# GUIDANCE ON CONTROL OF EXPOSURES RELATED TO USE OF CARBON TETRACHLORIDE SOLVENT SUBSTITUTES IN INDUSTRIAL JEWELRY CASTING


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gtz PROKLIMA

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The reader is advised to confirm the product specifications and related health/environmental hazards prior to purchase or use of any of the solvents profiled. No claim is made here for the absolute suitability of any solvent as a substitute for CTC in any application. Suitability of a product or method of cleaning for a particular application would need to be verified through trials prior to any larger-scale application with due consideration of health and safety aspects.

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# PREFACE

Carbon Tetrachloride (CTC) is widely used as a solvent in many industrial sectors in India. It is an ozone depleting substance (ODS) similar to chlorofluorocarbons (CFCs). The UV-B and UV-C radiation coming from the sun interacts with CTC molecules that drift into the stratosphere and release their chlorine atoms. Each chlorine atom can destroy as many as 100,000 ozone molecules over a period of nearly 100 years. Thus, even a small amount of CTC released into the environment can cause tremendous damage to the ozone layer. Further, the global warming potential (GWP) of CTC has been estimated to be about 1,400 times higher than that of carbon dioxide ($CO_2$), the principal greenhouse gas. It is also hazardous to health via all routes of exposure viz., inhalation, ingestion and skin absorption. There is sufficient evidence of carcinogenicity in experimental animals with an increasing body of evidence for being a human carcinogen.

To protect the ozone layer, India is one of the 196 signatories to the Montreal Protocol for phasing out the production and consumption of ozone depleting substances. Under this agreement India has committed to phase-out the use of CTC solvent completely by 31st December 2009.

As the phase-out is progressing, CTC supplies in the market are dwindling rapidly. Beyond 31st December 2009 CTC will not be available for use as a solvent. Given the reduction of supply, the price of CTC has risen substantially making it costlier today, than most of its alternatives.

Within the framework of the Multilateral Fund of the Montreal Protocol, the Governments of Germany and France have mandated GTZ-Proklima to provide technical assistance to CTC consuming industries in India. In addition, World Bank, UNIDO and UNDP (on behalf of the Government of Japan) are assisting India, to address this issue specifically in industry sectors with large volumes of CTC use. These activities are coordinated under the National CTC Phase-out Plan by the World Bank as the leading implementing agency and the Ozone Cell of the Ministry of Environment and Forests, Government of India.

GTZ-Proklima offers technical assistance to industries using up to 10 metric tons of CTC per year. In close interaction with these industries, GTZ-Proklima aims to provide guidance in identifying CTC substitutes by addressing environmental, health and safety concerns without compromising on quality and cost effectiveness.

The Department of Environmental Health Engineering (DEHE), Sri Ramachandra University (SRU), Chennai (India) prepared a list of nearly 500 potentially hazardous substances that could be present in proprietary or non proprietary cleaning agents and provided the same to GTZ to enable comparisons across potential CTC substitutes. Moreover, initial assessments at different workplaces indicated the potential for occupational exposures to solvent vapours (from products currently being used as CTC substitutes). Building on these earlier efforts, the present exercise was aimed at conducting a systematic evaluation of exposures and identification of risks associated with selected CTC substitutes across a spectrum of few ***Jewelry Casting*** industries in order to provide specific recommendations for control against workplace exposures to the solvents used.

The approaches adopted for risk management in the project have a dual focus on "risk prevention" through substitution and "risk mitigation" through installation of workplace engineering controls and improving general work practices.

Recommendations presented in this manual have been largely based on walkthrough visits and analytical results of workplace exposure measurements. Participatory discussions involving employers and professional organizations were used to generate feasible toolkits that can be readily implemented. Since improved handling also minimizes emissions and exposures, this manual is expected to contribute not only in improving occupational health and safety at work, but also facilitate the implementation of the Montreal Protocol with added environmental protection benefits as well.

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# CONTENTS

# ABBREVIATIONS

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienist |
| AFFF | Aqueous Film-Forming Foam |
| CAS | Chemical Abstract Services |
| CFCs | Chlorofluorocarbons |
| CIM | Centre for International Migration |
| CTC | Carbon tetrachloride |
| EHS | Environment Health and Safety |
| GG | Spectacles/Goggles |
| GL | Gloves |
| GTZ | German Technical Cooperation |
| GWP | Global Warming Potential |
| LC50 | Lethal Concentration |
| LD50 | Lethal Dose |
| MSDS | Material Safety Data Sheet |
| NIOSH | National Institute for Occupational Safety and Health |
| ODS | Ozone Depleting Substance |
| OEL | Occupational Exposure Limits |
| OSHA | Occupational Safety and Health Administration |
| PCE | Perchloroethylene |
| PEL | Permissible Exposure Limits |
| PFTs | Pulmonary Function Tests |
| PLE | Permissible Limits of Exposure |
| PPEs | Personal Protective Equipments |
| R | Respirator |
| SRU | Sri Ramachandra University |
| STEL | Short Term Exposure Limit |
| TLV | Threshold Limit Value |
| TWA | Time Weighted Average |
| UNDP | United Nation Development Programme |
| UNIDO | United Nation Industrial Development Organization |

# LIST OF FIGURES, TABLES AND BOXES

# 1. INTRODUCTION

Jewelry manufacturing is a time consuming process and demands a lot of skill and patience to transform natural components such as stones, metals and accessories into beautiful jewelry pieces through multiple intervening manufacturing processes.

During the jewelry manufacturing process, a design is first created by casting wax replicas by injection molding. These replicas are called patterns. The patterns require finishing for removing flashes, dimensional inadequacies and parting lines. Solvents like CTC are used to carry out this finishing process. The patterns are attached to a central wax stick, called a sprue, to form a casting cluster or assembly. Then a shell is built by immersing the assembly in liquid ceramic slurry and subsequently into a bed of extremely fine sand. Once the ceramic is dry, the wax is melted out, creating a negative impression of the assembly within the shell. Liquefied metal is then poured into the container which is allowed to cool; after complete cooling, the casting is removed to retrieve the jewelry. Finally, it is polished to the highest level of smoothness.

With the most widely used solvent, CTC being an Ozone depleting substance (ODS), there is now a legal obligation to use alternative cleaning agents. This manual has been prepared to provide guidance on "safe use" of potential CTC substitutes on the basis of results of workplace exposure measurements, work practice assessments and the opinion and outcome of concerned stakeholder discussions. The suggested interventions thus are likely to be both feasible and effective on a sector-wide basis to reduce occupational health risks. However, occupational health risks covered in this manual need to be matched with environmental aspects as well as cleaning efficiency and costs acceptable to the industry before adopting a product "substitute". Separate guidance on environmental and safety aspects that are general to all sectors using CTC substitutes is available at www.ctc-phaseout.org to enable the same.

# 2. WORK PRACTICES RELATED TO USE OF SOLVENTS IN THE JEWELRY SECTOR

Finishing processes such as removal of flashes, dimensional inaccuracies, parting lines appearing on the patterns etc. are typically carried out using solvents like CTC, Toluene, Xylene and Perchloroethylene (PCE). Producing the same pattern in different sizes increases the cost of production tremendously and therefore, one standard pattern is modified to required sizes and subsequently finished by using solvents. Generally the finishing is carried out by brushing and wiping.

## 2.1. Brushing

In this method (**Figure 1**) the solvent is applied on the wax pattern using a soft brush to remove flashes, dimensional inaccuracies, parting lines etc. The work is usually carried out in the sitting position by holding the wax pattern in one hand and the brushing with the other hand. This process is performed in both air-conditioned or non air-conditioned work areas.

***Figure 1:*** Finishing of wax pattern by brushing

***Figure 2:*** Solvent evaporation from open container

## 2.2. Wiping

Wiping is also another method (**Figure 2**) of cleaning that is applied for finishing of wax patterns. Generally, a solvent soaked cotton swab is used to remove flashes, dimensional inaccuracies, parting lines etc from the wax patterns.

# 3. HAZARD IDENTIFICATION AND RISK ASSESSMENT

The exposure concentration likely to be achieved with individual solvents primarily depends on physical, chemical and toxic properties, specific nature of cleaning procedures, work posture, work and hygiene practices, maintenance of machines and the workplace environmental conditions such as temperature, humidity and ventilation.

A key step in risk assessment is to recognize the job-specific exposure hazards and the associated risks. This can be done by shop floor visits/walk-through assessments, review of documents, interview with workers and supervisors and qualitative / quantitative assessments of workplace and environmental conditions. Based on a combination of such assessment methods, the following **Table 1** identifies the job-hazard-risk profile for key processes in industrial jewelry casting.

**Table 1: Job-hazard-risk profile**

| Job | Process/Hazard | Risk |
|---|---|---|
| **Finishing of wax pattern**  | • Finishing of wax pattern by brushing.<br>• Solvent vapourization from open container.<br>• Spillage of solvent during filling of solvent in to the test tube or solvent container.  | • Absorption through lungs, skin and eye due to evaporation from spills and open containers; handling with bare hands and naked eyes.<br>• Additional exposure through lungs and eyes due to solvent splashing and vaporization. |

# 4. EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION

Exposure assessments that measure levels of solvent exposure under specific workplace conditions allow comparisons to be made with reference to the exposure standards. In order to capture alternative exposure conditions or wherever measurements are difficult to perform, exposures can also be simulated under laboratory conditions to estimate potential exposures that may be encountered in the workplaces. Such exercises in this sector have shown that Xylene, PCE and Toluene levels are constantly lower than the permissible limits of exposure. However, Toluene levels are marginally lower than the prescribed limits of exposure. By using required quantity of solvents for specific cleaning applications, exposure concentration is reduced significantly. **Box 1** emphasizes the level of reduction in exposure concentration that is achievable through use of optimum quantity of solvents.

**Box 1: Optimum use of solvent and percentage reduction in exposure concentration**.

**Around 20 to 30 percent reductions in exposure levels are achieved through optimum use of solvents.**

Results of hazard recognition and exposure assessments made at individual work locations in this sector were used to characterize risks and provide job specific recommendations for prevention and control of exposures as described in the sections below.

# 5. CONTROL GUIDANCE

Risk management involves application of a sequence of control measures to minimize the exposures. A typical hierarchy of controls involves hazard (i.e. solvent) substitution, engineering, administrative and personal protective measures. While exposures are central in arriving at a control strategy, often exposure reduction goals have to be matched with feasibilities based on worker preference, skills and attitudes of workers/management, workplace environmental conditions and cost of control measures.

The following sections provide general and process/work practice specific guidelines for the jewelry sector.

## 5.1. General Work Practice Guidelines

It is the employer's or the management's responsibility to provide guidance and instructions to workers on environment, health and safety (EHS) management. At the same time it is employees' responsibility to follow the instruction laid by the employer to create a healthier working environment. Although managements may have a policy that allocates resources for EHS management, it has to identify a responsible person to implement and supervise the EHS management programme. Simple generic guidelines are, therefore, separately provided for the supervisors/managers and workers to maintain minimum EHS standards. These guidelines are provided in **Tables 2** and **3**.

**Table 2: General Guidelines for Managers and Supervisors**

**Storage and Handling**

- Layout of storage facility should be planned at an early stage (Refer Figure 22 in the Part-I manual).
- Storage protocols should be prepared depending on the compatibility (Refer Figure 23 in the Part-I manual).
- MSDSs must be referred for chemical compatibility.
- In the event MSDSs are not available, information must be secured from the manufacturer/distributor.
- Adequate safety measures (First-aid, Firefighting equipments, emergency showers, PPEs etc.) must be provided in the storage facility.
- Safety equipment must be periodically checked for fit and performance.
- Safety sign boards specific to hazards must be provided and placed at required locations.
- Instructions on handling procedures must be provided to the workers.
- Expired chemicals must be returned to the manufacturer or disposed according to standard protocol.
- Empty containers must be returned immediately to the supplier or the manufacturer or disposed in a proper manner.

| Labeling | Cleanup | Personal hygiene |
|---|---|---|
| • Labels to be prepared in local language in accordance to MSDS.<br>• Label must contain key information (such as Flammability, Health Risks, etc.)<br>• Hazard symbols must be provided on the label.<br>• Caution words and statements (Danger, Toxic, Irritant, Corrosive etc.) for hazardous chemicals would need to be provided.<br>• Damaged or worn out labels must be replaced.<br>• Embossed labels can be requested from the manufacturer. | • Routine implementation of clean up schedule and procedures.<br>• Identification of a responsible and trained person for cleanup activities.<br>• Planning and implementation of periodical maintenance of equipments and accessories.<br>• Deployment of spill control procedures to prevent health and environmental risks.<br>• Provision of appropriate PPEs during cleanup of spills.<br>• Provisions of proper waste disposal protocols. | • Practice of good hygiene practice amongst the workers.<br>• Provision of hand washing facility with adequate soaps and detergents.<br>• Provision of a separate lunch room.<br>• Provision of adequate work cloths.<br>• Provision of shower stations. |

**Provision of training on**

- The availability and importance of MSDS.
- Obtaining MSDS from the manufacturer or competent sources (Government or Safety Agencies) in case of non availability.
- Informing the workers on the importance of MSDS.
- Procedures and protocol development for safe handling of chemicals.
- Managing emergency situations.
- Risk assessment and implementing control measures.
- Evaluation of the training programs conducted for workers.
- Selection of appropriate PPEs.
- Importance of medical fitness for wearing PPEs and selecting workers for providing PPE.

**Table 3: General Guidelines for Workers**

| Storage and Handling |
|---|
| • Follow storage and handling procedures.<br>• If safe handling procedures are not available, request your supervisor.<br>• Observe safety sign boards for recognizing the hazards.<br>• Handle any new chemicals in the presence of Manager/Supervisor at initial stage.<br>• Learn to use safety equipments.<br>• Use protective device while handling hazardous chemicals.<br>• Request for PPE if not available.<br>• Report any damage or inconsistency of safety equipments to the Manager/supervisor.<br>• Report if chemicals are used beyond expiry dates.<br>• Place back containers at designated location after use.<br>• Transport the containers in closed condition.<br>• Close the containers with air tight fittings to prevent spoiling of chemicals.<br>• Store drinking water separately away from the chemical store. |

| Labeling | Cleanup | Personal hygiene |
|---|---|---|
| • Request for label and label information in local language<br>• Read the label before using the chemicals.<br>• Care should be taken to prevent label damage while transferring, transporting and handling.<br>• Request to your manager/ supervisor for replacing the spoiled label. | • Remove dust, oils and dirt regularly from the machines and floors.<br>• Regularly clean up at end of the shift or end of the day.<br>• Report immediately about the spills to managers/supervisors.<br>• Request for MSDS/instructions in local language for spill cleanup.<br>• Immediately clean the spills according to the instructions and protocol.<br>• Wear appropriate PPEs during cleaning the spills. | • Wash hands before eating.<br>• Use soap for washing the hands.<br>• Avoid smoking and eating at workplaces.<br>• Avoid placing your fingers into mouth, ears and nose while handling chemicals.<br>• Trim the nails periodically to prevent chemical accumulation.<br>• Dress open wounds before handling the chemicals.<br>• Wear clean work clothes.<br>• Change work clothes before leaving the workplace.<br>• Have a shower at the end of the shift (to reduce the dermal exposures and minimize the transportation of the contaminants to home)<br>• Clearly mark the drinking water bottles and always keep them in a clean place. |

| Provision of training on |
|---|
| • Recognizing and understanding the hazardous nature and risk of using chemicals.<br>• Importance of material safety data sheet (MSDS)<br>• Good housekeeping procedures (Storage, handling, labeling and cleanup of chemicals).<br>• Handling the chemical spills and proper disposal methods.<br>• Managing emergency situations – using first-aid, handling fire extinguishers, communications (persons to be contacted, contact phone number) etc.<br>• Checking the functioning of pollution control systems.<br>• Incident or failure reporting systems.<br>• PPE - use, storage, cleaning and maintenance. |

## 5.2. Process Specific Guidelines

Although generic guidelines provide an overall framework to design and implement an EHS policy, often supervisors and managers require customized guidance that is specific for a particular work situation and process, which is provided in **Table 4** and **5**. Each main process concerned with solvent use is provided with a set of engineering, administrative and personal protective controls applicable specifically for the nature of hazards and risks associated with the job. The guidance sheet may thus be used as a ready reckoner for implementing facility-wise or location specific controls. Instruction for using the guidance sheet is provided in **Box 2**.

**Box 2: Instruction for reading the guidance sheet**

**For identifying job specific hazard, risk and control measures, read the guidance sheet from left to right across the row.**

It must be emphasized that the guidance sheets only provide information on "safe use" of specific solvents being used in each process. Selection amongst solvent substitutes is governed by considerations that often go beyond occupational exposures. On the basis of a limited set of exposure measurements, it has been observed that Xylene concentrations are always lower than PCE and Toluene. In general, it has been observed that PCE concentrations are the lower owning to its higher boiling point and higher specific gravity. However, in re circulated air conditioned environment or in non-ventilated spaces, PCE concentrations may build up over time creating more risks of exposure and is also reported to be a suspected carcinogen.

Therefore, facilities are encouraged to prioritize the selected solvent against conditions required for safe use in a larger EHS (environment, health and safety) framework in order to provide best work practice in the process or sector. The information related to safe use of the solvents is provided in **Tables 6** to **8**.

**Table 4: Job Specific Control Guidance Sheet**

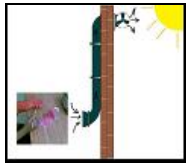
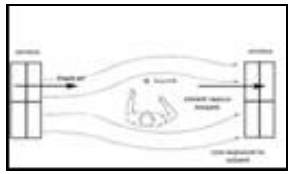
| Job | Hazard/Solvents | Risk/ Exposure Situation | Control Measures | | |
|---|---|---|---|---|---|
| | | | Engineering | Administrative | PPEs Refer Table 5 for PPE codes |
| Wax pattern finishing by brushing/wiping method  | • Xylene<br>• Perchloroethylene (PCE)<br>• Toluene | • Inhalation, dermal (skin) and eye contact due to splash from brushing operation<br>• Additional skin contact from not using gloves; inhalation exposure due to evaporation from open container and spills | **For Air conditioned environment:**<br>• Use LES if the ventilation air is re-circulated  <br>• Restrict sitting against the fan of AC unit<br>• Reduce fan speed to minimize the solvent vaporization in order to maintain comfort level<br>**For Non-air conditioned environment:**<br>• Finishing area should be well ventilated<br>• Select the work location near a window in accordance to the wind direction  <br>• Use mechanical ventilation like industrial or exhaust fan to dilute the vapours  <br>• If exhaust fan is not feasible use air filtering system to provide clean air | • Keep the container closed after use and during finishing<br>• Use optimum quantity of solvent<br>• Keep solvents away from ignition sources<br>• Prohibit smoking and place visual sign boards in the workplace to avoid fire hazard | **Gloves:**<br>Xylene: GL1<br>PCE: GL1<br>Toluene: GL2<br><br>A one inch cut can be made on fore finger and thumb of gloves to check the finish of wax pattern<br><br>**Spectacles:**<br>All Solvents: GG 1<br><br>• Use solvent resistant spectacle (power corrected if necessary)<br>• Not required if respirator (R2) is used<br><br>**Respirator:**<br>All solvents: Use R1 in absence of natural ventilation, LES, industrial and exhaust fan |

**Table 5: Codes and types of personal protective equipments**

| Sl. No | Code | Recommended protection | PPEs (Gloves/Goggles/Respirator) |
|---|---|---|---|
| 1 | GL1 | Nitrile latex gloves |  |
| 2 | GL 2 | 8 hr: PVA, Viton, | PVA  Viton  |
| **Sl. No** | **Code** | **Recommended protection** | **Spectacles** |
| 1 | GG 1 | Solvent resistant spectacle |  |
| **Sl. No** | **Code** | **Recommended protection** | **Respirator** |
| 1 | R1 | Half face respirator |  |
| 2 | R2 | Full face respirator |  |

*Source for selection of gloves: OSH Technical reference material, Department of Energy, USA and Chemical Protective Clothing, National Institute for Occupational Health and Safety (NIOSH), USA.*

## Table 6: Data Sheet for Xylene

| Toxic, Chemical and Physical properties | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Type** | **CAS number** | **$LD_{50}$ and $LC_{50}$** | **Boiling point** | **Vapour pressure** | **Specific gravity** | **Flash point** | **Flammability** | **Dipole moment** | **Solvency power (Hansen parameter)** |
| Aromatic hydrocarbon | (1330-20-7) | **ORAL (LD50): Acute:** 5000 mg/kg [Rat.]. **DERMAL (LD50): Acute:** 12400 mg/kg [Rabbit.]. **VAPOR (LC50): Acute:** 4550 ppm 4 hour(s) [Rat]. | 138$^0$C | 6-16 mm Hg | 0.86 g/cm3 | 38$^0$C | Flammable | 0.6 Debye(approx) | 18.0 |

| Health guidance | | | | | | |
|---|---|---|---|---|---|---|
| **Acute (Immediate) effects** | **Chronic (Delayed) effects** | **Target organ affected** | **Permissible limits of exposure** | | **First aid** | **Medical Surveillance** |
| | | | **STEL** | **TWA** | | |
| The substance irritates the eyes. Exposure far above the OEL may result in central nervous system depression, unconsciousness and death. | The liquid defats the skin. The substance may have effects on the central nervous system , resulting in decreased learning ability | Eyes, skin, respiratory system, central nervous system, gastrointestinal tract, blood, liver, kidneys | 150*<br>150***<br>150**** | 100*<br>100**<br>100***<br>100**** | Eye: Irrigate immediately<br>Skin: Water flush promptly<br>Breathing: Respiratory support<br>Swallow: Medical attention immediately | Complete Blood Count<br>Liver Function Tests<br>Testing Methyl hippuric acids in urine in the end of shift |

| Safety and environmental guidance | | | | |
|---|---|---|---|---|
| **Incompatible chemicals** | **Storage condition** | **Type of fire extinguisher** | **Spill control** | **Waste disposal** |
| Strong oxidizers, strong acids | Fireproof<br>Separate from strong oxidants | Powder, AFFF, foam, carbon dioxide | Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT let this chemical enter the environment | Waste must be disposed of in accordance with federal, state and local environmental control regulations |

**Table 7: Data Sheet for Perchloroethylene (PCE)**

| Toxic, Chemical and Physical properties | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Type** | **CAS number** | **$LD_{50}$ and $LC_{50}$** | **Boiling point** | **Vapour pressure** | **Specific gravity** | **Flash point** | **Flammability** | **Dipole moment** | **Solvency power (Hansen parameter)** |
| Chlorinated hydrocarbon | (127-18-4) | **ORAL (LD50):** **Acute:** 2629 mg/kg [Rat]. **DERMAL (LD): Acute:**>3228 mg/kg [Rabbit]. **MIST (LC50): Acute:** 34200 mg/m 8 hours [Rat]. **VAPOR (LC50): Acute:** 5200 ppm 4 hours [Mouse]. | $121^0$C | 14 mm Hg | 1.62 g/cm 3 | None | None | 0 Debye | 20.3 |

| Health guidance | | | | | | |
|---|---|---|---|---|---|---|
| **Acute (Immediate) effects** | **Chronic (Delayed) effects** | **Target organ affected** | **Permissible limits of exposure** | | **First aid** | **Medical Surveillance** |
| | | | **STEL** | **TWA** | | |
| The substance irritates the eyes, the skin and the respiratory tract. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the central nervous system. Exposure at high levels may result in unconsciousness | Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the liver and kidneys. This substance is probably carcinogenic to humans | Eyes, skin, respiratory system, liver, kidneys, central nervous system | 100**** | 100** 25**** | Eye: Irrigate immediately Skin: Water flush promptly Breathing: Respiratory support Swallow: Medical attention immediately | Testing tetrachloroethylene (PCE) content in end-exhaled air in prior to shift Testing tetrachloroethylene content in blood in prior to shift |

| Safety and environmental guidance | | | | |
|---|---|---|---|---|
| **Incompatible chemicals** | **Storage condition** | **Type of fire extinguisher** | **Spill control** | **Waste disposal** |
| Strong oxidizers; chemically-active metals such as lithium, beryllium & barium; caustic soda; sodium hydroxide; potash | Separate from metals See chemical dangers Keep away from food and feedstuffs Keep in the dark. Ventilate along the floor | In case of fire in the surroundings: all extinguishing agents allowed | Improve ventilation. Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT let this chemical enter the environment. (Extra personal protection: filter respirator for organic gases and vapours). | Waste must be disposed of in accordance with federal, state and local environmental control regulations |

**Table 8: Data Sheet for Toluene**

| Toxic, Chemical and Physical properties | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Type** | **CAS number** | **$LD_{50}$ and $LC_{50}$** | **Boiling point** | **Vapour pressure** | **Specific gravity** | **Flash point** | **Flammability** | **Dipole moment** | **Solvency power (Hansen parameter)** |
| Aromatic hydrocarbon | (108-88-3) | **ORAL (LD50):** **Acute:** 636 mg/kg [Rat]. **DERMAL (LD50):** Acute: 14100 mg/kg [Rabbit]. **VAPOR (LC50)**: Acute: 49000 mg/m 4 hours [Rat]. 440 ppm 24 hours [Mouse]. | 111$^0$C | 21 mm Hg | 0.87 g/cm 3 | 4-7$^0$C | Highly flammable | 0.3 Debye | 18.2 |

| Health guidance | | | | | | |
|---|---|---|---|---|---|---|
| **Acute (Immediate) effects** | **Chronic (Delayed) effects** | **Target organ affected** | **Permissible limits of exposure** | | **First aid** | **Medical Surveillance** |
| | | | **STEL** | **TWA** | | |
| The substance irritates the eyes and the respiratory tract. Exposure could cause central nervous system depression. Exposure at high levels may result in cardiac dysrhythmia, unconsciousness and death | Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system, resulting in decreased learning ability and psychological disorders. Animal tests show that this substance possibly causes toxic effects upon human reproduction | Eyes, skin, respiratory system, central nervous system, liver, kidneys | 150*<br>150*** | 100*<br>100**<br>100***<br>20**** | Eye: Irrigate immediately<br>Skin: Water flush promptly<br>Breathing: Respiratory support<br>Swallow: Medical attention immediately | Testing O-cresol content in urine or (Hippuric acid in urine) in end of the shift<br>Testing toluene content in blood in prior to last shift to workweek |

| Safety and environmental guidance | | | | |
|---|---|---|---|---|
| **Incompatible chemicals** | **Storage condition** | **Type of fire extinguisher** | **Spill control** | **Waste disposal** |
| Strong oxidizers | Fireproof<br>Separate from strong oxidants | Powder, AFFF, foam, carbon dioxide | Collect leaking liquid in sealable containers. Absorb remaining liquid in sand or inert absorbent and remove to safe place. Do NOT wash away into sewer (extra personal protection: self-contained breathing apparatus). | Waste must be disposed of in accordance with federal, state and local environmental control regulations |

* Permissible Limits of Exposure (PLE) prescribed by Indian Factories Act, 1948
** Permissible Exposure Limits (PEL) prescribed by Occupational Safety and Health Administration (OSHA), USA
*** Recommended Exposure Limit (REL) prescribed by National Institute for Occupational Safety and Health (NIOSH), USA
**** Threshold Limit Value (TLV) recommended by American Conference of Governmental Industrial Hygienists (ACGIH, 2008), USA