	Once a month

Table 1.2: Example of the classification of probabilities

*Lower limit, i.e. less likely than the specified probability.

Source: Harms-Ringdahl 2001 (Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.), Table 4.2, p. 48

Having highlighted some key points about quantitative assessment, you should now read the descriptions of the classification of risk assessment and quantitative assessments provided in Reading 1 (Part 1).

Reading 1

Harms-Ringdahl, L (2001) sections 4.1 and 4.2 of 'Risk assessment,' in Safety Analysis: Principles and Practice in Occupational Safety, CRC Press, pp. 43–49.

Now, please complete Activity 2 (Page 6) and answer the questions in Activity 3 (Page 7).

Do not forget to check the Activity 2 Feedback (Page 7) before moving on to the discussion on qualitative assessments.

1.4.1 Activity 2

Visit YouTube and watch a short video on examples of applications of a risk matrix.

www.youtube.com/watch?v=FRvsa-yNZk8

1.4.1.1 Activity 2 Feedback

Although the above video uses only two levels of impact (high or low)and two levels of probability (high or low), the same concept also applies to multi-level impacts and probabilities.

1.4.2 Activity 3

1. Reading 1 also mentioned two other types of risks assessments. Can you explain why these two types of assessments are not as common as quantitative assessment and qualitative assessments?
2. Should a risk be accepted or rejected if the result of risk estimation is within the grey area (i.e. zone B)? Why or why not?

Discuss your answers with your tutor and classmates.

1.4.3 Qualitative assessments

Qualitative assessments involve some kind of comparative criteria to determine whether a system in a workplace or other given situation should be approved or not. When compared to quantitative assessment, qualitative assessments are complicated because it is hard to define and interpret criteria in actual practice. Examples of qualitative criteria for risk acceptance and the European standard for risk assessment of machinery are briefly discussed in Reading 2.

Reading 2

Harms-Ringdahl, L (2001) section 4.3, of 'Risk assessment,' in Safety Analysis: Principles and Practice in Occupational Safety, CRC Press, pp. 49–50.

1.4.4 Direct risk assessment

In practice, the majority of hazards lie in the intermediate zone (i.e. zone B) between clear acceptance and obvious danger. You should have noted from Reading 2 that the As Low As Reasonably Achievable (ALARA) or the As Low As Reasonably Practicable (ALARP) (http://en.wikipedia.org/wiki/ALARP) principles need to be applied. One simple solution is to apply the direct risk acceptance scale, and the types of consequences (safety, health, environmental and production, SHEP) approaches.

Examples of the direct risk acceptable scale and classification of types of consequences (SHEP) are shown in Table 1.3 and Table 1.4, respectively.

Code	Description
0	Negligible risk
1	Acceptable risk, no safety measure required
2	Safety measure recommended
3	Safety measure essential

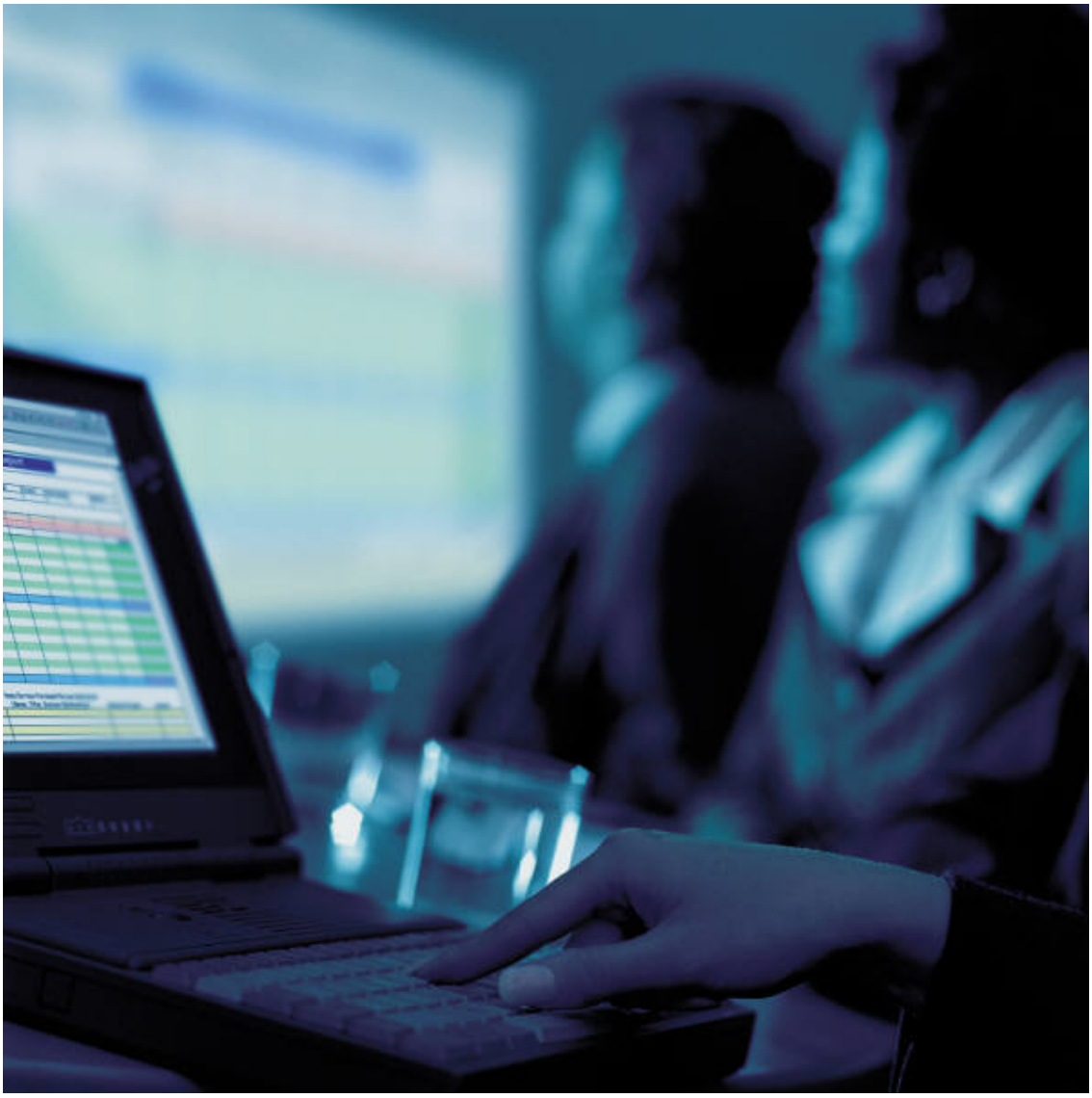
Table 1.3: Example of the direct risk acceptable scale

Source: Harms-Ringdahl 2001 (Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.), table 4.3, p. 51

Code	Description	
S	Safety	Accident hazard for people
H	Health	Health problem for people
E	Environment	Environmental problems
P	Production	Problems with production, quality, etc.

Table 1.4: Example of the classification of consequences

Source: Harms-Ringdahl 2001 (Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.), table 4.4, p. 52



1.4.5 Practical aspects of risk assessment

Risk assessment forms an important part of safety analysis. Each of the following aspects should be included in a risk assessment:

- **Aims of assessment**
  Appropriate aim(s) should be clearly defined.
- **Cost-benefit considerations**
  Financial issues should be addressed.
- **Team evaluation**
  Risk evaluations should come from a team.
- **Ways and alternatives for making risk assessment**
  Appropriate risk assessment approach should be selected.

Now read about direct risk assessment and the practical aspects of risk assessment.

Reading 3

Harme-Ringdahl, L (2001) sections 4.4 and 4.5, of 'Risk assessment,' in Safety Analysis: Principles and Practice in Occupational Safety, CRC Press, pp. 50–54.

1.4.6 Five steps to risk assessment

The Health and Safety Executive of the UK government has published a concise leaflet that summarizes the five steps to risk assessment.

A detailed explanation on each step is covered in the following reading.

Reading 4

HSE (2006) Five Steps to Risk Assessment (http://www.hse.gov.uk/pubns/indg163.pdf), Health and Safety Executive (UK).

When you have finished reading the online article, try the follow-up Activity 4 (Page 11) and Self-test 1 (Page 12).

Do not forget to check the feedback of the self-test.

1.4.7 Activity 4

Visit the Health and Safety Executive website (http://www.hse.gov.uk/risk/casestudies/index.htm) and review risk assessments examples.

You may be interested in the following examples:

- Example risk assessment for an office-based business (http://www.hse.gov.uk/risk/casestudies/office.htm)

- Example risk assessment for food preparation and service (http://www.hse.gov.uk/risk/casestudies/foodprep.htm)
- Example risk assessment for office work in a manufacturing company (http://www.hse.gov.uk/risk/casestudies/manufacturing.htm)
- Example risk assessment for a motor vehicle mechanical repair workshop (http://www.hse.gov.uk/risk/casestudies/pdf/mvr.pdf)
- Example risk assessment for maintenance work in a factory (http://www.hse.gov.uk/risk/casestudies/factory.htm)
- Example risk assessment for a warehouse (http://www.hse.gov.uk/risk/casestudies/warehouse.htm)

1.4.8 Self-test 1

Review the background of 'Example risk assessment for an office-based business': http://www.hse.gov.uk/risk/casestudies/office.htm

Then, read the risk assessment paperwork of this example at: http://www.hse.gov.uk/risk/casestudies/pdf/office.pdf

Based on the above document, complete the following:

1. Explain the setting of the scene.
2. What are the possible hazards? Who might be harmed, and how?

1.4.8.1 Self-test 1 Feedback

Answers are extracted from: http://www.hse.gov.uk/risk/casestudies/pdf/office.pdf

1. The office manager carried out the risk assessment at this company, which provides management and financial consultancy services, and which leases two storeys of a ten-storey office block.

   Eighteen staff work at the company; one is a wheelchair user. The offices contain typical office furniture and equipment. There is a staff kitchen, where drinks can be prepared and food heated, and there are toilet and washing facilities on each floor.

   The offices are cleaned every evening by general office cleaning contractors. They store the cleaning materials in a locked cupboard.

   The office block was built before 2000. The landlord has surveyed the building for the presence of asbestos, and has shared the findings of this survey with all of the tenants. Asbestos-containing materials (ACMs) were found, but were in good condition and in places where they were not likely to be damaged, worked on or disturbed, so it was decided to leave them in place.

   The office block is locked from 9 pm to 6 am Monday to Friday and at weekends,

although 24 hours a day, 7 days a week security cover is provided.

Although this example risk assessment is for an office-based business, it may equally be applied to any business that has office- based functions within it.

2. Possible hazards include:
   - Slips and trips
     Staff and visitors may be injured if they trip over objects or slip on spillages.
   - Manual handling of paper, office equipment, etc.
     Staff risk injuries or back pain from handling heavy/bulky objects, e.g. deliveries of paper.
   - Display screen equipment
     Staff risk posture problems and pain, discomfort or injuries, e.g. to their hands/arms, from overuse or improper use or from poorly designed workstations or work environments. Headaches or sore eyes can also occur, e.g. if the lighting is poor.
   - Working at height, filing on top shelves, putting up decorations, etc.
     Falls from any height can cause bruising and fractures.
   - Stress
     All staff could be affected by factors such as lack of job control, bullying, not knowing their role, etc.
   - Electrical
     Staff could get electrical shocks or burns from using faulty electrical equipment. Electrical faults can also lead to fires.
   - Asbestos:
     Asbestos-containing materials (ACMs) are present in some partition walls
     Staff and others carrying out normal activities, at very low risk as asbestos only poses a risk if fibres are released into air and inhaled. Maintenance workers are most at risk.
   - Fire
     If trapped, staff could suffer fatal injuries from smoke inhalation/burns.
   - Lone working
     Staff could suffer injury or ill health while out of the office, e.g. when visiting clients' offices, or while working alone in the office.

1.5 References

Below are the resources referred to or cited by the developer(s) of the original unit:

Harms-Ringdahl, L (2001) Safety Analysis: Principles and Practice in Occupational Safety, CRC Press.

US Departement of Labor (2002) Job Hazard Analysis, Occupational Safety and Health Administration, http://www.osha.gov/Publications/osha3071.pdf.

1.6 Conclusion

In this free courseware module, we have go through sections about risk assessment (http://en.wikipedia.org/wiki/Risk_assessment). The module starts step by step from explaining the meaning of risk assessments to how various kinds of risk assessments are conducted. We have examined topics including quantitative assessments, qualitative assessments and direct risk assessment. We have also studied risk assessment from practical aspects and introduce the five steps to risk assessment. After completed this free courseware module, you should now have the basic knowledge in formulating and applying risk assessment in your work place.

Apart from risk assessment we discussed in this free courseware module, the original unit also covers another important aspects of safety, i.e. safety analysis (http://en.wikipedia.org/wiki/Safety_engineering). Safety analysis is used in an occupational safety and health (OSH) environment (http://en.wikipedia.org/wiki/Occupational_safety_and_health) (i.e. the most common application of a safety analysis). It is commonly referred as job safety analysis (JSA) (http://en.wikipedia.org/wiki/Job_safety_analysis) or job hazard analysis (JHA). And since software developments have had a great influence on safety (e.g. railway signalling, aircraft controls, medical equipment, etc.), the original unit also includes sections about software safety analysis (http://en.wikipedia.org/wiki/Software_system_safety). Although we have not go into the above two topics, it is hoped that the concepts covered in this module could provide you some insights to look further into the safety analysis and risk assessment issue in work place.

If you would like to learn more on this subject, you are welcome to enrol in SCI S409 Safety and Reliability for Science and Technology (http://www.ouhk.edu.hk/wcsprd/Satellite?pagename=OUHK/tcGenericPage2010&c=C_ETPU&cid=191154132200&lang=eng&pri=0) offered by the School of Science and Technology (http://www.ouhk.edu.hk/wcsprd/Satellite?pagename=OUHK/tcSubWeb&l=C_ST&lid=191133000200&lang=eng) of the OUHK.