Solvents – Health and Safety at the Place of Work

Fig 1

What is a solvent?

A solvent is a substance that dissolves another substance to form a solute. Water is capable of dissolving a variety of substances, and is therefore a very good solvent. Since it dissolves more substances than any other liquid, water is known as the 'universal solvent'. However, in industrial processes water is incapable of dissolving a large number of substances, necessitating the use of other solvents. These types of solvents are commonly carbon-based and are referred to as 'industrial solvents'. Solvent formulations are also used which contain mixtures of different chemical agents.

Solvents used in industry can be classified into 9 groups namely:

1. **Hydrocarbons (aliphatic and aromatic)** – Generally, aliphatic hydrocarbons are narcotic (sleep-inducing) but have low toxicity. On the other hand aromatic hydrocarbons are very strong narcotic agents, and overexposure can lead to loss of muscular coordination, collapse and unconsciousness. All members of this group are flammable.

2. **Halogenated hydrocarbons** – For industrial purposes, the chlorinated compounds are the most important members of this group and although for most practical purposes the aliphatic members may be regarded as non-flammable, some of them are highly toxic and strong narcotic agents.

3. **Aldehydes and ketals** – These are volatile, flammable liquids and some can be considered a serious fire hazard. Aldehydes in particular have strong irritant effects on the eye, respiratory system and skin.

4. **Alcohols** – Alcohols commonly used as solvents such as methyl alcohol and ethyl alcohol have flash points at temperatures that could be reached in a workroom. Vapours of such solvents are only moderately narcotic on inhalation.

5. **Ethers** – These are highly flammable liquids possessing strong narcotic properties and are generally moderately toxic.

6. **Glycol derivatives** – The most popular are ethylene glycol monomethyl ether and ethylene glycol monoethyl ether. Both solvents are flammable and have a toxic effect on the nervous system and the blood.

7. **Esters** – These solvents are flammable with flashpoints of most solvents corresponding to room temperature. In general they do not pose a serious health hazard but exposure to their fumes may result in irritation of the eyes, nose and upper respiratory tract.

8. **Ketones** – The most common are acetone and methyl ethyl ketone. All ketones are flammable liquids having low systemic toxicity.

9. **Miscellaneous solvents** – These include the nitroparaffins, certain solvents of vegetable origin and carbon disulphide. The nitroparaffins are flammable, narcotic and irritant to the mucous membranes, and may cause irritation or damage to the liver and kidneys. On the other hand carbon disulphide, being one of the most dangerous solvents used in industry, is highly flammable and toxic, acting mainly on the central and peripheral nervous system.

Uses of solvents

Solvents are widely used in chemical, pharmaceutical, oil, and gas industries, including in chemical synthesis and purification processes.

Examples of industrial activity where solvents may be encountered include:

- Pharmaceutical manufacture
- Woodworking
- Paint & Ink manufacture
- Chemical synthesis
- Printing
- Engineering works
- Construction activities
- Dry Cleaning
- Textile manufacture
- Rubber industry
- Plastics industry
- Foodstuff manufacturing

Solvents are also used as every-day objects in households.

- Personal care products (eg: nail varnish remover, hairspray)
- Adhesives/glues
- Paints/varnishes
- Cleaning agents (eg: detergents, polishes, surface cleaners)

Routes of entry

Solvents can enter the body through three main routes:

- Inhalation – breathing in through the mouth or nose so that air contaminated with solvents enters the lungs.
- Skin (or eye) absorption – solvents which come in contact with the skin, either directly or through contaminated clothes, can get absorbed directly through the skin.
- Ingestion – solvents can either enter directly through swallowing (intentionally or accidentally) or when food which is contaminated with solvents is consumed.

Health effects due to solvent exposure

Different solvents can affect health in various ways. These effects can be short-term or acute:

- Irritation of eyes / lungs / skin (dermatitis)
- Headache
- Drowsiness
- Nausea
- Dizziness
- Light-headedness
- Vomiting
- unconsciousness and even death when exposed to high concentrations of solvent vapours

Fig 2

Or Chronic which may include dermatitis. Other possible health effects depend on the solvent in use.

Examples include:

- Psychosis caused by carbon disulphide. This is characterised by extreme irritability, uncontrollable anger, insomnia, terrifying nightmares, loss of memory, delirium and headache.
- Nerve toxicity by carbon disulphide and hexacarbons such as n-Hexane.
- Liver toxicity by carbon tetrachloride and other halogenated hydrocarbons.
- Kidney damage by unleaded petrol.
- Leukaemia by benzene.

Health Surveillance

Employers should establish a medical surveillance program to evaluate both the acute and chronic effects of exposure to organic solvents. The physician should be given information regarding which organic solvents are being used at the workplace and the results of the chemical risk assessment carried out including an estimate of the worker's potential exposure to them. This information should include any available results from workplace sampling and a description of any protective devices or equipment the worker may be required to use.

A medical and work history should be taken initially and updated periodically. Workers who are currently exposed or who may be exposed to organic solvents should have preplacement and periodic evaluations focusing on their histories of previous exposure to organic solvents and other agents, particularly those associated with neurotoxic effects. The examining physician should direct particular attention to the nervous, respiratory, reproductive, and cardiovascular systems, and to the skin, eyes, liver, blood, kidneys, and gastrointestinal tract, as these are the most likely targets for the adverse effects of organic solvents.

Health and Safety Measures

As stated in Legal Notice 227 of 2003 (S.L. 424.24), where chemical agents (such as solvents) are present at the workplace, the employer shall assess any risk to the health and safety of workers arising from the presence of those chemical agents, taking into consideration the following:

a) their hazardous properties;

b) the Material Safety Data Sheet, a copy of which shall be kept at the place of work and made available to the workers and, or the Workers' Health and Safety Representative, and to the persons designated by the employer in terms of regulation 9 of the General Provisions for Health and Safety at Work Places Regulations;

c) the level, type, duration and frequency of exposure;

d) the circumstances of work involving such agents, including their amount;

e) any occupational exposure limit values or biological limit values established by the laws of Malta;

f) the effect of preventative measures taken or to be taken;

g) where available, the conclusions to be drawn from any health surveillance already undertaken.

Fig 3

Chemical Risk Assessment

The aim of a chemical risk assessment is to assess the nature, magnitude, and probability of a potential adverse health or environmental effect of a chemical, taking into account both hazard and exposure.

In general, a chemical risk assessment consists of the following steps:

Hazard characterization: determining which substances are harmful and who might be at risk and determining the relationship between the magnitude of exposure to a hazard and the probability and severity of adverse effects.

Exposure assessment: identifying the extent to which exposure actually occurs. Exposure levels are usually estimated or measured.

Risk characterization: combining the information from the hazard characterization and the exposure assessment in order to form a conclusion about the nature and magnitude of risk, decide on precautions, and if indicated, implement additional risk management measures.

Hierarchy of Prevention

Risks to the health and safety of workers at work involving hazardous chemical agents shall be eliminated or reduced to a minimum by:

- **Elimination**: Physically remove the hazard.
- **Substitution**: If it is not possible to eliminate the hazard, the use of hazardous chemical agents should be replaced with a chemical agent that is not hazardous or less hazardous to workers' health and safety.
- **Engineering Controls**: Isolate people from the hazard. Examples of engineering controls include segregation or encapsulation and proper ventilation.
- **Administrative Controls:** This includes job rotation, workers education and training and safe work procedures amongst others.
- **Personal Protective Equipment (PPE)**: In case of residual exposure, where the workers are still exposed to a particular chemical after all possible measures were taken, the use of PPE must be enforced.

Practical measures

Whereas solvent use in the absence of suitable control measures can cause serious health effects, sensible control measures and precautions can reduce risk to acceptable levels. For this reason, it is important that every person using solvents should obtain as much information as possible about the chemical itself, its routes of entry into the body, the control measures that should be taken and the safe disposal of the chemical when no longer used.

It is every employee's right to obtain such information from the employer, including about the procedures to follow in an emergency.

Most of the above information is readily found in the safety data sheet and container labels – the instructions given in these documents should be followed at all times.

Control of vapours

Solvent use should be limited to the barest minimum possible – only the necessary amount for the job should be used. Alternative procedures should always be considered before deciding on solvent use – for example, paint strippers should be used to remove paint instead of solvent-based paint removers. Where possible, water-based solvents should be used.

Vapours can be removed at source through the use of local exhaust ventilation, or if exposures are not expected to be prolonged and the solvent is not especially hazardous, through general exhaust ventilation.

Where the design of the workplace permits, full use of natural ventilation should be made use of, by opening doors and windows. This measure should only be contemplated where there is infrequent solvent use which is of short duration.

Vapour production should be limited by keeping all solvent containers tightly closed. Tightly closed containers should be used for the disposal of waste which is contaminated by solvents. No rags contaminated by solvents should be left lying around – when these need to be thrown away, they should immediately be placed in a container which is then kept closed.

When indicated, personal protective clothing should be used – depending on the circumstances of use, such items of ppe may include face shields, googles, aprons and gloves – all items of ppe should be kept clean, checked regularly and replaced when necessary.

Work in certain situations may create a higher risk than normal, as when having to work in a confined space (for example tanks, pits, or other places where (I) ventilation and air circulation is lacking, and (ii) where entrance and exits are limited), since vapour concentrations can increase very quickly. Vapours can also displace air and cause asphyxiation. It is essential that work in such areas is carried out under strict conditions as established in the Work Place (Minimum Requirements for Work) (Confined Spaces and Spaces having Explosive Atmospheres) Regulations.

Basic precautions

Always wash thoroughly after working with solvents and before eating, smoking or drinking.

Do not eat, smoke or drink in areas where there are solvents.

Do not smoke, weld, burn or use any naked lights in areas where chlorinated solvents are used as very toxic gases may be given off.

Risk preventive measures

ALWAYS stay safe when using chemicals and make sure that:

- ✓ All containers are properly **labelled**
- ✓ Chemicals are stored only in **approved areas**
- ✓ The correct **protective equipment** is used
- ✓ Leaks and spills are immediately **reported**
- ✓ Chemicals and containers are **disposed** of properly

References

Working with solvents. [online] Available at: http://www.hse.gov.uk/pubns/indg273.pdf [Accessed 2 April. 2018]

Parmeggiani, L. (Ed.). (1983). *Encyclopaedia of Occupational Health and Safety*. Geneva: International Labour Office.

Legal Notices

Protection of the health and safety of workers from the risks related to chemical agents at work regulations, Subsidiary Legislation 424.24.

Image resources

Fig 1: http://www.solvents.org.uk/wp-content/uploads/2015/02/sia-beakers.jpg

Fig 2: https://www.chemicalsafetyfacts.org/solvents/

Fig 3: http://www.solvents.org.uk/wp-content/uploads/2015/02/sia-paint-solvents.jpg