

Content-8: Chemical Risk Control – Engineering Control and PPE

Orientation

What can this unit help you with?

You may use this unit if you

- want to know about engineering control process, equipment and practice;
- want to know the basic principle and scope of personal protection;
- want to know about selecting and implementing measures for exposure control and personal protection.

Intended results of the unit

- Students can identify control gaps and recommended measures;
- Students can link control/risk band and control sheets;
- Students can adopt proper engineering control process, equipment and practice;
- Students can relate to the basic principle and scope of personal protection;
- Students can select and implement measures for exposure control and personal protection.

Input

There is a hierarchy of controls that consists of five different steps - elimination, substitution, engineering controls, administrative controls and PPE. The effectiveness decreases from the upper to the lower portion of the hierarchy. So, elimination is the most effective, while PPE is the least effective way to control a hazard. In the hierarchy, engineering controls are in the middle.

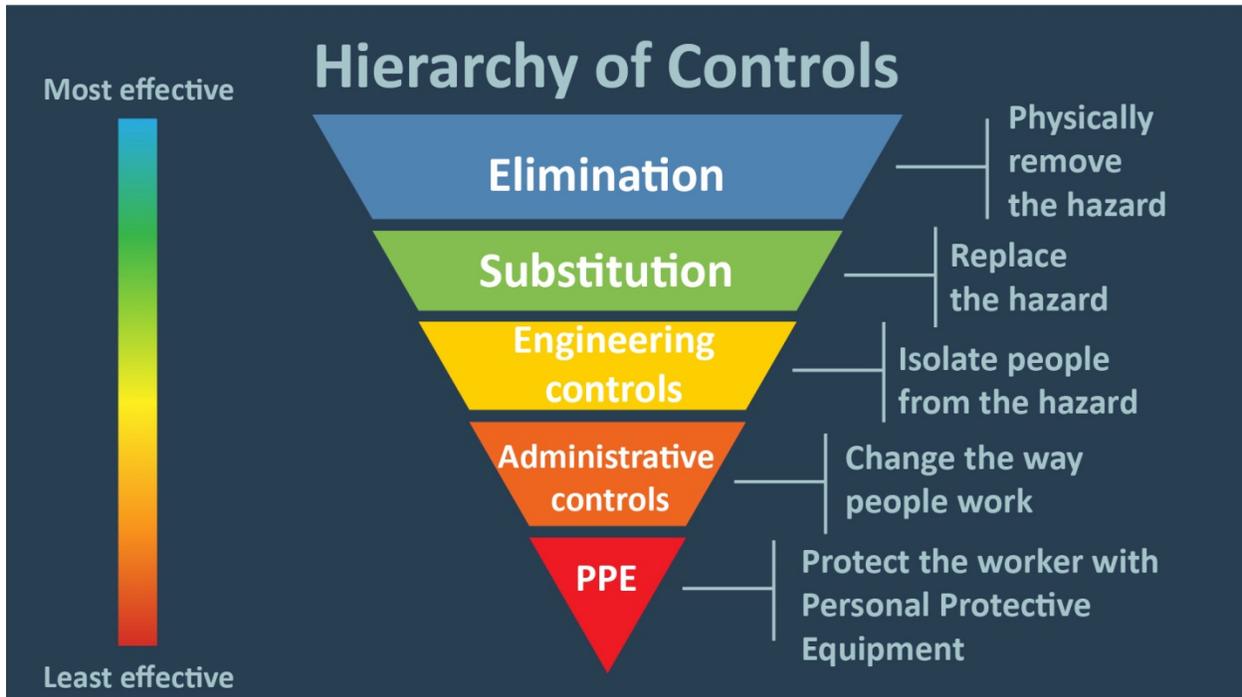


Figure 1: Hierarchy of controls. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

Elimination means removing the hazard physically from the workplace. It is like using non-hazardous chemicals if possible. Substitution is replacing the more hazardous chemical with a less hazardous chemical if elimination is not possible.

Engineering control includes designs and modifications to the plant, equipment, ventilation system and processes that reduce the source of exposure. Administrative control includes a control that alters how the work is done, the timing of work, policies, and other rules and work practices. PPE is the step of protecting a responsible person with personal protective equipment.

In this unit, we are going to explore engineering controls and PPE elaborately.

Where to Find Information?

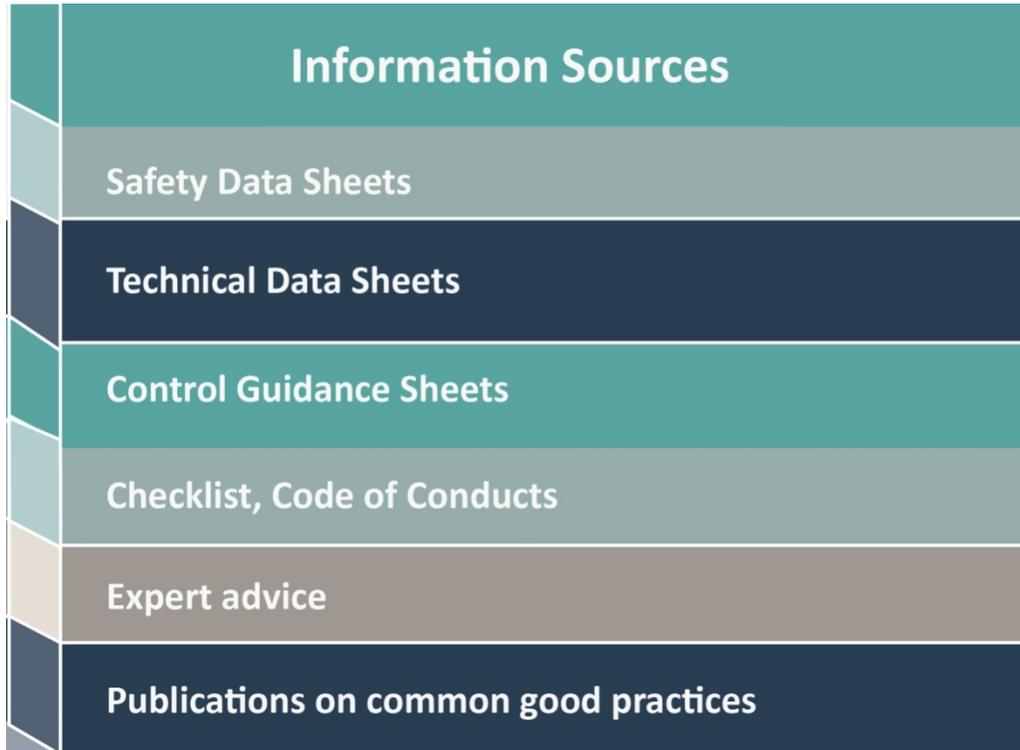


Figure 2: Where to find information for engineering controls. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

It is essential to know where we can get the required information for engineering controls and PPE. The sources are safety data sheets, technical datasheets, control guidance sheets, checklist, code of conducts, expert advice, publications on common good practices etc.

The control guidance sheet provides us with advice on needed measures to prevent or minimize risks. It also provides us with a sufficient level of protection that is needed in the workplace. It allows the assessment of existing control measures and identifies control gaps onsite. It is linked to risk/control banding methodology.

Control Gaps and Recommended Measures – Where to Start?

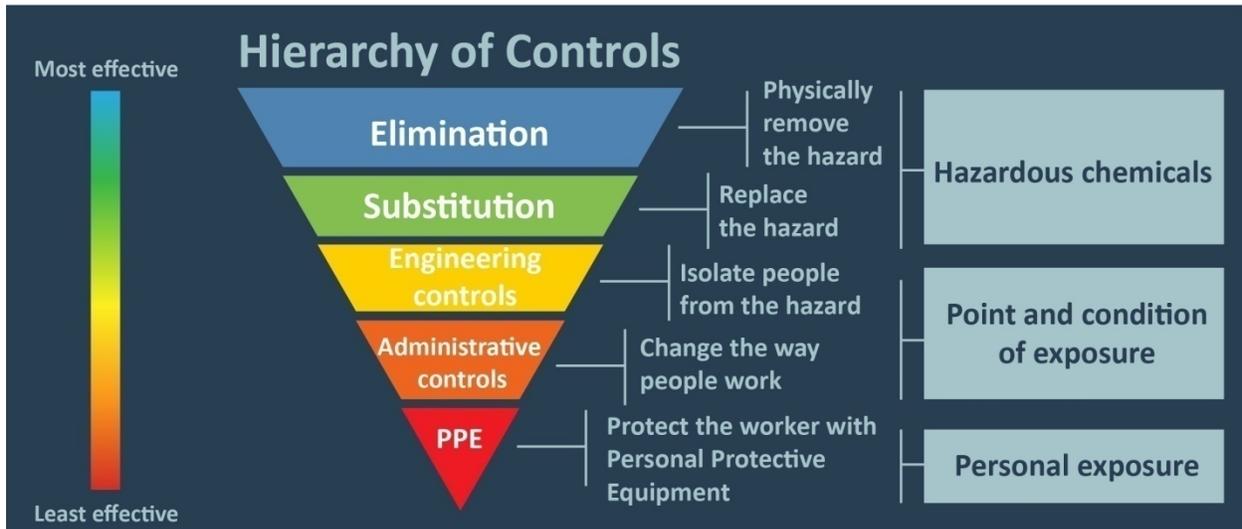


Figure 3: Control gaps and recommended measure-where to start? Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

For identifying control gaps and recommended measures, it is important to know from where we will start. The first two steps in the hierarchy of controls discuss hazardous chemicals. Either the hazardous chemicals will be eliminated or substituted from the workplace.

The next two steps discuss the point and condition of exposure. At which points or conditions of chemical usage it may expose and how this exposure can be minimized are the main discussion of these two steps.

The last step is all about personal exposure. If the chemical exposes, what kind of effects may cause a person and how they can be minimized are consulted here.

So, according to the workplace condition, we have to decide where to find control gaps.

Processes Involved in Engineering Controls

Some processes that are involved in engineering controls are mentioned below:

- Using wet methods rather than dry when drilling or grinding. "Wet method" means that water is sprayed over a dusty surface to keep dust levels down, or material is mixed with water to prevent dust from being created.
- Using an appropriate vacuum or "wet method" instead of dry sweeping (e.g., with a broom) to control dust and reduce the inhalation hazard.
- Using steam cleaning instead of solvent degreasing.
- Using electric motors rather than diesel ones to eliminate diesel exhaust emissions.
- Decreasing the temperature of a process so that less vapour is released.
- Using automation - the fewer workers have to handle or use the materials, the less potential for exposure.
- Using mechanical transportation rather than manual methods.

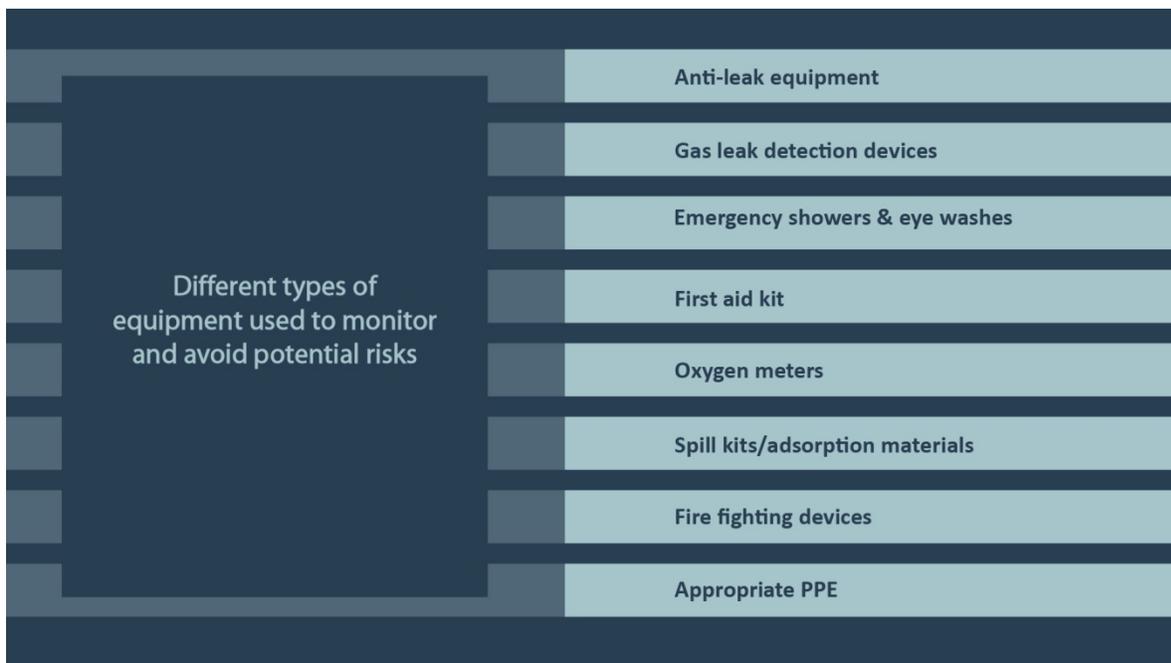


Figure 4: Different types of equipment used to monitor and avoid potential risks. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

Different types of equipment are used to monitor and avoid potential risks like anti-leak equipment, gas leak detection devices, oxygen meters, spill kits/adsorption materials, emergency showers and eyewashes, first aid kit, fire-fighting devices, appropriate PPE etc.

Engineering Controls in Practice

One of the most effective engineering controls is the ventilation process. It is a method of control that mainly adds or removes air in the working environment. If ventilation is designed correctly, it can remove or dilute contaminated air.

Local exhaust ventilation is very suitable for almost all chemicals and operations. It removes the contaminants from the source at the time of generating contaminants. That's why it cannot spread into the workplace. Local exhaust ventilation generally uses lower exhaust rates than general ventilation.

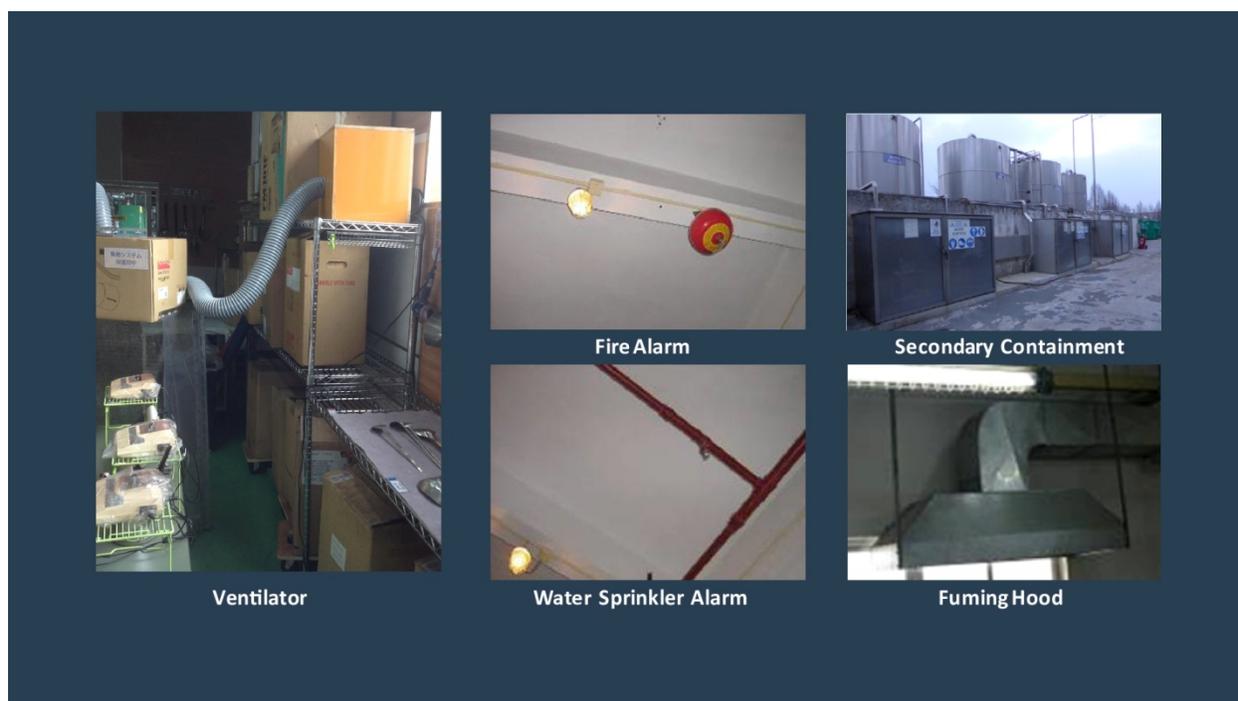


Figure 5: Engineering controls in practice. Photo source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

A fire alarm is one of the very common engineering control practices that we use. Different types of fire alarm detectors are used. Some of them are heat detectors, smoke detectors, carbon monoxide detectors, multi-sensor detectors, manual call points etc.

A wet pipe system is that one in which water is continuously maintained within the sprinkle piping. When the sprinkle activates the water, it is immediately discharged into the affected area. This process is simple and reliable. It also has low installation and maintenance cost.

Secondary containment is a liquid-tight barrier containing hazardous chemicals leaked or released from the primary container. By this process, the risks of many leaked chemicals can be minimized.

Fumehood is an air pollution control equipment installed to capture fume gases, smoke and dust. This specially designed suction hood captures the fumes containing dust at high temperature.

Linking Control/Risk Band and Control Guidance Sheets

In the previous units, we discussed inventorying and classifying chemicals by hazard and hazard bands. We also learnt about control/risk banding. Here we will learn to link between control/risk band and control guidance sheets. To proceed with an example, an inventory of Acetone containing its hazard statements, hazard group/band, risk/control band, along with other necessary information is presented below.

Area/Section	Name	SDS yes/no	H-statement	P	H	E	Hazard group/band	Amount per batch/day	Dustiness/Volatility	Quality on skin	Duration of exposure on skin	Risk/control band
Printing - Cleaning screens	Acetone	Yes	H225	✓			4/D	Medium	Medium	Small	Small	1 (Skin) 2 (inhalation)
			H315		✓		2/B					
			H319		✓		2/B					
			H335		✓		2/B					
			H336		✓		2/B					
			EUH066		✓		2/B					

Figure 6: Inventorying and Classifying Chemicals by Hazard and Hazard Bands. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

From this table, we see that Acetone has both skin and inhalation risk band. We will discuss how risk/control banding is linked to select appropriate engineering controls for managing chemical inhalation risks in the next few learning cards.

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.				

Control approaches for inhalation risks

1. Good working practice
General ventilation

2. Engineering control
Local exhaust ventilator

3. Engineering control
Containment

4. Special advice (substitution etc.)

Figure 7: Risk/control banding to select engineering controls for managing chemical risks. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

In case of situations where the risk involves the possible inhalation of chemicals, there are four standard categories of controls, as shown in figure 7, ranging from general ventilation to specialist advice.

Each control band is linked to either a checklist tool, a specific control guidance sheet or a combination of both.

When we use the control banding approach, one additional source of information is the "control guidance sheets". We can use these sheets as a reference base to identify suitable control measures and assess the control gaps.

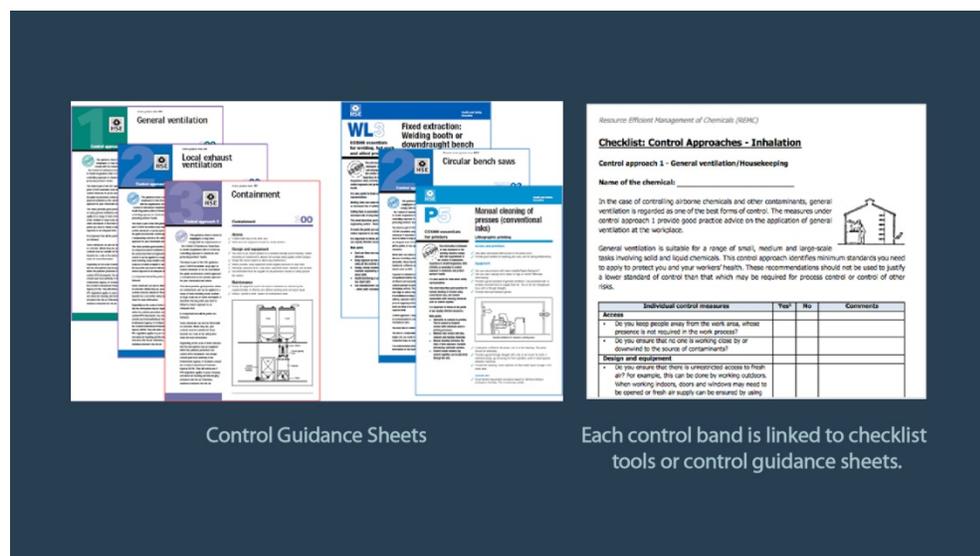


Figure 8: Control guidance sheets. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

The result of the risk assessment process, the risk or control band, is linked to a guidance sheet that corresponds to a specific set of measures. Such guidance sheets are provided through the UK Health and Safety Executive as part of its Control of Substances Hazardous to Health or COSHH approach and part of the ILO Control Banding Tool.

200	General principles	212	Mixing liquids with liquids or solids
201	Ventilated workbench or cupboard	213	Mixing solids

204	Conveyor transfer	214	Sieving
205	Sack emptying	215	Screening
207	Charging reactor or mixer from sack or keg	216	Spray painting
209	Drum filling	217	Pickling / Plating bath
210	Drum emptying with a drum pump	218	Vapor degreasing bath
211	Weighing solids	219	Tray drying oven

Figure 9: A table containing a list of guidance sheets recommended by the ILO (International Labor Organization). Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

The above example of the ILO Control banding tools shows the available control guidance sheets can be very specific to a certain task.

We can either choose the more general guidance sheets, for example, with the number 200, or a specific one 213, if the task at hand involves mixing solid chemicals.

Local Exhaust Ventilation (LEV) is one of the most common practices of control approach-2. So, the access of workers to the affected area becomes limited if LEV is installed previously. It reduces the exposure time of the workers. As a result, risks are minimized. For operators, local exhaust ventilation and PPE are combined. By this, inhalation risk becomes lower. LEV is suitable for smaller tasks rather than bigger ones.



Figure 10: How to improve working conditions with LEV. Courtesy: ILO, collected from Resource Efficient Management of Chemicals in Textile and Leather Sector Companies training materials.

In the first picture of figure 9, a worker is pouring a chemical from a container. She is not wearing any mask, and no ventilation system is present here. As a result, she is inhaling the whole fume coming from the chemical.

In the second picture, the whole fume is sucked by the LEV installed at the workplace. So, the inhalation risk is decreased, and the working condition is improved.

In the third and fourth picture, the generated fumes are sucked by the LEV system. Both of the workers are wearing the proper PPE required for their working condition. By these, the inhalation risk is minimized.

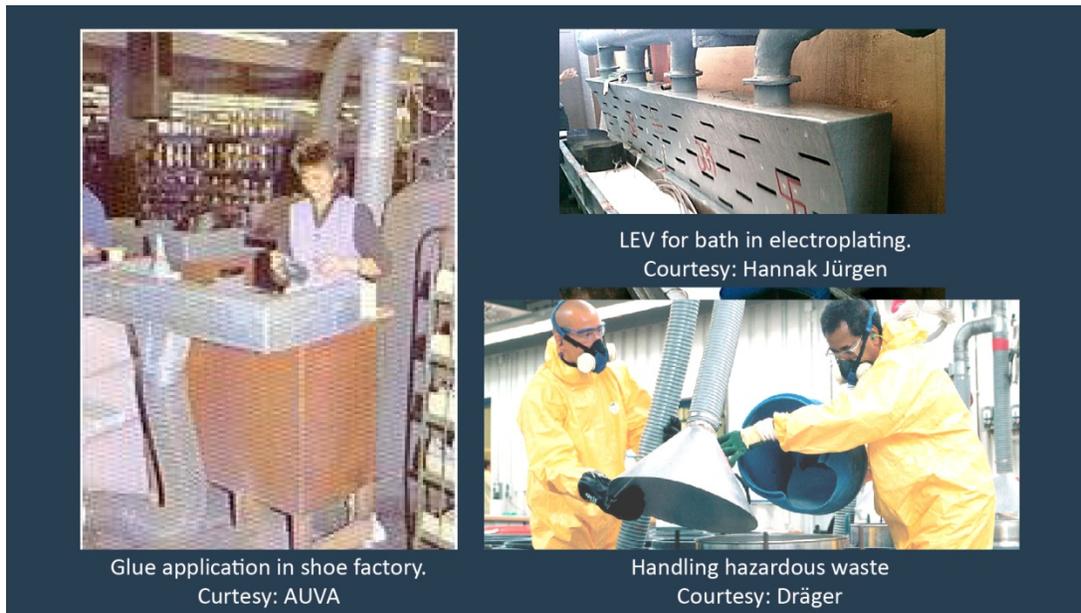


Figure 11: Control approach 2 in practice. Courtesy: AUVA, Hannak Jürgen and Dräger, collected from Resource Efficient Management of Chemicals in Textile and Leather Sector Companies training materials

The first picture of the figure shows the application of glue in a shoe factory. Most of these glues are solvent-based like alcohol, aliphatic hydrocarbon, aromatic hydrocarbons, chlorinated hydrocarbons, ester, glycol ether and ketone. A big portion of these solvents are hazardous. So, LEV is installed to reduce the inhalation risk.

The second picture shows the usage of LEV for the electroplating bath. Hazardous chemicals like acids, alkalis and hydrogen cyanide and metals such as chromium, cadmium, zinc, copper and silver are used in electroplating. As these chemicals or the products of these chemicals contain inhalation hazards, LEV is used there.

The third picture represents the handling of hazardous wastes. These wastages can be treated with chemical, biological or thermal processes. Collection and treatment of these wastages

contain inhalation risks. So, to minimize the risk, LEV is installed in the picture, which sucks all the dust and fumes generated during handling and processing.

The presence of local exhaust ventilation is not enough to reduce risks. Its design also matters. Some factors affect the design of local exhaust ventilation. Some of them are the distance between source and hood, air velocity, LEV application at source of exposure, and avoidance of air drafts interfering with the LEV.

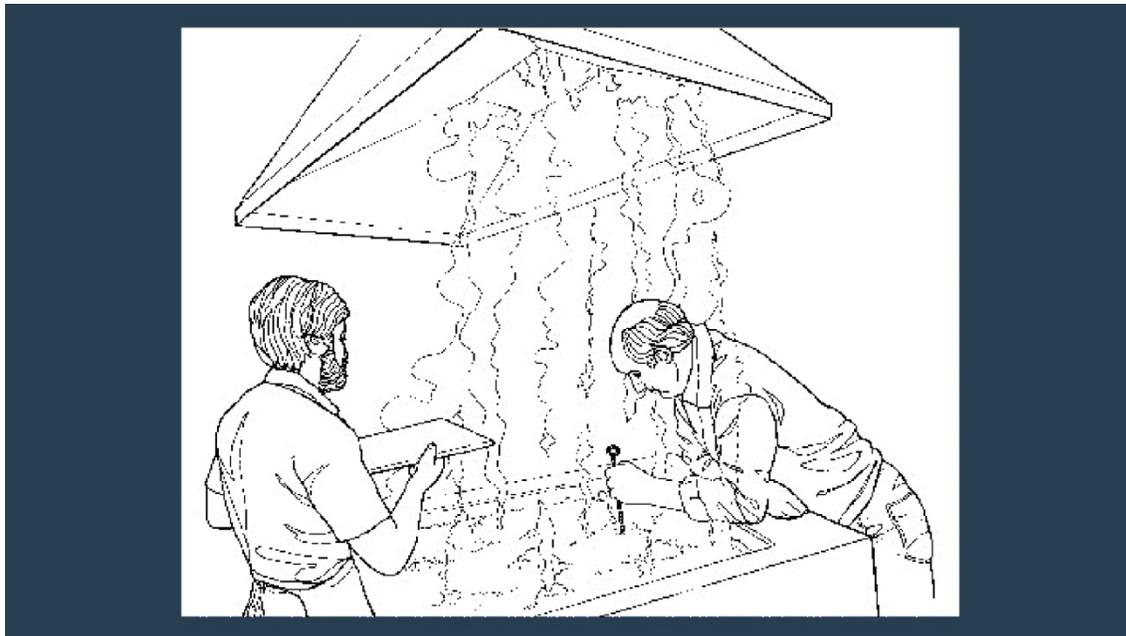


Figure 12: Good LEV design is important. Courtesy: ILO, collected from Resource Efficient Management of Chemicals in Textile and Leather Sector Companies training materials

In the picture, we see that two workers are working under LEV. Does the presence of LEV is enough to reduce inhalation risks? The answer will be negative. Even though LEV is present, the workers are still in contact with the dust and fumes. Inhalation risk is still present here. So, we have to reconsider the design of the workstation.

Control Skin Contact Risks

In our example of Acetone, we have seen both skin contact and inhalation risk band. Till now, we have covered the engineering controls to minimize inhalation risk. For Acetone, we also need to take appropriate engineering controls to minimize risks linked with skin.

Three different types of control approaches are sufficient to control skin contact risks. These are classified with number 1, 2, 3.

Control approach-2 includes engineering controls. It prevents and reduces the release of dust and splashes. Selection and use of PPE for specific types of chemicals in use are also essential. Maintenance and replacement of this control approach are necessary when required.

Selection of Personal Protective Equipment (PPE)

According to the hierarchy of control, the last stage for controlling hazard is personal protective equipment (PPE). It includes gloves, Nomex clothing, overalls, Tyvek suits, respirators, hard hats, safety glasses, high-visibility clothing, and safety footwear. PPE is the least effective means of controlling hazards.

Personal protection principles are primarily based on two principles: personal hygiene and personal protective equipment.

Personal hygiene is looking after the body and keeping it clean and healthy. On the other hand, PPE can only be part, though a necessary action of a safety concept.

We need to consider PPE as an immediate but temporary solution or as the final solution if the contaminants cannot be controlled otherwise.

Principles and Scopes of Personal Protection

There are three primary routes through which chemicals can enter the human body:

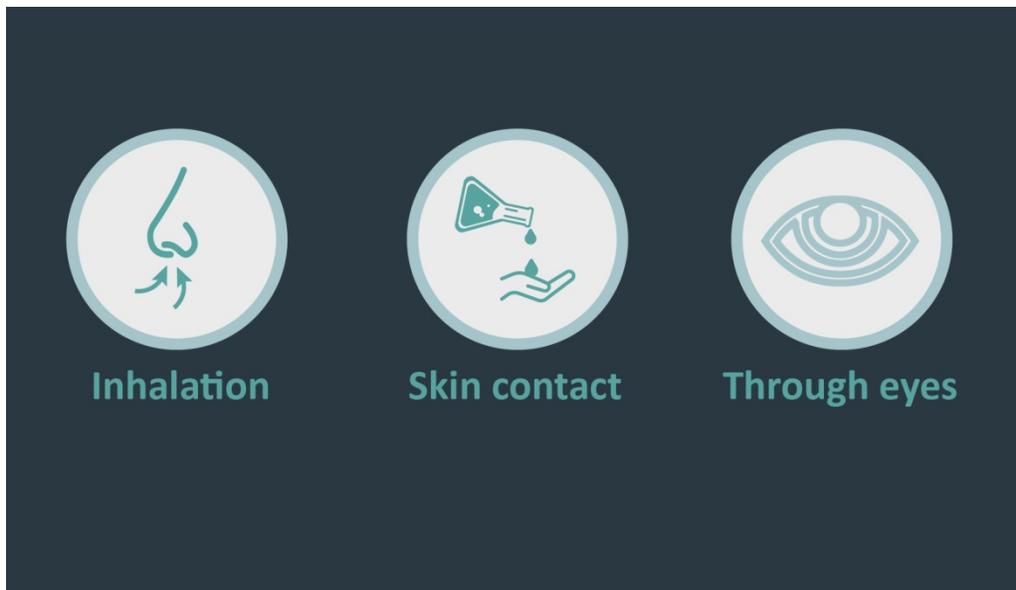


Figure 13: Primary routes through which chemicals can enter the human body. Courtesy: Kazi Farhan Hossain Purba.

By inhalation: It is the most common way in the workplace; chemicals enter the body. This can happen if respiratory protection is not worn correctly.

Secondly, skin contact: The skin is the second most common route by which chemicals enter the body.

Finally, by absorption through eyes: Eye splashes or eye contamination by workplace chemicals is relatively common. Chemicals usually do not enter the body this way. Small amounts of

chemicals may enter by dissolving in the liquid surrounding the eyes, and larger, but probably not significant amounts, may enter the eyes if they are splashed with chemicals.

Selecting Respiratory Protection

Respiratory protection is the most important in the textile wet processing environment since respiration is still the most common way chemicals enter the human body in the workplace. Contaminated air can be inhaled in solids as fumes or dust or in liquids as mists or aerosols. Gases, as well as vapours, can contaminate the workplace air through chemical evaporation.

On the other hand, by inhalation and partly eye absorption, chemicals can also enter the respiratory tract.

There are many factors to consider when choosing the right types of respiratory protection, such as routine use or non-routine use, workplace hazards, physical characteristics, physical demand of the work and respirator capabilities and limitations.

Respiratory Protection Types

The two main respiratory protection types are air-purifying respirators (APRs) and supplied-air respirators (SARs).

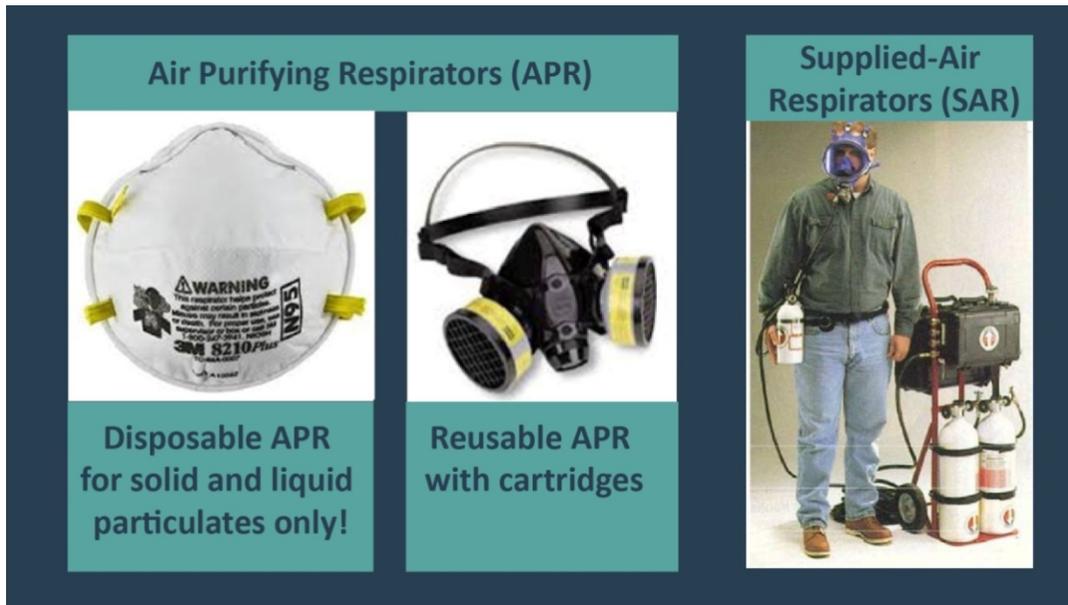


Figure 14: Reusable APR with cartridges. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies. Collage courtesy: Kazi Farhan Hossain Purba.

Air-purifying respirators can remove contaminants in the air that we breathe by filtering out particulates (e.g., dust, metal fumes, mists, etc.). Other APRs purify the air by adsorbing gases or vapours on a sorbent (adsorbing material) in a cartridge or canister. Both Disposable and Reusable APRs are available in the market.

On the other hand, supplied-air respirators (SARs) supply clean air from a compressed air tank or through an airline. This air is not from the workroom area. The air supplied in tanks or from compressors must meet certain standards for purity and moisture content

There are three types of air-purifying respirators (APR) available. APRs are used when the atmospheric oxygen level is greater than 19.5% when it becomes hazardous to life or health.



Figure 15: Three types of Air-purifying respirators (APR). Courtesy: Kazi Farhan Hossain Purba.

- **Filters:** They are made of a material that is designed to trap particles as we breathe. It captures solid and liquid particulates such as dust, aerosols.
- **Cartridges:** Cartridges contain material that absorbs gases and vapours. It is crucial to make sure the right filter or cartridge is used for the chemicals or substances present in the workplace.
- **Canisters:** The third type of APRs are Canisters, which are used with the gas mask. It contains a filter, sorbent, catalyst, or combination of these items, removing specific contaminants from the air passed through the container.

Quarter mask respirators are used with cartridges or cloth filters. The quarter mask fits from the top of the nose to the top of the chin. The breathing resistance is high in comparison to larger masks.

On the other hand, half-face respirators cover the nose and mouth area, whereas full-face respirators cover the entire face. Both types of respirators - full face and half face – use any combination of cartridges, pre-filters, and filters.

Reusable APR can be classified according to the cartridge type and colour-code indicating chemical (groups). For example, cartridge type 'E' means it contains SO₂. Its colour code is

yellow. They can be half or full-face and can be used in any combination of cartridges, pre-filters, and filters.

Single/double cartridge-single contains one side filter box, and double cartridge contains both side filter box. It can effectively filter particles for more than 99.95%.

We also need to understand Protection Factor (PF) such as half mask PF is 10, and full mask PF is 50.

The term "Protection Factor PF" is used in the US Protection Factor (PF) is calculated through = ((the concentration of contaminant) / (occupational exposure limit (OEL))

For example: concentration of contaminant in ambient air is = 500 mg/m³ and OEL is = 10 mg/m³. So, the PF is 500/10 = 50.

There are three types of atmosphere-supplying respirators or supplied-air respirators (SARs). They are self-contained breathing apparatus (SCBAs), airline supplied-air respirator, and protective suits that encapsulate the wearer's body and incorporate a life-support system (e.g., biohazard suits). Respirators need to be approved by the National Institute for Occupational Safety and Health (NIOSH).

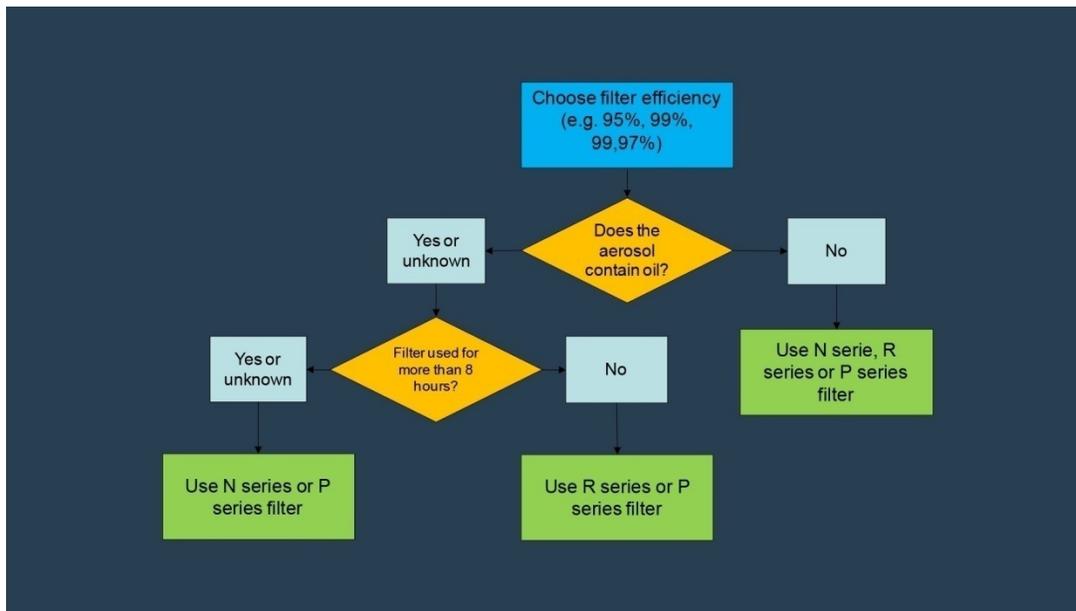


Figure 16: Selecting a respirator filter type. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies.

This illustrated flow diagram represents what types of respirator filters should be selected in different situations.

At the beginning of the flow diagram, the specific respirator filter efficiency should be chosen, such as 95%, 99%, 99.97%. Next, it was found out if the aerosol contains 'oil' or not. If the answer is no, then N ((not resistant to oil), R (resistant to oil) or P (oil proof) series filter are used

for this situation. If the answer is yes or unknown, we need to determine if the filter is used for more than 8 hours. After that, if the answer is no, then we use the R or P series filters. On the other hand, if the answer is yes or unknown, the N or P series filter is used.

Selecting PPE for Skin and Eyes

Personal Protective Equipment (PPE) for the eyes and face is designed to prevent or lessen the severity of injuries to workers. The employer must assess the workplace. Then determine if environmental hazards that necessitate the use of eye and face protection are present or are likely to be present before assigning PPE to workers.

For skin protection, protective gloves and clothing can be used to prevent skin exposure (gloves, apron, boots). On the other hand, protecting the eye, protective glasses, goggles, or face shields can be used.

The information of the right PPE in a specific work situation will be available in the Safety Data Sheet. While choosing protective materials, we need to be aware of their limitations, such as permeation rate, breakthrough rate, and degradation.

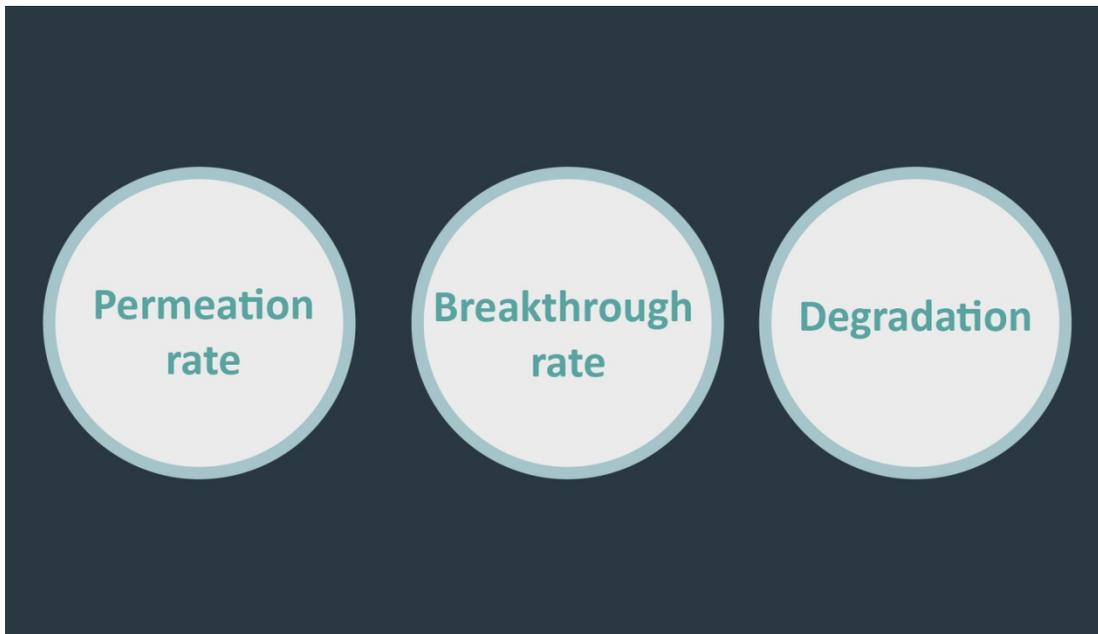


Figure 17: Limitations of protective materials. Picture courtesy: Kazi Farhan Hossain Purba.

Permeation rate is the rate at which the chemical will move through the material. It is measured in a laboratory and is expressed in units like milligrams per square meter per second.

In the context of chemical exposure, breakthrough time refers to the time between when a harmful chemical liquid touches the outside of a glove or other personal protective equipment and when it breaks the surface to reach the skin.

Lastly, degradation is the measurement of the physical deterioration of the material due to contact with a chemical. The material may get harder, stiffer, more brittle, softer, weaker, or the material may dissolve in the chemical.

The foundation of an excellent personal protection plan begins with anticipating our environment, exercising vigilance, reducing exposure, and reporting suspicious activities.

We need to remember to arrange required training (initial, refresher) such as on hazards and effects of contact with chemical limitations of personal protective equipment when and how to use, when, and how to clean or dispose of personal protective equipment.

Didactical Elements

Quizzes and Self-Tests:

True-False

1	Local exhaust ventilation generally uses higher exhaust rates than general ventilation.	
	<ul style="list-style-type: none">▪ Correct▪ False	False
2	One of the most effective engineering controls is the ventilation process.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
3	Elimination means removing the hazard physically from the workplace.	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
4	According to the hierarchy of control, the last stage for controlling hazard is personal protective equipment (PPE).	
	<ul style="list-style-type: none">▪ Correct▪ False	Correct
5	Respiratory protection is the least important factor in the textile wet processing environment since respiration is not how chemicals enter the human body in the workplace.	
	<ul style="list-style-type: none">▪ Correct▪ False	False

Choose Multiple:

1	Different types of equipment are used to monitor and avoid potential risks. They are: (Choose multiple)	
	<ul style="list-style-type: none"> ■ Anti-leak equipment, ■ Gas leak detection devices, ■ Bath tubs, ■ Oxygen meters, ■ First aid kit, ■ Washing machines, ■ Fire-fighting devices, ■ Appropriate PPE etc. 	<p>Answer:</p> <ul style="list-style-type: none"> ■ Anti-leak equipment, ■ Gas leak detection devices, ■ Oxygen meters, ■ First aid kit, ■ Fire-fighting devices, ■ Appropriate PPE etc.

Sorting Tasks:

Sort the words to the correct sentences:

Respiratory	experiential	vacuum	capabilities	dry	workplace
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1. Using an appropriate ___ or "wet method" instead of _ sweeping (e.g., with a broom) to control dust and reduce the inhalation hazard are processes involved in engineering controls.
2. There are many factors to consider when choosing the right types of ___ protection, such as routine use or non-routine use, ___ hazards, physical characteristics, physical demand of the work and respirator ___ and limitations.

Answers:

1. vacuum, dry
2. respiratory, workplace, capabilities.

Exercise: 1

'Denim Fashions', a denim washing company, is opening up a new PP spraying area. To assess the risks and learn about the necessary control guidance, they showed their inventory for the existing spraying area and asked for your consultancy support.

See the chemical inventory below and complete the following tasks:

Area/ Section	Name	SDS yes/ no	H- statemen t	P	H	E	Hazar d group / band	Amoun t per batch/ day	Dustine s/ Volatility	Risk/ control band
Sprayin g area	Potassium Permanganat e	Yes	H272	✓			4/D	Mediu m	Medium	?
			H302		✓		3/C			
			H400			✓	5/E			
			H410			✓	5/E			

- I. Find out the risk/control band associated with potassium permanganate using risk/control banding tool.
- II. Using the control band, determine the necessary control guidance sheet/s and recommend control guidance to the factory.

Provided materials:

- I. [Risk/control banding chart](#)
- II. [COSHH Essentials: Index to the Control Guidance Sheets](#)

Exercise: 2

Worker A plans to use a respirator for protection against styrene. Through measurement devices, the maximum concentration is 125 ppm, and OEL is 12 ppm. Find out the PF of the respirator.

Hotspots

Which one is a disposable APR?

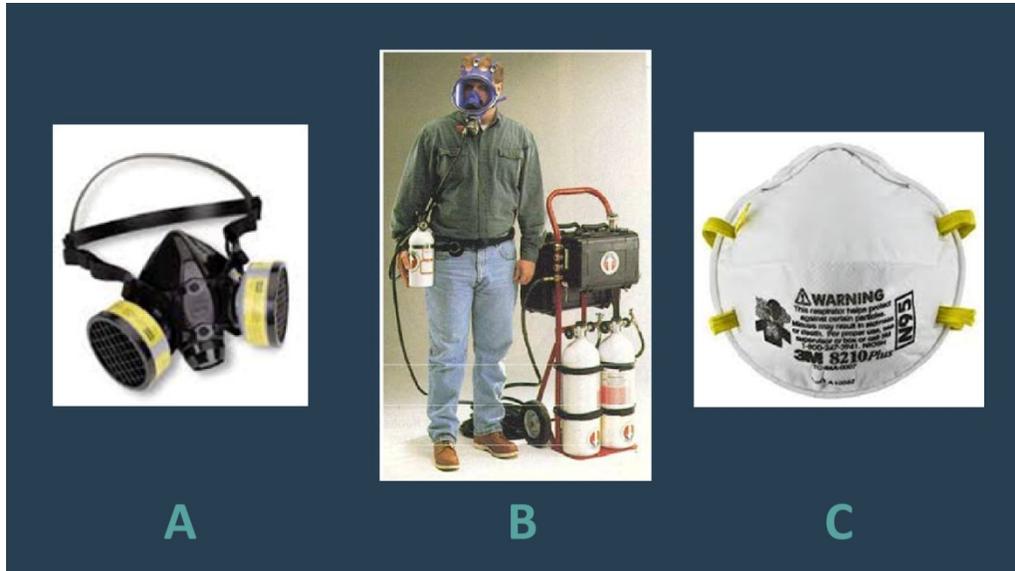


Figure 18: Hotspot. Source: Resource Efficient Management of Chemicals in Textile and Leather Sector Companies. Collage courtesy: Kazi Farhan Hossain Purba.

Answer: C.

References/Additional Literature/Links

1. More information on assessing and mapping chemical risks can be found from this link: <https://www.sia-toolbox.net/solution/resource-efficient-management-chemicals-textile-and-leather-sector-companies>. By downloading the REMC Company Handbook from the 'Further information section', you can read section: 4.1 for that purpose.
2. To know more about controlling airborne contaminants at work, you can read "A guide to local exhaust ventilation (LEV), HSE/UK" from this link: www.hse.gov.uk/pubns/books/hsg258.htm
3. To find the ILO control guidance sheets, you can use this link: www.ilo.org/legacy/english/protection/safework/ctrl_banding/toolkit/icct/sheets.htm

To find the COSHH Control Guidance Sheets, you can follow this link: <https://www.hse.gov.uk/plastics/coshh.htm> To know more about control exposure and releases, and the selection and use of Personal Protective Equipment, you can visit [the same link](#) of reference number: 1. By downloading the REMC Company Handbook, you can read sections: 6.2 and 6.3.

Unit Feedback

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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