HSE Impacts of VOCs

Introduction

Volatile organic compounds (VOCs) are substances with low boiling points that evaporate from solids or liquids used in industrial processes, for example, formaldehyde evaporating from paint, or benzene from fuel[1]. Workplace exposure limits (WEL) are the legal limits set on the amount of substances that can be present in workplace air. Hazardous substances must be below the relevant workplace exposure limit.[7].

What is a VOC?

Volatile organic compounds (VOCs) are a wide range of naturally and synthetically occurring chemicals that are found almost everywhere on earth. They are described as volatile because they evaporate at standard temperature and pressure, releasing molecules into the atmosphere. VOCs are also extremely useful as they form the building blocks of many synthetic materials (plastics, rubbers, glues, paints, etc.), and are used to create pharmaceuticals and are a great fuel for transport and heating.

Health and safety issues

As VOCs exist as a gas at room temperature the main exposure route is through breathing. Exposure to harmful VOCs can happen at home, outdoors, or in the workplace.

Some sources of VOCs in a domestic and light industrial setting include building materials, furniture, carpets, heating and cooking systems, stored solvents, and cleaning products. Generally, VOCs are released slowly from these sources giving off low levels and would not cause a problem. However, modern buildings have low air exchange rates which can cause concentrations to easily rise to harmful levels. This has been emphasised during the Covid-19 pandemic where good air flow and air exchange are an easy way to ensure any virus in the air is removed from the space and helps reduce the risk from aerosol transmission, when someone breathes in small particles (aerosols) in the air after a person with the virus has been in the same enclosed area. VOCs are now widely recognized as a major contributor to sick building syndrome which in turn compromises Indoor Air Quality (IAQ).

Research has shown that people spend approximately 90% of their time indoors. Consequently, for many individuals, the risks to health may be greater due to air pollution exposure from indoors rather than outside.

In medium and heavy industries, there are a wider source of VOCs and higher concentrations can also exist. Here, VOCs pose additional threats as some VOC vapours are heavier than air and may displace oxygen in confined spaces posing an asphyxiation risk to workers.

Whilst many VOCs have minimal adverse effects on health and the environment, some are harmful. Health effects include eye, nose, and throat irritation from short term (acute) exposures but long-term (chronic) exposure to very low concentrations you are not aware of (parts per billion) may cause damage to your liver, kidneys or central nervous system, as well as cancers.

It is estimated that occupational cancers are a leading cause of work-related death worldwide. According to a study in Great Britain over one year, 5% of cancer deaths (8000) were attributable to occupational exposure.

A well-studied example of a VOC with health effects is benzene. Benzene evaporates easily and can be smelt at approximately 3 ppm. Figure 1 indicates that the physical symptoms caused by acute benzene exposure occur at much higher concentrations so our own senses would give us warning of potential harm.

However, the effects of long term, low-level (chronic) exposure to concentrations below that which our nose can detect are known to increase cancer rates and have been extensively documented. In a study of 250 workers exposed to benzene, white blood cell and platelet counts were significantly lower than in 140 controls, even for exposure below 1 ppm in air.

To protect workers from dangerous exposure to VOCs, Workplace Exposure Limits (WELs) have been put in place. WELs are the maximum concentration an unprotected worker can be exposed to in the workplace and are divided into two categories i) Time Weighted Average (TWA) calculated over an 8-hour exposure ii) Short Term Exposure Limit (STEL) the maximum exposure over 15 minutes.

WELs for benzene across Europe and the USA are typically below 1 ppm, well below what we can smell. WELs for hundreds of VOCs have been set and range from 100s of ppm to sub-ppm levels.

Concentration (ppm)	Duration of exposure (m)	Effect(s)
25	480	No observable effect
50-150	300	Headache, lassitude, weakness
500	60	Symptoms of illness
1500	60	Serious symptoms
3000	30	Endurable
7500	30	Dangerous to life
19000-20000	5-10	Fatal

Adapted from [1]

Figure 1

Environmental issues

Air pollution is now something we are all aware of and is often included on weather forecasts. VOCs are themselves directly an air pollutant but also have secondary effects. When sunlight and heat react with VOCs, specifically sulphur dioxide and nitrogen oxides which can be released from many industrial processes as well as motor vehicles ozone is generated, and smog is formed.

The individual components of smog can compromise human health and harm the environment – mixed they form a deadly cocktail. Smog can cause or aggravate health problems such as asthma, emphysema, chronic bronchitis, and other respiratory problems. The ozone in the smog also inhibits plant growth and can cause widespread damage to forests and crops.

But it is not just in the air VOCs can be found they are can also be found in our wastewater or contaminating our land. Most contamination found in our water systems are from industrial wastewater and studies have found toxic gases up to 46 ppm around manhole covers of VOCs including benzene, toluene, ethylbenzene, xylene (BTEX) and tetrachloroethane

The two most common places to find VOCs with in is brown field sites where industry has left contaminated land and historic or disused landfill sites. Removal of these harmful VOCs can be done by cleaning the soil and is known as soil remediation, but while it is expensive there are many companies that offer this service and has a high success rate to clean contaminated land.

E-mail: info@ionscience.com
Website: www.ionscience.com
Telephone: 01763 208503

References

1. https://www.gov.uk/guidance/control-and-monitor-emissions-for-your-environmental-permit#volatile-organic-compounds-vocs (09/06/21)
2. https://www.rcplondon.ac.uk/projects/outputs/every-breath-we-take-lifelong-impact-air-pollution (09/06/21)
3. https://www.iosh.co.uk/books-and-resources/our-oh-toolkit/occupational-cancer.aspx (09/06/21)
4. https://www.iosh.co.uk/books-and-resources/our-oh-toolkit/occupational-cancer.aspx (09/06/21)
5. Christopher J. Quigley & Richard L. Corsi (1995) Emissions of VOCs from a Municipal Sewer, Journal of the Air & Waste Management Association, 45:5, 395-403, DOI: 10.1080/10473289.1995.10467371
6. Hematotoxicity in Workers Exposed to Low Levels of Benzene BY QING LAN, LUOPING ZHANG, GUILAN LI, ROEL VERMEULEN, RONA S. WEINBERG, MUSTAFA DOSEMECI, STEPHEN M. RAPPAPORT, MIN SHEN, BLANCHE P. ALTER, YONGJI WU, WILLIAM KOPP, SURAMYA WAIDYANATHA, CHARLES RABKIN, WEIHONG GUO, STEPHEN CHANOCK, RICHARD B. HAYES, MARTHA LINET, SUNGKYOON KIM, SONGNIAN YIN, NATHANIEL ROTHMAN, MARTYN T. SMITH SCIENCE03 DEC 2004 : 1774-1776
7. Workplace Exposure Limits Explained | WELs Consultancy IOM (iom-world.org) (05/07/21)
8. Ventilation and air conditioning during the coronavirus (COVID-19) pandemic (hse.gov.uk) (05/07/21)