

National Occupational Health and Safety Commission

SOLVENT VAPOUR DEGREASING

December 1989

Australian Government Publishing Service
Canberra

WAP 89/030
GS 007-1989

© Commonwealth of Australia 1989

ISBN 0 644 09191 6

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without written permission from the Director Publishing and Marketing, AGPS. Inquiries should be directed to the Manager, AGPS Press, Australian Government Publishing Service, GPO Box 84, Canberra ACT 2601.

The National Commission's address is:

National Occupational Health and Safety Commission
Level 30, St Martins Tower
31 Market Street
Sydney NSW 2000
GPO Box 58
Sydney NSW 2001
Tel: (02) 265 7555
Facsimile: (02) 265 7538
Telex: 177243

Printed in Australia by Pirie Printers Sales Pty Ltd, Fyshwick, A.C.T. 2609

Foreword

The National Occupational Health and Safety Commission, Worksafe Australia, is a tripartite body established by the Commonwealth Government to develop, facilitate and implement a national approach to occupational health and safety.

The National Commission comprises representatives of the peak employee and employer bodies - the Australian Council of Trade Unions (ACTU) and Confederation of Australian Industry (CAI) - as well as the Commonwealth, State and Territory governments.

Since its establishment, the National Commission has produced occupational health guides. Before the National Commission was established, a series of similar guides was published by the National Health and Medical Research Council.

This Guide has been reviewed and endorsed by a working group of the National Commission as part of the co-ordinated effort by the Commonwealth, State and Territory governments and employee and employer organisations to make Australian workplaces safe and healthy.

Although this Guide has been endorsed by the National Commission, it is an advisory document only. It is produced and distributed in the interests of providing useful information on occupational health and safety for employers, employees and others. This document does not replace statutory requirements under relevant State and Territory legislation.

This Guide is aimed primarily at workers and managers but should also be useful to occupational health and safety personnel and others. It may be used in conjunction with appropriate training and consultation, in line with good management practice.

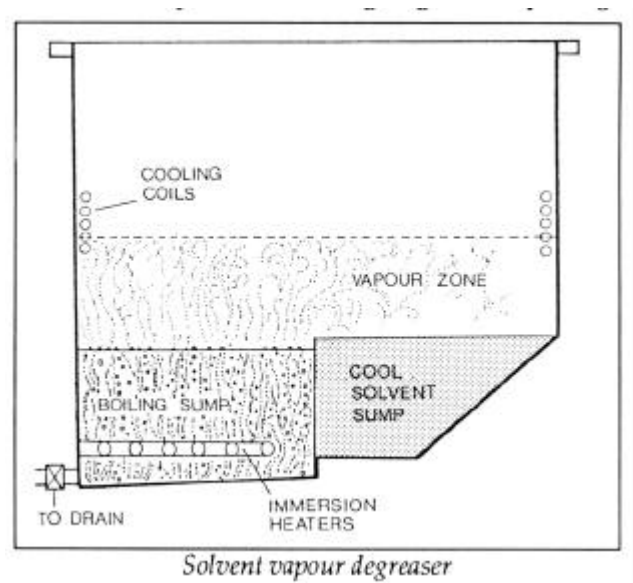
Contents

<i>Foreword</i>	<i>iii</i>
<i>Introduction</i>	<i>1</i>
<i>Identification</i>	<i>2</i>
<i>Health Hazards</i>	<i>3</i>
<i>Prevention and Control Measures</i>	<i>6</i>
<i>Atmospheric and Biological Monitoring</i>	<i>13</i>
<i>First Aid</i>	<i>15</i>
<i>Appendix</i>	<i>17</i>
<i>Further Reading</i>	<i>18</i>

Introduction

This Guide addresses the occupational health and safety aspects of solvent vapour degreasing.

Degreasing is the process whereby all greases and adherent material are removed from the surface of metal prior to undergoing electroplating, galvanising, tin plating, painting, varnishing and other surface protection processes. Under certain circumstances degreasing is undertaken to clean metal prior to welding and brazing. Many types of degreasing processes can be employed depending on the nature of the impurity being removed, the metal being degreased, the final surface state required and the scale of the degreasing operation. Types of degreasing solutions include alkaline solutions, emulsifying agents, safety solvents, freon and steam.



One of the most widely practised types of degreasing carried out in industry is vapour degreasing, using organic solvents.

This Guide should be used in conjunction with the following Worksafe Australia Guides:

- *Industrial Organic Solvents;*
- *Atmospheric Contaminants;*
- *Occupational Health Services;* and
- *Occupational Diseases of the Skin.*

Where relevant, reference should be made to specific material safety data sheets (MSDS).

Identification

The process

In vapour degreasing, the solvent which is contained in a specially designed tank is heated to its boiling point to produce a controlled solvent vapour zone. The article to be degreased is then mechanically immersed into this vapour zone, the vapour condensing on the metal surface. The condensed solvent runs off the metal, washing away the impurities. The metal dries when it reaches the temperature of the vapour. At this stage the clean article can be slowly removed from the tank.

The common type of solvent degreaser is the simple vapour machine. This may be combined with *immersion*, where the article being degreased is immersed in the boiling solvent and rinsed with cool clean solvent, or *spraying*, where the solvent is forcefully sprayed on to the article. Some degreasers incorporate *ultrasonics* in their cleaning technique.

Common solvents

The organic solvents commonly used for vapour degreasing are chlorinated hydrocarbons. The following three are in widespread use:

- 1,1,1-trichloroethane - (methyl chloroform, chloroethane);
- trichloroethylene - (1,1,2-trichloroethene, 'tricho', TCE, 'trike'); and
- perchloroethylene - (tetrachloroethylene, 'perc').

For information on the properties of these solvents, see the Appendix.

Health Hazards

When considering the hazards associated with any workplace, it is essential to understand the relationship between 'hazard', 'exposure' and 'risk'.

'Hazard' is the potential for an agent or process to do harm. 'Risk' is the likelihood that an agent will produce injury or disease under specified conditions.

Health effects can only occur if a worker is actually exposed to the hazard. The risk of injury or disease usually increases with the duration and frequency of exposure to the agent, and the intensity/concentration and toxicity of the agent.

Toxicity refers to the capacity of an agent to produce disease or injury. The evaluation of toxicity takes into account the route of exposure and the actual concentration of an agent in the body.

Exposure routes

The harmful effects of organic solvents follow inhalation of vapour, eye and skin contact with liquid or vapour, or ingestion, which are described below:

- *Inhalation* is the most significant route of entry by which harmful substances enter the human body at work.
- Toxic solvent vapours may have *local effects*, if they harm the part of the body they come in contact with. They may also have *systemic effects*, causing changes to the function of other organs.
- Some solvent vapours may be *absorbed* through the skin without any noticeable change to the skin, while others may cause serious damage to the skin itself.
- *Ingestion* is of relatively minor significance in occupational exposure to toxic materials.

Health effects

With good occupational hygiene practice, health hazards are unlikely to arise from the use of the three solvents mentioned (trichloroethylene, perchloroethylene and 1,1,1-trichloroethane). Inhalation of the vapour is the most important route of acute and chronic exposure to degreasing solvents.

Exposure to hazardous material may be acute or chronic. *Acute exposures* generally refer to single dose, high concentration exposures over short periods, while *chronic exposures* involve repeated or continuous exposures over long periods. These exposures may have acute, immediate effects or chronic, long term effects.

Acute effects

Exposures to low concentrations may result in nausea, dizziness, headache and irritation to eyes, nose and throat.

The predominant outcome of inhalation of high concentrations of solvent vapour is central nervous system depression, with stupor and drowsiness. In extreme situations, loss of consciousness and even death can result.

If alcohol is taken after exposure to solvent vapour, effects may be felt which include flushing of the skin. This is sometimes referred to as 'degreaser's flush'.

Chronic effects

Trichloroethylene may damage the liver and kidneys and perchloroethylene may affect liver function.

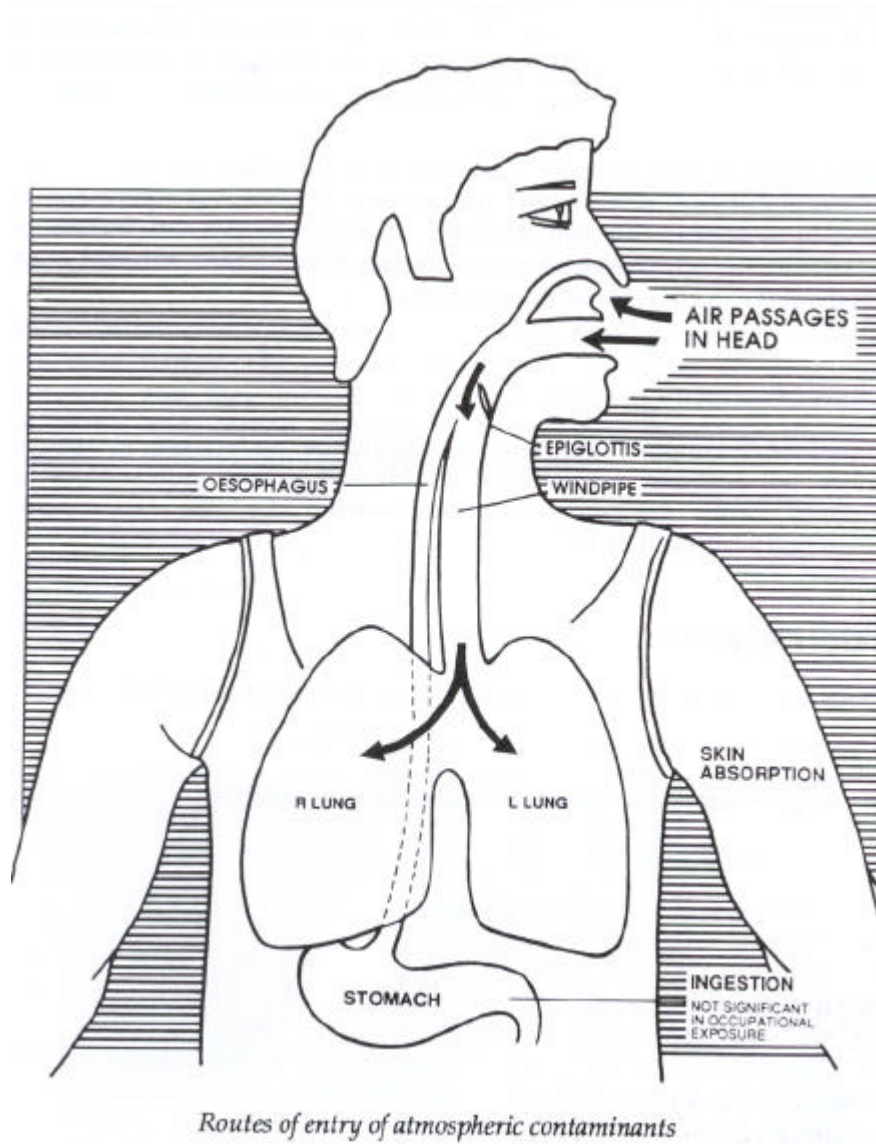
Animal studies have shown that exposure to some chlorinated hydrocarbons may be associated with an increased risk of cancer in some species. On the basis of available human research evidence, the World Health Organization has concluded that there is insufficient evidence to make an evaluation on the carcinogenic effects of trichloroethylene and perchloroethylene.

Excessive frequent exposure may cause long term psychological and neurological effects. Such effects may include loss of ability to concentrate and memory impairment.

Because of a defatting action, prolonged skin contact with these solvents removes natural greases and oils. This may result in an irritant dermatitis with redness, dryness and flaking of the skin.

Solvent abuse

Volatile solvent abuse has been reported among some workers with access to these solvents. Sudden death, caused by heart failure, can result from 'sniffing'. Repeated exposure can lead to impaired psychological and neurological function.



Prevention and Control Measures

To establish appropriate prevention of significant health effects, an evaluation of work practices and conditions must be undertaken by qualified health and safety personnel. These practices should be considered an integral part of management. Good occupational hygiene promotes elimination of hazards, where practicable. Engineering controls to minimise the hazard at the source, where practicable, and administrative controls should be adopted.

Potential health hazards of vapour inhalation can be prevented by correct design, installation, operation, cleaning and maintenance of plant and equipment, as directed by Australian Standard AS 2661. Education to promote knowledge about relevant hazards is essential if safe working procedures are to be followed. MSDS should be made available to all personnel.

Evaluation

Environmental sampling and analysis should be undertaken at regular intervals by qualified occupational health and safety professionals in accordance with the methods recommended by the appropriate occupational health authority.

Control measures

Prevention and control measures include, but are not limited to, the following:

- elimination/substitution and process modification;
- engineering controls, such as local exhaust ventilation;
- administrative controls; and
- use of personal protective equipment.

Design and installation

Only equipment designed for the specific degreasing process should be used and it should be properly manufactured and installed. From an operational point of view, the preferred solvent for degreasing with water-cooled condensers is trichloroethylene. Perchloroethylene can be used in these degreasers, but only after adjustments have been made to satisfy the characteristics of the higher boiling point solvent. Degreasers not equipped with water-cooled condensers should be operated with perchloroethylene only.

The use of 1,1,1-trichloroethane necessitates special engineering, design and corrosion-resistant material, for example, stainless steel. Appropriate controls to prevent overheating of solvents are necessary, and consideration should be given to incorporating a high temperature and low solvent level alarm into the system.

Emission control of vapour from open-topped tanks, when not in use, should be controlled by close fitting, sliding or rolling covers, not hinged covers. Water-cooled condenser units provide more reliable control of atmospheric emissions than thermostatic control types.

Vapour degreasers should be situated in large, open locations with good general ventilation, away from sources of direct draughts, for example, fans, ventilation duct openings which could carry vapours into surrounding work areas, furnaces, naked flames and welding operations.

Note: Chlorinated hydrocarbons are readily decomposed by hot surfaces and open flames. The products of this decomposition are toxic and/or corrosive, and they include, in varying amounts, hydrogen chloride, phosgene and carbon monoxide. Accordingly, smoking should be prohibited in the vicinity of degreasing operations.

Exhaust systems in open-topped degreasing units should be incorporated in accordance with the American Conference of Government Industrial Hygienists' Ventilation Manual. Such ventilation can be in the form of a slot along one or more sides of the tank. Exhaust ventilation will control escape of vapour into the work environment. The discharge should not be recycled into the workplace environment. When degreasers are installed in pits, ventilation should be provided at the lowest part of the pit.



A vapour degreasing tank in operation

Safety signs

These should be displayed in prominent positions near the degreasers. The needs of workers from non-English speaking backgrounds should be taken into account. The signs should, for example, include information about:

- 'no smoking' restrictions within a certain area;
- first aid instructions;
- emergency procedures, including personal protective devices;
- prohibitions on naked flames;
- prohibitions on welding operations; and
- operating instructions.

Safety signs should comply with Australian Standard AS 1319.

Operation

Operators should be given thorough training and instruction in safe work practices, including knowledge of all the risks involved in such an operation. Operators involved in solvent degreasing should be instructed in, and be competent in, relevant first aid and emergency procedures.

The manufacturer's instructions for the operation of degreasing plants should be strictly adhered to. Tanks should be provided with an overhead lifting device operating at a controlled rate not exceeding 3 m/min, to minimise the displacement of vapour and hence exposure to the operator. Metallic baskets should be used to hold small articles. Absorbents such as rag, cloth or wood should not be part of the material being degreased, or of the rack or the hoist.

Articles being degreased in the vapour zone should not be removed until all liquid condensation on the surface has ceased and the articles are dry. There is a potential source of exposure at this stage, with factors to be considered including minimising drag out of the solvent vapour and removing articles slowly, using a lifting device.

If there is a likelihood that solvents may be trapped and carried out of the tank in articles such as tubes and cups, such work should be stacked at an angle or rotated and tilted in the vapour zone to empty any solvents trapped in the recesses.

Degreasers should remain covered when not in use. The covers should be *opened slowly* on loading and *closed slowly* after unloading. Frequent or abrupt covering and uncovering may cause vapour to be fanned out of the tank, resulting in operator exposure.

Frequent checks should be made on the sump temperature of the boiling solvents. Degreasers should be equipped with high temperature and low solvent level alarms.

Cleaning and maintenance

Degreasing tanks and their accessories should be inspected at regular intervals. The inspection should include an assessment of:

- solvent levels;
- ventilation systems;
- water separators;
- thermometers;
- thermostats;
- relief valves; and
- other devices necessary for the safe working of the degreasing plant.

The plant should be shut down prior to cleaning. This may include isolating the heating mechanism, draining or distilling the liquid, opening clean-out doors and forcing out the vapour, using mechanical ventilation.

Tanks should be cleaned regularly to remove sludge and to separate solvent from oil and grease. The solvent should be drained off with minimal exposure to the air and then stored in closed labelled drums. For specific disposal details, refer to the relevant MSDS.

Degreasing tanks should have a sludge door which is large enough and so placed that normal cleaning can be carried out from the outside of the tank.

Maintenance and repair of degreasing tanks present considerable hazards. The tank should be cooled, cleaned thoroughly and mechanically ventilated for at least twelve hours prior to entry into the tank, or before work involving open flames or intense heat (either inside or outside) is performed. A permit is required to work inside the tank. The atmosphere should be tested before entry into a confined space or before welding or other hot work is attempted.

The person entering the tank should wear appropriate protective clothing, a well fitting face air-supplied respirator and a safety harness with life-line. Protective equipment should comply with Australian Standards AS 1716 and AS 1891. The person inside the tank should be observed by at least one able person outside the tank who is competent to provide any immediate assistance to the person inside the tank and to hold the life-line. An air-supplied respirator should be available to the employee outside the tank and other employees should be available to assist in case of an emergency. Work practices should comply with Australian Standard AS 2865.

A work permit should be provided for any persons undertaking maintenance or cleaning operations on a degreasing plant (see Australian Standard AS 2661).

Personal protective equipment

In certain circumstances, personal protection of the individual employee is necessary. Personal protective devices should be regarded as being supplementary to substitution and engineering control and should not be used in preference to the latter because they do nothing to eliminate the hazard.

Personal protective equipment must be appropriately selected, individually fitted and workers trained in their correct use and maintenance. Personal protective equipment must be regularly checked and maintained to ensure that the worker is being protected.

Personal protective devices should not be used as a substitute for safe work practices.

All protective clothing and devices should meet the standard set in the appropriate Australian Standard (see Australian Standards AS 1715, AS 1716, AS 1337). Operators should wear eye protective equipment such as full-face shields or goggles. For persons entering the tank, refer to control measures outlined earlier.

Note: PVC, neoprene and rubber are broken down by solvents and therefore teflon, viton and some PVA gloves should be used where necessary.

Storage

Solvents should be stored:

- in well-labelled steel-lined containers, not galvanised iron, plastic or aluminium;
- away from heat and direct sunlight;
- in a separate, cool and well-ventilated room; and
- off the floor on pallets.

Solvents should not be stored:

- near foodstuffs, medicines, strong acids, alkalis or oxidising agents; or
- near strong heat and naked flames.

Handling of solvents

When the solvent is to be added to the tank:

- the sump should be cooled;
- the solvent should be pumped or gravity fed into the tank and should not be poured from one container to another;
- containers should only be opened when required and sealed after use; and
- eye protection and other protective clothing should be worn.

Spillage

In case of spills or leaks, avoid breathing the vapour and avoid liquid coming into contact with the skin and eyes. Clear area of all unprotected personnel and move upwind. Wear appropriate protective clothing and equipment. Isolate the leak and stop the flow if safe to do so. If spill is large enough or necessitates it, alert the fire brigade.

Spilt solvent should be contained with earth, sand or other inert adsorbent material. The clean-up operation follows that recommended in Australian Standard AS 2508. Also, follow instructions given by the supplier. It should not be washed into storm water or sewage drains.

Waste disposal

Disposal of recovered solvents and contaminated material should be carried out in the manner prescribed by Commonwealth, State or local waste disposal authorities. Solvents must not be poured down stormwater or sewage lines.

Fire and explosion hazards

Exposure to flames or other high-intensity heat sources will result in thermal decomposition of degreasing solvents, forming toxic gases.

In the event of fire, employees should be evacuated from the area and follow accepted emergency procedures, as set down by the place of work.

Firefighters should wear positive pressure-demand self-contained breathing apparatus (see Australian Standard AS 1716).

Note: Also see Australian Standard AS 1678 for information on emergency transport procedures for trichloroethylene and 1,1,1 - trichloroethane, and Australian Standard AS 2508 for MSDS on the three solvents.

Education and training

All employees working in degreasing processes must be informed of the hazards from exposure to the contaminant and the precautions necessary to prevent damage to their health. They should be made aware of the need to carry out their work so that as little contamination as possible is produced, and of the importance of the proper use of all safeguards against exposure to themselves and their fellow workers. Adequate training, both in the proper execution of the task and in the use of all associated engineering controls, as well as of any personal protective equipment, is essential.

Employees exposed to contamination hazards should be educated in the need for, and proper use of, facilities, clothing and equipment and thereby maintain a high standard of personal cleanliness. Special attention should be given to ensure all personnel understand instructions, especially newly recruited employees and those with English language difficulties, where they are known.

Before handling all potentially hazardous substances, MSDS should be obtained from the suppliers of such materials.

A management representative should be nominated as responsible for personal protective equipment supply, maintenance and training.

Atmospheric and Biological Monitoring

Exposure standards

Worker exposure to solvent vapours should be kept as low as practicable. Every attempt should be made to keep exposures to solvent vapour below the relevant exposure standards. For current values, refer to the National Commission publication, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (latest edition).

Examples of exposure standards for solvents are listed below:

Solvent	Exposure Standard	
Trichloroethylene	50 ppm	270 mg/m ³
Perchloroethylene	50 ppm	335 mg/m ³
1,1,1-Trichloroethane	125 ppm	1900 mg/m ³

The exposure standards represent airborne concentrations of individual chemical substances which, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers. Additionally, the exposure standards are believed to guard against narcosis or irritation which could precipitate industrial accidents.

Except where modified by consideration of excursion limits, exposure standards apply to long term exposure to a substance over an eight-hour day for a normal working week, over an entire working life.

The exposure standards do not represent 'no-effect' levels which guarantee protection to every worker.

Monitoring

Monitoring may be used for the evaluation of a hazard and for assessing the effectiveness of control measures. The design and implementation of a monitoring program should be carried out by, or in consultation with, a properly qualified person.

In the control of health hazards due to a specific contaminant, where it has been demonstrated that the exposure of the employee to the contaminant is approaching the relevant exposure standard, or

where biological monitoring indicates that an unacceptable exposure is occurring, immediate action must be taken to reduce the health hazard and intensive monitoring should continue.

Records of the results of any monitoring should be maintained and employees should be informed of these results.

Atmospheric monitoring

Monitoring of the work environment involves the measurement of atmospheric contaminants at selected locations in the workplace (static, positional monitoring). Personal monitoring involves the measurement of atmospheric contaminants in the breathing zone of the individual worker. Devices are available for testing atmospheric concentrations of chlorinated hydrocarbons. These data may then provide a guide to the need for a more detailed evaluation of exposures and review of control measures. Sampling and analytical procedures should be in accordance with the requirements of the relevant occupational health authority.

New degreasers should be tested when first commissioned for use, when modifications are made to equipment, where there are other workplace changes in the vicinity of the equipment, or every two years.

Biological monitoring

Biological monitoring involves measurement of the concentration of a contaminant, its metabolites or other indicators in the tissues or body fluids of the worker. In some cases, biological monitoring may be required to supplement static or personal monitoring. Biological monitoring should only be conducted by appropriately qualified persons. Further information on biological monitoring can be sought from the relevant occupational health authority. Biological monitoring is not to be used to evaluate the success of engineering controls.

Health assessment

In some occupations, health assessment may form part of a comprehensive occupational health and safety strategy. Where employees are to undergo health assessment, there should be adequate consultation prior to the introduction of any such program. Where medical records are kept, they must be confidential. In some cases it is valuable to be able to relate employee health and illness data to exposure levels in the workplace.

First Aid

All personnel involved should be trained in resuscitation techniques.

Inhalation

Where there has been exposure to high concentrations of solvent vapour resulting in *loss of consciousness*:

- Move the patient quickly to a safe place with fresh air.
- Arrange for immediate medical attention and transfer to a medical facility.
- Lie the patient in a semi-prone position, ensure airway is clear and patient is breathing. If the patient is not breathing, apply mouth-to-mouth resuscitation, and oxygen if available. If no pulse can be found, apply cardio-pulmonary resuscitation (CPR).
- Remove contaminated clothing and place in an appropriate container for decontamination. Ensure that the rescuers do not place themselves at risk. Keep the patient warm.
- Do not administer drugs or alcohol.

Note: An unconscious patient will usually be found in a situation where solvent vapour is still present.

Rescuers should wear proper protective equipment or take care not to remain exposed to the vapour themselves. Proper procedures should be followed when entering confined spaces.

If the patient is *conscious* and has *symptoms* of exposure to high concentrations of solvent vapour:

- Move the patient quickly to a safe place with fresh air.
- Remove contaminated clothing and place in an appropriate container for decontamination. Ensure that the rescuers do not place themselves at risk. Keep the patient warm.
- Do not administer drugs or alcohol.
- Keep the patient at rest. Medical advice should be sought before the patient resumes work or is taken home to rest.

Eye contact

If a solvent gets into the eyes:

- thoroughly irrigate the affected eye with clean tepid water;
- wash surrounding eye area to remove solvent from skin;
- if irritation persists, cover eye with a clean bandage, if available, and seek medical advice; and
- if contact lenses are worn by the person in whose eye the splash occurs irrigate the eye thoroughly for a few minutes then remove the contact lenses and continue with further eye irrigation.

Skin contact

If the patient has had skin contact with solvent:

- remove any contaminated clothing and launder thoroughly before re-use; and wash affected area well with soap and water.

Ingestion

If the patient has ingested solvent vapour:

- If *fully conscious*, induce vomiting. If available, use 50 mL of Ipecac Syrup with a glass of water, to induce vomiting.
- If *drowsy or unconscious*, do not induce vomiting.
- Seek urgent medical advice.

Note: Ipecac Syrup can be slow to act and the patient may become drowsy or unconscious before it has acted. Vomiting may also be induced by stimulating the back of the throat of the person who has ingested the solvent.

Advice to doctor

1,1,1-trichloroethane, perchloroethylene and trichloroethylene sensitise the heart to adrenalin.

Appendix

Properties of common solvents

- 1,1,1-trichloroethane (CH₃CCl₃) CAS No. 71-55-6
synonyms: methyl chloroform, chloroethane, methyl trichloromethane.
flammability: not flammable by standard tests in air.
Miscible with some organic solvents, slightly soluble in water, clear colourless liquid with a sweetish odour. Decomposes to large amounts of hydrogen chloride and traces of phosgene at 260°C. It reacts with aluminium and aluminium alloys and other reactive metals, for example, Mg and Zn, to form explosive chloroacetylene.
- trichloroethylene (CCl₂ = CHCl) CAS No. 79-01-6
synonyms: 1,1,2-trichloroethene, 'tricho', TCE, 'trike', acetylene trichloride, 1-chloro-2,2-dichloroethylene, 1,1-dichloro-2-chloroethylene, ethylene tri-chloride.
flammability: not flammable by standard tests in air.
Miscible with most organic solvents, slightly soluble in water, colourless liquid with a sweetish odour. In the presence of oxygen and heat or short wavelength ultraviolet radiation, trichloroethylene may decompose to hydrogen chloride (hydrochloric acid) and phosgene, which are highly toxic. Trichloroethylene should not be used with aluminium and other reactive metals, as it forms dichloroacetylene, which is explosive.
- perchloroethylene (CCl₂ = CCl₂) CAS No. 127-18-4
synonyms: tetrachloroethylene, 'perc', ethylene tetrachloride, 1,1,2,2-tetrachloroethylene.
flammability: not flammable by standard tests in air.
Miscible with most organic solvents and oils, insoluble in water, clear colourless liquid with a sweetish odour.

Stabilisers

Commercial degreasing solvents usually contain a small amount of stabiliser, that is, less than 2 per cent, frequently an organic amine, which neutralises the hydrogen chloride that might form. These stabilisers can be highly toxic but are unlikely to cause serious injury, either by inhalation or skin absorption, when used in degreasing solvents in a well-managed operation with good occupational hygiene practices.

Further Reading

ACTU-VTHC Occupational Health and Safety Unit, *Guidelines on Working with Solvents*, Health and Safety Bulletin no. 48, ACTU-VTHC, Melbourne, 1986.

American Conference of Governmental Industrial Hygienists, *Documentation of the Threshold Limit Values and Biological Exposure Indices*, 5th Edition, American Conference of Governmental Industrial Hygienists, Cincinnati, 1986.

American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, *Industrial Ventilation - A Manual of Recommended Practice*, 20th Edition, American Conference of Governmental Industrial Hygienists, Lansing, Michigan, 1989.

Clayton, G. and Clayton, F., eds, *Pattys Industrial Hygiene and Toxicology*, 3rd Revised Edition, Wiley Interscience Publications, New York, 1981.

Collings, A.J. and Luxon, S.G., eds., *Safe Use of Solvents - Proceedings of the International Symposium on the Safe Use of Solvents Held at the University of Sussex, UK, 23-27 March 1982*, Academic Press Inc., London, 1982.

Harrington, J.M., ed., *Recent Advances in Occupational Health Number 2*, Churchill Livingstone, Melbourne, 1984.

Health and Safety Executive, *Trichloroethylene Health and Safety Precautions*, Guidance Note EH 5, Her Majesty's Stationery Office, London, 1985.

International Agency for Research on Cancer, *Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans - Some Halogenated Hydrocarbons*, vol. 20, International Agency for Research on Cancer, October 1979.

International Labour Office, *Encyclopaedia of Occupational Health and Safety*, vol. 1, 3rd Edition, International Labour Office, Geneva, 1983.

National Health and Medical Research Council, *Standard for the Uniform Scheduling of Drugs and Poisons*, Australian Government Publishing Service, Canberra, 1986.

National Institute of Occupational Safety and Health, *Organic Solvent Neurotoxicity*, Current Intelligence Bulletin no. 48, National Institute of Occupational Safety and Health, Cincinnati, 1987.

National Occupational Health and Safety Commission, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (latest edition).

Standards Australia, AS 1319-1983 *Safety Signs for the Occupational Environment*, Sydney.

- AS 1337-1984 *Eye Protection for Industrial Applications*, Sydney.
- AS 1627 *Code of Practice for Preparation and Pretreatment of Metal Surfaces Prior to Protective Coating*, Part 1-1974 *Degreasing of Metal Surfaces Using Solvent or Alkaline Solutions*, Sydney.
- AS 1678 *Emergency Procedures Guides - Transport*, 6.1.008 *Trichloroethylene (TRI)*. 6.1.009 1,1,1, *Trichloroethane (Methyl Chloroform)*, Sydney.
- AS 1715-1982 *Selection, Use and Maintenance of Respiratory Protective Devices*, Sydney.
- AS 1716-1984 *Respiratory Protective Devices*, Sydney.
- AS 1891-1983 *Industrial Safety Belts and Harnesses*, Sydney.
- AS 2508-1987 *Safe Storage and Handling Information Cards for Hazardous Materials*, Sydney.
- AS 2661-1984 *Vapour Degreasing Plant - Design, Installation and Operation - Safety Requirements*, Sydney.
- AS 2865-1986 *Safe Working in a Confined Space*, Sydney.

World Health Organization, *Tetrachloroethylene*, Environmental Health Criteria no. 31, World Health Organization, Geneva, 1984.

World Health Organization, *Trichloroethylene*, Environmental Health Criteria no. 50, World Health Organization, Geneva, 1985.