Occupational Health & Safety Practitioner

Reading

INTRODUCTION TO HAZARDOUS SUBSTANCES MANAGEMENT

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# Contents

**OVERVIEW** ...................................................................................................................................................... 1

**SECTION 1: INTRODUCTION** .................................................................................................................................. 2

**SECTION 2: BRIEF HISTORY** .................................................................................................................................. 6

**SECTION 3: WHAT ARE HAZARDOUS SUBSTANCES?** ................................................................................................ 14

**SECTION 4: MANAGEMENT OF HAZARDOUS SUBSTANCES** ................................................................................... 19

**REFERENCES AND FURTHER READING** ............................................................................................................... 26

**MATERIAL SAFETY DATA SHEET – RECOMMENDED FORMAT** ................................................................................. 27

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Overview

This reading provides a brief history of hazardous substances in the workplace. It also provides an introduction to the basic principles of risk management for the handling of hazardous substances, i.e. hazard recognition (identification), evaluation of risk (assessment) and controlling the risk.

Objectives

After reading this information you should be able to recall the basic classification of hazardous substances and state the basic principles of occupational hygiene.

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### Section 1: INTRODUCTION

#### Glossary of terms

When they are first used, glossary terms are indicated with an asterisk (*). Make sure that you are familiar with the Glossary of terms before going any further.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological Monitoring</td>
<td>The measurement and evaluation of hazardous substances or their metabolites in the body tissues, fluids or exhaled air of an exposed person.</td>
</tr>
<tr>
<td>By-Product</td>
<td>A substance produced during a chemical reaction which does not form part of the final reaction product.</td>
</tr>
<tr>
<td>Hazard</td>
<td>in relation to a person, means anything that may result in -</td>
</tr>
<tr>
<td></td>
<td>a) injury to the person; or</td>
</tr>
<tr>
<td></td>
<td>b) harm to the health of the person.</td>
</tr>
<tr>
<td>Health Surveillance</td>
<td>The monitoring of individuals for the purpose of identifying changes in health status due to occupational exposure to a hazardous substance. It includes biological monitoring (as defined) but not monitoring as defined elsewhere in this section.</td>
</tr>
<tr>
<td>Material Safety Data Sheet</td>
<td>Document which contains the information in relation to a substance that required by the National Code of Practice for the Preparation of Material Safety Data Sheets, whether or not the document is in the form required by that code of practice.</td>
</tr>
<tr>
<td>or MSDS</td>
<td></td>
</tr>
</tbody>
</table>
Monitoring
To survey regularly all measures which are used to control hazardous substances in the workplace. This includes the monitoring of atmospheric contaminants, but does not include biological monitoring which is an element of health surveillance.

Occupational Hygiene
Science and art devoted to the recognition, evaluation and control of those environmental factors and stresses, arising in or from the workplace, which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of the community (AIHA, 1959).

Practicable
means reasonably practicable having regard, where the context permits, to:
(a) the severity of any potential injury or harm to health that may be involved, and the degree of risk of it occurring;
(b) the state of knowledge about -
   (i) the injury or harm to health referred to in paragraph (a);
   (ii) the risk of that injury or harm to health occurring; and
   (iii) means of removing or mitigating the risk or mitigating the potential injury or harm to health; and
(c) the availability, suitability, and cost of the means referred to in paragraph (b) (iii).

Risk
in relation to any injury or harm, means the probability of that injury or harm occurring.

Substance
Any natural or artificial entity, composite material, mixture or formulation, other than an article.
| Toxic Substance / Toxicity. | Toxicity is defined as the capacity of an agent to produce damage to an organism. This usually refers to functional (systemic) damage, but may be developmental in respect of tissue and skeleton in the case of the embryo. The damage may be permanent or transient. |
| Corrosive Substance. | A corrosive substance causes destruction of, or damage to, materials or living tissue on contact. |
| Carcinogenic Substance. | A carcinogenic substance is one which is capable of causing cancer. A cancer is a malignant tumour which can spread to other organs of the body, as distinct from a benign tumour which cannot. Although leukaemia and some other malignant diseases are not solid tumours, they meet other criteria for cancer, and can be, and often are, included under this definition. |
| Teratogenic Substance. | A teratogenic substance is one which is capable of causing abnormalities in a developing foetus, that is, causing birth defects. |
Mutagenic Substance. An agent capable of producing a mutation or an agent which gives rise to an enhanced occurrence of mutations. A mutation is a permanent change in the genetic material of cells. This may be a change in the amount or structure of the genetic material in the organism, resulting in a change in the phenotypic characteristics of the organism. The alterations may involve a single gene, a block of genes or a whole chromosome. Effects involving single genes may be a consequence of effects on single DNA bases (point mutations) or of large changes, including deletions, within the gene. Effects on whole chromosomes may involve structural or numerical changes. A mutation in the germ cells in sexually reproducing organisms may be transmitted to the offspring.

Irritant Substance. A substance is an irritant if it causes inflammation of the skin, eye irritation, serious eye effects or irritation to the respiratory system.

Sensitiser. A substance which causes sensitisation, i.e., to become sensitive/allergic to the effects of minute quantities of a substance.

Reprotoxic Substance. This category includes substances that cause reproductive impairment in adults and developmental impairment or death in the unborn child. Reproductive impairment can include infertility, impotence, menstrual irregularities, spontaneous abortion and damage to offspring. Individuals may vary widely in their exposure and susceptibility to reproductive hazards.
1.1 Occupational exposure to hazardous substances is a significant area of concern

It has been claimed that the estimated number of deaths in Australia each year from occupational exposure to hazardous substances* is just under 2,300 (1), although the basis for this figure has been challenged (2). The overall impact of hazardous substances upon the health of workers may never be accurately assessed; the manifestations of exposure are so varied and ranging in severity that they may often go unrecognised. This is particularly relevant to those substances that do not directly affect the health of the worker, but affect a third party, such as an unborn child.

Hazardous substances, for the purpose of this reading, means those chemical substances that are harmful to the health of humans. As such, it includes those substances which are toxic, corrosive*, irritant*, sensitizers*, carcinogenic*, mutagenic*, teratogenic* or otherwise reprotoxic*. It does not include dangerous goods, radioactive or infectious substances.

Section 2: BRIEF HISTORY

From earliest times it has been known that exposure to some substances in the workplace can have an adverse effect on the health of people working with those substances. The early civilisations recognised this, and rather than attempting to make the work safer, would often instead use this as a punishment for slaves or convicts, or relegate the work to the lowest classes of the people. Hunter (3) gives a full and entertaining account of the history of occupational disease, and this text is recommended to the student, for interest.
2.1 Exposure to mercury and the mad hatter

In Roman times, mining in the Spanish cinnabar mines was regarded as being akin to a death sentence due to the shortened life expectancy of the miners, who were either slaves or convicts. We now know that this was due to the exposure of the miners to mercury. Lewis Carroll later highlighted the role of mercury as a hazardous material in the children's classic, *Alice's Adventures in Wonderland*, where the Mad Hatter displayed psychotic symptoms typical of a victim of mercury intoxication. Mercury was widely used in the manufacture of hats, in the process of carrottting rabbit fur to make felt. The expression 'as mad as a hatter' can be traced to the mental condition which was exhibited by some of the unfortunate workers in this industry. 

"In that direction," the Cat said, waving its right paw round, "lives a Hatter: and in that direction," waving the other paw, "lives a March Hare. Visit either you like: they're both mad."

"But I don't want to go among mad people," Alice remarked.

"Oh, you can't help that," said the Cat: "we're all mad here. I'm mad. You're mad."

_Alice's Adventures in Wonderland_, Lewis Carroll.

The Mad Hatter
2.2 Agricola (1556) identified mining health problems

Agricola recounts how workers in the mines, during the fifteenth and sixteenth centuries, suffered from diseases as a consequence of their work. This he attributed to the dusts, stagnant air and the gases found in the mines. Nowadays, these diseases would be recognised as pneumoconiosis, tuberculosis or lung cancer. He also describes other effects, which seem to be consistent with oxygen depletion, or asphyxiation (4).

"... some mines are so dry that they are entirely devoid of water, and this dryness causes the workmen even greater harm, for the dust which is stirred and beaten up by digging penetrates into the windpipe and lungs, and produces difficulty in breathing, and the disease which the Greeks call (asthma). If the dust has corrosive qualities, it eats away the lungs, and implants consumption in the body; hence in the mines of the Carpathian Mountains women are found who have married seven husbands, all of whom this terrible consumption has carried off to a premature death."

_De Re Metallica_, Georgius Agricola, 1556.
2.3 Paracelsus (1567) established the dose-response relationship

After Agricola came Philippus Aureolus Theophrastus Bombastus von Hohenheim-Paracelsus who can claim to have laid the foundations for the study of modern toxicology. It was Paracelsus who established the dose-response relationship with respect to toxic substances*; his famous comment on this relationship is quoted in the box. He contended that:

- experimentation is essential in examination of responses to chemicals;
- one should make a distinction between therapeutic and toxic properties of materials;
- these are sometimes, but not always, indistinguishable except by dose; and
- one can ascertain a degree of specificity of chemicals and their therapeutic or toxic effects (5).

“All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy.”

Von der Besucht, Paracelsus, 1567.
2.4 Ramazzini (1700) - the father of occupational medicine

In the seventeenth century, Bernardo Ramazzini (1633-1714) wrote a treatise on Diseases of Occupations (De Morbis Artificum Diatriba) which was published in 1700, and because of this he has since been bestowed with the title of the Father of Occupational Medicine. His major contributions are twofold. Firstly, through his systematic examination of a number of trades and occupations, he observed their conditions of work and their occupational diseases. In so doing, he made a number of recommendations on welfare, hygiene, posture, ventilation and protective clothing which are still as valid today as they were in 1700. His second lasting contribution is his advice to physicians that when taking a patient's history, they should enquire as to the nature of their work as a means of assisting in the diagnosis of the patient's condition (see text in box above).

When a doctor visits a working-class home he should be content to sit on a three-legged stool, if there isn’t a gilded chair, and he should take time for examination; and to the questions recommended by Hippocrates, he should add one more - What is your occupation?

De Morbis Artificum Diatriba, Bernardo Ramazzini, 1700.
2.5 Percival Pott (1775) linked scrotal cancer to chimney sweeps exposed to soot

In the eighteenth century, an English physician named Percival Pott linked scrotal cancer in chimney sweeps to the nature of their work and their exposure to cancer causing agents in soot. This work in 1775 is one of the earliest accounts of a cause and effect linkage being established for an occupational carcinogen, and as such, represents the beginning of the study of occupational cancer. It is now well known that soot owes its carcinogenic properties to tar, and that the carcinogenic substance responsible is 3,4-benzopyrene.

2.6 The industrial revolution (1760-1830) increased exposure of workers to hazardous substances

With the Industrial Revolution, which occurred in the years between 1760 and 1830, workers no longer owned the means of production. The demand for goods had grown to a point whereby the only means of meeting the demand was through mass production. This production was achieved through the invention of machines, such as James Hargreave's Spinning Jenny, which could do the work of several individual workers. With the machines came the textile mills and factories, which in turn generated a proportionate increase in the quantity of chemicals such as acids, alkalis, soaps and mordants needed for processing textiles.
2.7 Charles Thackrah (1831) was the first to practice industrial medicine in the English-speaking world

Charles Turner Thackrah (1795 - 1833) was a Yorkshireman who developed an interest in the diseases he came to see among the poorer classes of people living in the city of Leeds. His observations led him to develop guidelines for the prevention of certain diseases. He advocated the elimination of lead as a glaze in the pottery industry; the use of ventilation and respiratory protection to protect knife grinders; and he suggested a change in the work practices of tailors and in the design of their work stations to eliminate their cramped postures which he felt contributed to the high prevalence of tuberculosis in their profession.

Thackrah employed some of the most basic principles of occupational hygiene* to improve the health of his patients. He published a book in 1831 entitled *The Effects of the Principal Arts, Trades and Professions, and of Civic States and Habits of Living, on Health and Longevity, with Suggestions for the Removal of many of the Agents, which produce Disease and Shorten the Duration of Life*. Although Ramazzini recognised the relationship between a worker's occupation and health, Thackrah's importance lies firstly in the fact that the Industrial Revolution began in England and he was the first physician in the English speaking world to establish the practice of industrial medicine; and secondly, his writing led to a raised public awareness of the plight of many of the new working class.

The conditions in the mills and factories were often abominable. Public outcry, and the efforts of early Victorian reformers such as Thackrah, led to the passing of the *Factory Act* in 1833 and the *Mines Act* in 1842.
2.8 Despite early legislation working conditions were appalling

Despite such legislation being passed, working conditions continued to be dangerous and workers were exposed to hazardous substances both in the traditional trades and in the newer industries that developed in the latter half of the nineteenth century. Hunter (3) describes cutlers and potters dying before their time of silicotic diseases; he also describes workers being exposed to arsenic in the staining of paper and textiles and to white phosphorus in the manufacture of Lucifer matches. The latter was responsible for a phosphorus necrosis of the jaw (phossy jaw), which was easily avoided by the use of red phosphorus as an alternative. However, many manufacturers persisted with the use of white phosphorus as it was a cheaper raw material. In an interesting development, the Salvation Army opened a model match factory in 1891 to demonstrate how matches could be made using the safer red phosphorus in a more pleasant working environment.

2.9 Alice Hamilton noticed the effects of exposure to lead

In the U.S.A. around the turn of the century the remarkable Alice Hamilton (1869 - 1970) of Harvard University was noticing the effects of exposure to lead in American workers. She later documented her work in her autobiography, *Exploring the Dangerous Trades* (1943).
Section 3: WHAT ARE HAZARDOUS SUBSTANCES?

For the purpose of this reading, a hazard*, in relation to a person, means anything that may result in injury to the person or harm to the health of the person; and risk* in relation to any injury or harm, means the probability of that injury occurring and the consequence.

Risk Management is basically a 3-step process. The first step is to identify the hazards, the second step is to assess the risk and, having determined whether the risk is acceptable or otherwise, the third step is to consider and implement any changes to reduce the risk.

3.1 Recognition or identification of hazardous substances

For the purposes of this reading, hazardous substances will be categorised using the classification criteria adopted by Safe Work Australia. The definitions given below are all taken from the Approved Criteria for Classifying Hazardous Substances (6).

**Toxic Substances.** Toxicity is defined as the capacity of an agent to produce damage to an organism. This usually refers to functional (systemic) damage, but may be developmental in respect of tissue and skeleton in the case of the embryo. The damage may be permanent or transient (7).

**Corrosive Substances.** A corrosive substance causes destruction of, or damage to, materials or living tissue on contact.

**Carcinogenic Substances.** A carcinogenic substance is one, which is capable of causing cancer. A cancer is a malignant tumour, which can spread to other organs of the body, as distinct from a benign tumour, which cannot. Although leukaemia and some other malignant diseases are not solid tumours, they meet other criteria for cancer and can be, and often are, included under this definition.
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**Reprotoxic Substances.** This category includes substances that cause reproductive impairment in adults and developmental impairment or death in the unborn child. Reproductive impairment can include infertility, impotence, menstrual irregularities, spontaneous abortion and damage to offspring. Individuals may vary widely in their exposure and susceptibility to reproductive hazards (7).
The toxicology of reproductive and sexual functioning involves either reproductive or developmental toxicity. A reproductive toxicant interferes with reproductive or sexual functioning of the adult from puberty to adulthood, for example, depressed libido, impotence, irregular menstrual cycles and infertility. A developmental toxicant produces an effect in the offspring from conception to puberty. This has four principal manifestations:

- death of the foetus;
- structural abnormality;
- altered growth; and
- functional deficiency in the offspring (5).

3.2 Sources of information

Under most jurisdictions, there is a legal obligation on manufacturers or suppliers to provide adequate information to ensure that the substance can be handled safely and without risk to the health of employees during handling, processing, storage, transport or disposal of the substance. The most obvious information sources on a substance are labels and material safety data sheets* (MSDSs).

3.3 Minimum information for labels on containers

Containers of hazardous substances must be appropriately labelled and as a minimum should contain the following information:

- signal word (eg POISON);
- name & address of the manufacturer or supplier;
- product name;
- chemical name (if different to product name);
- risk & safety phrases;
- first aid procedures; and
- directions for use.
3.4 Recommended format of material safety data sheets (MSDS)

The MSDS should expand upon the limited information provided by the product label. While there are various formats for MSDSs, the format recommended for use in Australia can be found at the end of this reading.

3.5 Relevant toxicological data may not be available

The MSDS describes the likely health consequences of exposure to the substance, via the main routes of entry to the body:

- inhalation (breathing the substance in);
- ingestion (swallowing the substance);
- dermal (by contact or absorption with the intact skin); and
- eye contact.

This information may be supplemented by toxicological data where appropriate or available. It has been estimated that there are approximately 70,000 chemicals used in making up around 5 million various substances. Yet toxicological data is only available for about 3% of these substances. Rarely does this data relate to human exposure. Animal data is most often used to describe the acute lethal dose for that species, and this is then extrapolated to humans.

3.6 In some situations labels and MSDSs are not available

What about situations where information on hazardous substances, such as labels or MSDSs, are not readily available? Such situations may occur in chemical processing when a complex reaction occurs and a number of intermediaries or by-products* are formed or alternatively, at hazardous waste sites where workers may be working with unknown materials.
3.7 Interactions

There are a number of ways in which substances can interact in the body, for example:

- the effects of substances may add up to give a greater response;
- they may antagonise each other so that the effect seen is reduced; or
- the effect of one substance may enable another to produce a much-increased effect (synergism).
Section 4: MANAGEMENT OF HAZARDOUS SUBSTANCES

As Paracelsus said, it is the dose that makes the poison. The purpose of the risk assessment is to quantify the dose in order to establish whether the substance is indeed a poison. The risk assessment process involves the steps of recognition, assessment and control of the risk. These will be considered briefly in the next section of this reading, and in more detail in material elsewhere in the SafetyLine Institute.

3.1 Recognition

The Walk-Through Survey

As a means of making a preliminary investigation into potential exposure problems, the walk through survey is a good first step in the consideration of the substances and processes involved. This is essential in recognising the hazards.

The components of such a survey would include:

- the process;
- the personnel likely to be exposed and their behaviour and their comments;
- the substances used, handled or produced;
- evidence of reactions, including energy inputs/outputs;
- controls in place - isolation, engineering, administrative;
- observation of general housekeeping conditions;
- workplace facilities for washing, eating, drinking, etc;
- sensory information - noise, odours, visible dust or mist; and
- personal protective clothing & equipment - type and patterns of use.
In addition to the above, certain further information will be useful, including:

- process flow charts or diagrams;
- inventory of substances;
- records of first-aid treatments, incident and accident statistics;
- production and other logs; and
- verbal information from relevant personnel.

To facilitate the walkthrough survey, it helps to break up the process into small sub-processes. For example, in chemical manufacturing industry, one would consider all the above points at each of the following steps:

- research & development;
- raw materials inwards;
- processing & handling;
- packaging;
- storage;
- transport;
- distribution;
- utilisation or consumption of product; and
- waste management, disposal or recycling.

Other Factors

When assessing the risk from exposure to a substance, it should be recognised that some persons may be more vulnerable than others, due to the influence of certain factors such as:

- sex;
- age;
- predisposing medical conditions; and
- time (of day/year).
3.2 Assessment

Preliminary Assessment
When assessing the risk of exposure to the worker from the hazardous substance in question, a number of factors need to be considered by way of a preliminary assessment:

- physical nature of the contaminant - this may be solid, liquid or an aerosol;
- toxicity of the contaminant;
- quantity of the hazardous substance present;
- number of people with potential for exposure; and
- likelihood of exposure.

Air Sampling
Where a preliminary assessment indicates a potential for exposure, the next step is to quantify this level of exposure in order to establish whether the exposure is acceptable.

This may be done by sampling the air that the worker inhales to determine an indication of the level of exposure or by taking biological samples to determine the actual level of exposure.

Air sampling of the workplace atmosphere may be done by means of static samplers to obtain a general or area sample, or it may be done by means of a personal sample, which is collected in the breathing zone of the worker. This is usually collected with the worker using a personal monitor.
For the purpose of ensuring that the sample is genuinely representative of the worker's exposure, a sampling strategy must be developed to encompass a number of factors:

- collection techniques;
- analytical techniques;
- where to sample;
- whom to sample;
- when to sample;
- how long to sample;
- how many samples to collect; and,
- required accuracy and precision.

Following analysis, a result of the exposure concentration is found and is usually expressed as the quantity of contaminant for a given volume of air; for example, mg/m³, ppm or f/mL. This figure is also expressed as a Time Weighted Average (TWA) for the entire period of the time of sampling. Ideally, this period should be the full time in which the worker is potentially exposed, i.e., the full length of the shift.

Grab sampling using Drager Tubes

Personal sampling
Compare Results to Exposure Standard

In the ideal world, there would be no exposure. Failing this, exposures should be as low as is reasonably achievable, sometimes referred to as the ALARA principle. To determine whether the level of exposure is acceptable, the result should be compared against the exposure standard for the contaminant in question. Exposure standards will be covered elsewhere, so for the purposes of this reading it is enough to note that they are provided as a means of determining whether or not it is appropriate to employ some method of controlling the exposure to the worker. Exposure standards are not intended to indicate a 'safe/unsafe' level of exposure, nor should they be taken to indicate any adverse health effect to the worker.

3.3 Control

When exposure monitoring* indicates unsatisfactory levels of exposure may be occurring, then this must be reduced. While there are various ways in which this may be achieved, a hierarchy of controls has been established, listing methods in their order of effectiveness.

- **Elimination** - if a hazard exists then the most appropriate control is to eliminate it completely by not using a particular substance. For example, it may be possible to eliminate the use of chemical adhesives by fastening items together with screws or nails.

- **Substitution** - when it is not possible to eliminate the use of a chemical substance, it may be possible to use a safer alternative, for example, using a water based paint instead of a solvent based paint.

- **Isolation** - the exposure may be reduced by the use of a substance in an area which is remote to the rest of the workplace (isolation by distance) or by carrying out a process during quiet hours when fewest people are likely to be exposed (isolation by time).
- **Engineering methods** - a process may be modified in such a way to minimise the release of aerosols, for example, by enclosure or by means of local extraction ventilation systems.

- **Administrative methods** - this could include the development of standard operating procedures to limit exposures, or by restricting access to areas of high exposure.

- **Personal protective equipment (PPE)** - this is generally regarded as being the least effective method of reducing exposure, as the hazard still exists in the workplace and PPE is open to abuse by the wearer.

Whatever method of control is employed, whether singly or in combination, it is important to check that it is functioning effectively by regularly monitoring the workplace environment. Analysis of data from monitoring, particularly of trends, may indicate that maintenance is required, or that workers need further training in the use of the control methods.
3.4 Record keeping

When handling hazardous substances, it is good practice and a legal obligation to keep detailed records. As the effects of exposure to hazardous substances may not manifest themselves for many years, or may manifest themselves in the offspring of the exposed persons, it is also important that these records should be kept for at least 30 years. It does not matter in what form the records are kept, whether on paper or in electronic format, as long as they are accessible by persons who may be exposed, or by the authorities. The only exception to this is confidential medical records. As a minimum, the records should include:

- the workplace chemical register including Material Safety Data Sheets;
- assessment reports;
- monitoring data;
- health surveillance* reports; and
- training records.

Your feedback

WorkSafe is committed to continuous improvement. If you take the time to complete the online Feedback Form at the SafetyLine Institute website you will assist us to maintain and improve our high standards.
REFERENCES AND FURTHER READING


8. Further information on the American Industrial Hygiene Association (AIHA) [www.aiha.org](http://www.aiha.org)
MATERIAL SAFETY DATA SHEET - RECOMMENDED FORMAT

This Checklist outlines the necessary information to prepare the 16-header MSDS format required under workplace hazardous substances and Dangerous Goods legislation. A copy of this checklist can be downloaded from www.ascc.gov.au

SECTION 1 IDENTIFICATION OF THE MATERIAL AND SUPPLIER

- Product (material) name
- Other names
- Recommended use
- Supplier name/address/telephone no./Emergency phone number

SECTION 2 HAZARDS IDENTIFICATION

- Hazard classification, including a statement of overall hazardous or dangerous nature
- Risk phrase(s)
- Safety phrase(s)

SECTION 3 COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE

- Chemical identity of the pure substance
- Common name(s), synonym(s)
- CAS Number(s)

MIXTURE

- Chemical identity of ingredients
- Proportion of ingredients
- CAS Number(s) for ingredients
SECTION 4 FIRST AID MEASURES

- Description of necessary measures according to routes of exposure
- Indication of medical attention and special treatment needed including description of most important symptoms, acute and delayed

Additional information

- Aggravated medical conditions caused by exposure

SECTION 5 FIRE FIGHTING MEASURES

- Suitable extinguishing media
- Hazards from combustion products
- Special protective precautions and equipment for fire fighters

Additional information

- Hazchem Code

SECTION 6 ACCIDENTAL RELEASE MEASURES

- Emergency procedures
- Methods and materials for containment and clean up

SECTION 7 HANDLING AND STORAGE

- Precautions for safe handling
- Conditions for safe storage, including any incompatibilities

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

- National exposure standards
- Biological limit values
- Engineering controls
- Personal protective equipment
SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

- Appearance (colour, physical form, shape).
- Odour.
- pH.
- Vapour pressure.
- Vapour density.
- Boiling point/range.
- Freezing/melting point (specify which).
- Solubility (specify solvent, e.g. water).
- Specific gravity or density.

Information for flammable materials, including:
- flash point and method of detecting flash point;
- upper and lower flammable (explosive) limits in air; and
- ignition temperature.

Additional information
- Specific heat value.
- Particle size.
- Volatile organic compounds (VOC) content.
- Evaporation rate.
- Viscosity.
- Percent volatile.
- Octanol/water partition coefficient.
- Saturated vapour concentration (include reference temperatures).
- Additional characteristics not noted above may also be provided if applicable to the material.
- Flame propagation or burning rate of solid materials.
- Properties of both flammable and non-flammable materials that may initiate or uniquely contribute to the intensity of a fire (e.g. Class 4 or Class 5).
- Potential for dust explosion.
- Reactions that release flammable gases or vapours.
- Fast or intensely burning characteristics.
- Non-flammables that could contribute unusual hazards to a fire, such as strong oxidizing and reducing agents or peroxide formers.
- Release of invisible flammable vapours and gases.
- Decomposition temperature.

SECTION 10 STABILITY AND REACTIVITY

- Chemical stability

- Conditions to avoid

- Incompatible materials

- Hazardous decomposition products

- Hazardous reactions
SECTION 11 TOXICOLOGICAL INFORMATION
- Health effects from the likely routes of exposure

SECTION 12 ECOLOGICAL INFORMATION
- Ecotoxicity
- Persistence and degradability
- Mobility

Additional information
- Environmental fate (exposure)
- Bioaccumulative potential

SECTION 13 DISPOSAL CONSIDERATIONS
- Disposal methods and containers
- Special precautions for landfill or incineration

SECTION 14 TRANSPORT INFORMATION
- UN Number
- UN Proper Shipping Name
- Class and subsidiary risk
- Packing Group
- Special precautions for user
- Hazchem Code