

Content-7: Chemical Risk Assessment – Approach and Methods

Orientation

What can this unit help you with?

You may use this unit if you

- Have to know what chemical risk assessment is and why it is used;
- Have to assess chemical risk.

Intended results of the unit

- Students have an understanding of the approaches and methods of chemical risk assessment like risk matrix and control/risk banding;
- Students are capable of assessing chemical risk in a factory.

Input

Chemical risk assessment refers to identifying chemical hazards in the workplace and how to reduce exposure and minimize those hazards. In this unit, we are going to be familiar with chemical risk assessment methods and approaches.

For risk assessment, we are going to know about risk matrix and control banding methods.

Assessing Potential Impacts of Hazardous Chemicals and Processes

Before going into the methods, we will know which chemicals to select for risk assessment. We will assess those hazardous chemicals and processes which are responsible for the followings:

Assessing potential impacts of hazardous chemicals and processes	
	Monetary loss to company
	Air pollution
	Water/ground water contamination
	Soil contamination
	Contribution to global warming, ozone depletion
	Additional waste disposal and environmental costs
	Additional consumption of natural resources
	Adverse health effects for staff/worker/society
	Emergencies (fire/explosion, accident)
	Negative/positive effects in customer relationships
	Legal consequences or unwanted public reactions

Figure 1: Assessing the potential impacts of hazardous chemicals and processes. Picture courtesy: Kazi Farhan Hossain Purba.

- If the company faces monetary loss due to such chemical;
- If the chemical is causing air pollution, groundwater contamination, soil contamination or global warming, ozone depletion etc.;
- If it is responsible for additional waste disposal, environmental costs or additional consumption of natural resources;
- If it causes adverse health effects on workers, staff or society and the risk of emergencies like fire, explosion or any accident;
- If there is any positive or negative effect on consumer relationship or other legal consequences.

Risk Assessment Using Risk Matrix

After finding the chemicals for which we need to assess the risk, we can now use a tool called risk matrix for risk assessment.

The image shows a 5x5 Risk Matrix table. The rows are labeled 'Frequency' from 1 to 5 (bottom to top), and the columns are labeled 'Severity' from 1 to 5 (left to right). Each cell contains a risk factor in the format 'Frequency/Severity'. The cells are color-coded: white for risk factors 1/1 through 2/3, light red for 2/4 through 3/5, and dark red for 4/4 through 5/5. A series of black arrows starts at the top-left cell (5/1) and moves diagonally down to the bottom-right cell (1/5), passing through (4/2), (3/3), (2/4), and (1/5).

Frequency 5	5/1	5/2	5/3	5/4	5/5
Frequency 4	4/1	4/2	4/3	4/4	4/5
Frequency 3	3/1	3/2	3/3	3/4	3/5
Frequency 2	2/1	2/2	2/3	2/4	2/5
Frequency 1	1/1	1/2	1/3	1/4	1/5
	Severity 1	Severity 2	Severity 3	Severity 4	Severity 5

Figure 2: Risk assessment using risk matrix. Adapted from Resource Efficient Management of Chemicals Presentation by GLZ.

Here we can see a risk matrix that is used to assess chemical risks considering severity and probability. It is a very simple and easy tool to point out the hazards in the workplace.

On the X-axis, severity is given from class 1 to class 5. Correspondingly on the Y axis, frequency is given from class 1 to class 5. The first step is to identify and categorize the severity of any incident in the factory. The second step is to measure the probability or likelihood of the incident or situation. Then we can find the risk factor with the help of them.

Severity is the damage a hazard can create. Establishing severity is the first thing to do for this assessment, which can be done by accurate information and team discussion. The severity scale has five classes: negligible, limited, serious, very serious and catastrophic. This scale can be adapted according to the local rules and regulations of the country. It should consider the impact on community and workers' health, agriculture, fisheries, water sources, air quality, site facilities, transport and social infrastructure, company image, etc.

Steps of Using Risk Matrix

First Step: Establishing Severity

Our first step is to establish severity scale according to both the country and the local context.

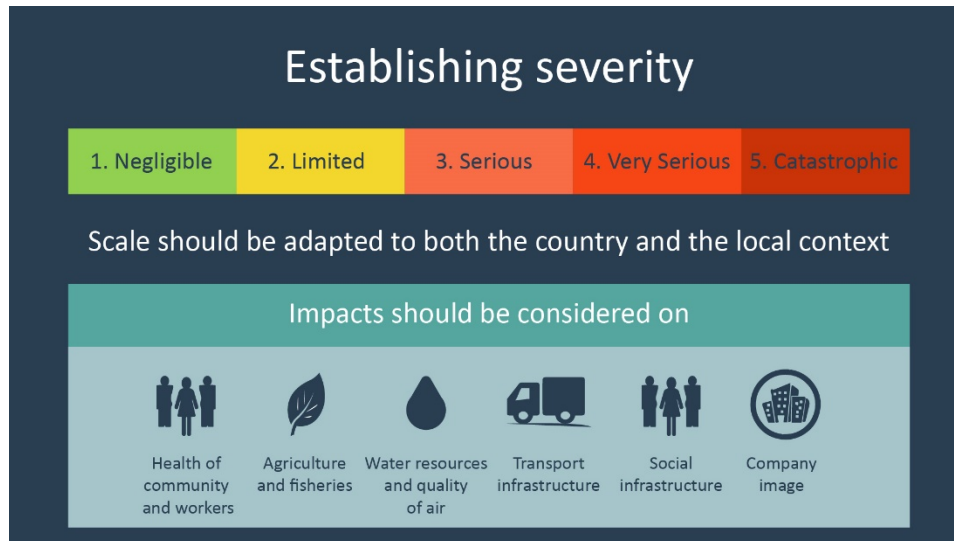


Figure 3: Establishing severity: severity scale and impacts to be considered on. Picture courtesy: Kazi Farhan Hossain Purba.

The table in the above picture shows us the five classes of severity. The first one is unimportant or negligible, which can be temporary slight discomfort to workers and community health with no environmental contamination. The cost impact of material loss, production or community infrastructure damage is less than half a million dollars. The company image can face a small disturbance but no consequences.

Severity class 2 is the limited category which may cause injury resulting in the absence of workers or discomfort to community persons. The environmental impacts are simple contaminations that can be handled by natural remediation. The cost impact is half to one million dollars and company image disturbance in the local area with no media coverage.

Class 3 is stated as a serious category that may cause injury or health effect resulting in the disablement of workers or community. The environment has widespread effects that need simple remediation. The cost impact is one to five million dollars. This may result in negative media coverage or even partial evacuation of the company.

Class 4 is the very serious category that causes serious injury, health hazards or death to any worker or community person. It has heavy environmental contamination which needs remediation at the cost of five to twenty million dollars. This could lead to an evacuation of the company and negative national media coverage.

Class 5 is the catastrophic category that results in several deaths or permanent disablement of workers or community. The environmental contamination is very heavy, which needs immediate remediation or even evacuate the community if needed. The cost impact is more than 20 million dollars. This results in negative press coverage in international media.

Second Step: Estimating the Likelihood of Each of the Identified Hazard Situations Actually Taking Place

The second step is measuring the frequency or likelihood. The likelihood is how often any incident is actually taking place.

Probability/ Frequency		Example 1	Example 2
1	Practically impossible	Not expected to happen during the lifespan of the operation	Infrequent; known to have happened somewhere else
2	Unlikely	Never happened, but could occur, perhaps during the lifespan of the operation	At least once in a year.
3	Rarely	Expected to occur at least once every 10 years	At least once to five times a month
4	Regularly	Expected to occur at least once per year	At least once to five times a week
5	Frequently	Occurring more than once per year	At least once a day

Definition as part of company's standard risk assessment procedure

Figure 4: Estimating the likelihood of each of the identified hazard situations actually taking place. Source: Resource Efficient Management of Chemicals Presentation by GIZ.

Frequency 1 is any incident that is practically impossible and not expected to happen during the lifespan of the chemical or known to have happened somewhere else. That depends on the company's risk assessment procedure. Frequency 2 is unlikely that never happened but could occur during the lifespan of the operation or at least once a year. Frequency 3 is rare events that occur at least once every ten years or five times a month. Frequency 4 refers to the incidents regularly occurring at least once per year or five times a week. Lastly, frequency 5 refers to the incidents frequently occurring more than once per year or at least once a day.

Final Step: Assigning Risk Factors

The final step is to determine the risk level by assigning these two factors in the risk matrix. We have to assign each hazard situation risk factor from 1/1 (lowest) to 5/5 (highest) considering different hazard scenarios of what other situation can occur. This process must be repeated for each activity. Placing the two factors will indicate the risk factor in the matrix.



Figure 5: The meaning of pink and red coloured areas in a risk matrix. Picture courtesy: Kazi Farhan Hossain Purba.

The risk factors where the area is pink coloured is considered critical risks and requires monitoring. And the red area of the matrix is where the risks are considered unacceptable. In that case, the problem requires an engineering solution or modification of the operation.

Risk Assessment Using Control Banding

Control banding is another way of chemical risk assessment and management approach to improve occupation health and safety. This method quantifies how toxic the substances are, how easily and how long the workers are exposed to the substance.

First, we have to make an inventory of all chemicals used in the factory and identify hazardous chemicals from symbols indicated in their labels or hazard statement from SDS. We have to classify the hazards according to their exposure to physical, environmental or human health, followed by the hazard information and hazard groups to find out hazard levels. Thus, we can assess the risks and identify recommended control approaches for them.

The basic concept of control banding is simple. The greater the potential hazard, the greater the degree of control needed to manage the situation and make the risk acceptable. The method gives us a value of the exposure, which indicates the risk and priority for control. A bigger number means greater risk, so higher priority. The values will match a specific control technology or strategy to apply to control and minimize the risk. This includes physical, health and environmental hazards.

For assessment, we need some information about the chemical. We need to know the amount of chemical present or used per operation or batch. We also need to know the chance of exposure to the chemical. For that, we need to find out the dustiness or volatility of the chemical depending upon the phase it. Duration of exposure is also important in case of inhalation and skin contact.

Skin hazard group	Affected area	Duration of contact	Risks/control/band
Skin 1/A	Small	Short	Low (1)
	Small	Long	Low
	Large	Short	Low
	Large	Long	Medium (2)
Skin 2/B	Small	Short	Low
	Small	Long	Medium
	Large	Short	Medium
	Large	Long	Medium
Skin 3/C	Small	Short	Low
	Small	Long	Medium
	Large	Short	Medium
	Large	Long	High (3)
Skin 4/D	Small	Short	Medium
	Small	Long	Medium
	Large	Short	Medium
	Large	Long	High
Skin 5/E	Small	Short	High
	Small	Long	High
	Large	Short	High
	Large	Long	High

Table 1: Finding risk/control band for exposure through skin contact. Adapted from: Resource Efficient Management of Chemicals Presentation by GIZ.

From Table 1, we can find out the control band for exposure through skin contact. We need to find out the affected area and the duration of exposure for a given hazard group. The affected area and the duration can vary depending on the incident. We need to observe the operations several times to find that. Putting these two factors on the table will give us the control band. For low, medium and high, the value is 1, 2, 3, respectively.

Amount used	Low dustiness or low volatility	Medium volatility	Medium dustiness	High dustiness or high volatility
Hazard Group A				
Grams or milliliters	1	1	1	1
Kilograms or liters	1	1	1	2
Tonnes or cubic meters	1	1	2	2
Hazard Group B				
Grams or milliliters	1	1	1	1
Kilograms or liters	1	2	2	2
Tonnes or cubic meters	1	2	3	3
Hazard Group C				
Grams or milliliters	1	2	1	2
Kilograms or liters	2	3	3	3
Tonnes or cubic meters	2	4	4	4
Hazard Group D				
Grams or milliliters	2	3	2	3
Kilograms or liters	3	4	4	4
Tonnes or cubic meters	3	4	4	4
Hazard Group E				
	For all substances in hazard group E, control approach 4 is required.			

Table 2: A table to find out the control band for the exposure through inhalation and the control approaches Copyright REMC GIZ?Adapted from: Resource Efficient Management of Chemicals Presentation by GIZ.

Table 2 shows the control band for exposure through inhalation and the control approaches for inhalation risks. From the hazard group and the amount of chemical used, we can find out the control band. The values refer to different control approaches.

If the value is 1, the general ventilation system can be used to control the situation. It supplies outside fresh air inside the factory, diluting the concentration of the contaminant.

If the value is 2, strategies are required to protect workers from hazardous substances. Local exhaust ventilation must be used. It is a system that removes dust, vapours and fumes from the source area, thus reducing the inhalation risk of chemicals.

Value 3 indicates engineering control with containment is required to control the situation. It will stop the hazardous materials to contaminate the surrounding air.

Conclusion

Chemical risk assessment is very important as it plays a significant part in an occupational health and safety management plan. Not only such assessments help us to create awareness of hazards and risk but also, they identify who may be at risk. We can prioritize hazards and control measures while doing such assessments, thus saving our time and money by focusing on the most required tasks. We can also determine if existing control measures are adequate or more should be done to prevent the risk. By taking the actions determined by chemical risk assessment, we can prevent injuries or illnesses. It also helps us to meet legal requirements where applicable.

We have learned about chemical risk assessment and the two methods to assess with examples which will help us greatly in our better chemical management approach.

Didactical Elements

Quizzes and self-tests:

True-false

1	The greater the potential hazard, the lesser the degree of control needed to manage the situation and make the risk acceptable.	
	<ul style="list-style-type: none">▪ Correct▪ False	False
2	Class 5 is the catastrophic category that results in several deaths or permanent disablement of workers or community.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
3	Control banding method assesses risks and identifies recommended control approaches for given risk levels.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
4	The second step of risk assessment using a risk matrix is measuring the frequency or likelihood.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
5	On the Y-axis, severity is given from class 1 to class 5.	
	<ul style="list-style-type: none">▪ Correct▪ False	False

Open Questions:

1	Do you think that chemical risk assessment is important? Why?	
	<i>Open text</i>	<p>Yes, I think chemical risk assessment is very important as it plays a significant part in an occupational health and safety management plan. Not only these assessments help to create awareness of hazards and risk but also, they identify who may be at risk. We can prioritize hazards and control measures while doing such assessments, thus saving our time and money by focusing on the most required tasks. We can also determine if existing control measures are adequate or if more should be done to prevent the risk. By taking the actions determined by chemical risk assessment, we can prevent injuries or illnesses. It also helps us to meet legal requirements where applicable.</p>

Choose multiple:

1	While establishing severity for a risk matrix, impacts should be considered on (Choose multiple)	
	<ul style="list-style-type: none">▪ Health of community and workers▪ Agriculture and fisheries▪ Primary education▪ Water resources and quality▪ Every employee's image▪ Social infrastructure▪ Company image	<p>Answer:</p> <ul style="list-style-type: none">▪ Health of community and workers▪ Agriculture and fisheries▪ Water resources and quality▪ Social infrastructure▪ Company image

Sorting tasks:

Sort the words to the correct sentences:

chronic	important	unimportant	occupation	catastrophic	limited
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1. The severity scale has five classes. They are stated as negligible, __, serious, very serious and __.
2. According to the five classes of severity, the first one means __.
3. Control banding is a way of chemical risk assessment and management approach to improve __ health and safety.

Answers:

1. limited, catastrophic
2. unimportant
3. occupation

Exercise:

Hazard and Risk Assessment Situation

Complete the tasks according to the below situation:

During the walk-through assessment at a medium-size tannery, together with the company team, you observe the following process of chemical dosing into the tanning drums.



Figure 6: Factory scenario. Source: Resource Efficient Management of Chemicals Presentation by GIZ.

At the temporary storage area near the tanyard entrance, one worker is engaged in transferring concentrated sulphuric acid from 100-litre barrels into 25-litre buckets. On average he fills about six buckets in one hour, three times a day. He dips a small mug into the barrel and pours the content into the buckets next to the barrel.

Three other workers in similar attire collect the buckets and carry these to the different tanning drums. There, they carry the buckets up the stairs to a small platform (about 1.3 meters above the floor level), lift the buckets above their shoulders and empty the content into the funnel (see picture). On average they pour two buckets for each batch. According to the production manager, they process three batches a day on each drum.

After processing the batch, the workers open the drum door for removal of material. You see that residual liquid which consists of wastewater containing the highly diluted acids and other process chemicals splashes on them.

There is some washing facility available in the tannery, but you are unsure whether these workers use the same after each batch or only at the end of their shift. No signboards, instructions are visible in the tanyard.

Your tasks

1. Identify and list the potential chemical hazards to the environment, health, safety.
2. Assess how the workers are exposed to these as well as what the possible effects may be.
3. Finally assess the risk using one of the assessment tools (e.g. control banding, risk matrix).
4. Present your results.

Hotspots

Which should be the risk factor for the following severity and frequency?

Severity Class 3	A serious category that may cause injury or health effect resulting in the disablement of workers or community. The environment has wide-spread effects that need simple remediation. The cost impact is one to five million dollars. This may result in negative media coverage or even partial evacuation of the company.
Frequency Class 2	The incident is unlikely that never happened but could occur during the lifespan of the operation or at least once a year.

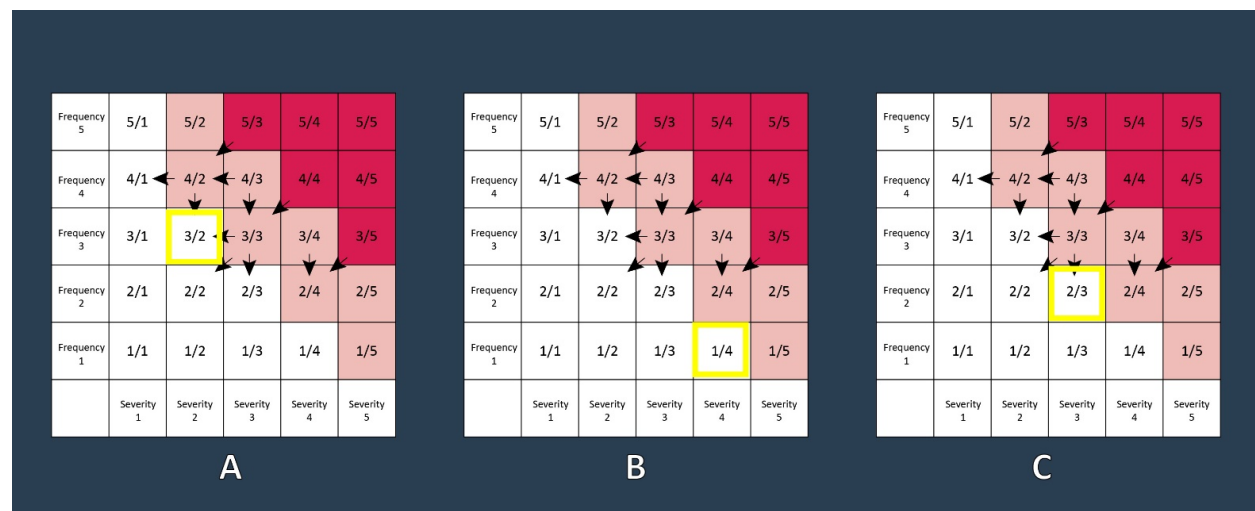


Figure 7: Hotspot. Picture courtesy: Kazi Farhan Hossain Purba.

Answer: C (2/3)

References/Additional Literature/Links

1. Resource Efficient Management Of Chemicals In Textile And Leather Sector Companies <https://www.sia-toolbox.net/solution/resource-efficient-management-chemicals-textile-and-leather-sector-companies>
2. Health Safety Authority, Chemical risk assessment https://www.hsa.ie/eng/Your_Industry/Chemicals/Legislation_Enforcement/Chemical_Agents/Risk_Assessment/

Ruge B. (2004) Risk Matrix as Tool for Risk Assessment in the Chemical Process Industries. In: Spitzer C., Schmocker U., Dang V.N. (eds) Probabilistic Safety Assessment and Management. Springer, London. https://doi.org/10.1007/978-0-85729-410-4_431
3. Control Banding by American Chemical Society <https://www.acs.org/content/acs/en/chemical-safety/hazard-assessment/ways-to-conduct/control-banding.html>
4. UNEP/IPCS Training Module No. 3, Chemical Risk Assessment: https://apps.who.int/iris/bitstream/handle/10665/66398/WHO_PCS_99.2_eng.pdf;jsessionid=37A71C68B-B2117009E068CC1F51B22D4?sequence=1

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If you wish you can give us feedback on the learning unit here. This is of course, optional.

Technical Elements

How did the technical elements of the unit work for you? Did you have any difficulties?

Didactical Elements

How did the didactical structure of the learning unit work for you? Do you have any comments or suggestions to make it better?

Open

Do you have any other comments on this unit?

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