

GUIDANCE ON CONTROL OF EXPOSURES RELATED TO USE OF CARBON TETRACHLORIDE SOLVENT SUBSTITUTES IN THE TEXTILE SECTOR



Department of Environmental Health Engineering
Sri Ramachandra University
Porur, Chennai, Tamil Nadu, India

and

Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ) GmbH
(German Technical Cooperation), GTZ- Proklima
A-33 Gulmohar Park, New Delhi - 110 049, India



November 2009

**GUIDANCE ON CONTROL OF EXPOSURES RELATED TO USE OF
CARBON TETRACHLORIDE SOLVENT SUBSTITUTES IN THE
TEXTILE SECTOR**

Prepared by:

Department of Environmental Health Engineering (DEHE)

Sri Ramachandra University (SRU)

Porur, Chennai - 600 116

India

and

Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ) GmbH

(German Technical Cooperation), GTZ- Proklima

A-33 Gulmohar Park, New Delhi – 110 049

India

November 2009

Authors:

Sankar Sambandam, Krishnendu Mukhopadhyay, Ayyappan Ramalingam,
Chittaruvikkal John Mathew, Sona Mahajan and Kalpana Balakrishnan.

DISCLAIMER

Though all care has been taken to compile the information provided in this manual, DEHE-SRU and GTZ-Proklima accept no liability related to its contents. The findings represent results of research exercises and stakeholder discussions and are not intended as applicable under all possible circumstances.

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.

Information provided here does not constitute an endorsement or recommendation of any brand or product by DEHE- SRU and GTZ-Proklima.

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 (CO₂), 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 the 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 *Textile* 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.

ACKNOWLEDGEMENT

We sincerely acknowledge the contributions of Mr. Gopalaraman Swaminathan, Scientist, Central Leather Research Institute (CLRI), Chennai and Mr. Markus Wypior, Project Manager, GTZ-Proklima, for their invaluable inputs in design and implementation of the manual.

We are thankful to Dr. Ralf Steinberg, CIM expert, GTZ, Germany and Mr. Felix Nitz, Consultant GTZ-Proklima for their technical efforts and cooperation during the initial stage of the project.

We acknowledge the support of OASIS Garments, Karur; Praveen Finishers, Tirupur; and Sambandam Spinning Mill, Selam in Tamil Nadu, Rathi Textiles MIDC and Balaji Spinning Mills & Cotton Cording Industry, Solapur in Maharashtra and GoGo International, Bengaluru in Karnataka in granting us access to their facilities to execute the study.

We are grateful to all GTZ-Proklima consultants (sector focal points) for their assistance with conduct of work-place assessments and discussions with stakeholders.

We are also thankful to Premier Institute of Apparel Management Tirupur and M/S. Dew Point Appliances Pvt. Ltd., Bengaluru for providing the facilities and support for carrying out simulation measurements with alternative solvents under laboratory conditions.

CONTENTS

1. INTRODUCTION	9
2. WORK PRACTICES RELATED TO USE OF SOLVENTS IN THE TEXTILE SECTOR	10
2.1. Roller Cleaning	10
2.2. Stain removal in fabrics and garments.....	11
3. HAZARD IDENTIFICATION AND RISK ASSESSMENT.....	12
4. EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION	14
5. CONTROL GUIDANCE.....	15
5.1. General Work Practice Guidelines.....	15
5.2. Process Specific Guidelines	18

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
IPA	Isopropyl alcohol
LC50	Lethal Concentration
LD50	Lethal Dose
MDC	Methylene dichloride
MEK	Methyl ethyl ketone
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

FIGURES

- Figure 1 Cleaning of roller (assembled)
Figure 2 Cleaning of roller (dismantled)
Figure 3 Stain removal by fixed spray gun
Figure 4 Stain removal by portable spray gun

TABLES

- Table 1 Job-hazard-risk profile
Table 2 General guidelines for managers and supervisors
Table 3 General guidelines for workers
Table 4 Job specific control guidance sheet
Table 5 Codes and types of personal protective equipments
Table 6 Data sheet for Methyl ethyl ketone,
Table 7 Data sheet for Acetone
Table 8 Data sheet for n-Hexane,
Table 9 Data sheet for Methylene dichloride
Table 10 Data sheet for Perchloroethylene

BOXES

- Box 1 Optimum use of solvent and percent reduction in exposure concentration
Box 2 Instruction for reading the guidance sheet

1. INTRODUCTION

Textile industry is based upon the conversion of fibers into fabrics and other textile products. There are several processes such as rolling, spinning, weaving and finishing operations associated with textile industries. By mechanical methods, fibers are processed into yarns and are then woven, knit, or otherwise processed into fabric. The fabrics are dyed, printed, and/or finished into final goods. India has become a major textile outsourcing hub for the global market with composite mills and large integrated firms playing a major role.

Varieties of solvents used in the textile industries have specific chemical, physical, and biological properties with respect to health and safety aspects that warrant national attention for occupational and environmental health interventions. These solvents are usually applied to dissolve, degrease, clean or remove the stains in the fabrics. In few of these applications, CTC is still used in large number of industries.

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 TEXTILE SECTOR

Numerous operations are employed in the textile manufacturing; but only a few of these involve the use of solvents. Solvents are mainly used to remove oil, wax, grease, and lubrication fluids from equipment, prepare dye and printing inks. A large number of processes involve manual operations for cleaning the machine components or for stain removal in the finishing stage of the fabrics.

Generally, the cleaning method is selected based on the chemical and physical properties of solvents. The solvents which have good cleaning power for organic materials and have a low heat of evaporation are used in cold cleaning processes. The quantity of solvent consumed in the cleaning process varies depending on the individual operations.

In textile sector the use of CTC was identified mainly in roller cleaning and in stain removal process and therefore, this manual has been focused on the use of alternate solvents to CTC in these processes.

2.1. Roller Cleaning

CTC is usually used for cleaning the rollers to avoid accumulation of rolled up fibers on the cots/rollers (Lapping) due to deposits such as cotton wax, honeydew, cotton seed oil, humidity and fine dust. Cots and rollers used in spinning mills are in continuous contact with the fibre. Due to this contact, static electricity builds up on the surface of the cot. This also attracts fibre to the cot's surface which results in lapping. CTC is applied on the surface of cot/roller and wiped with a cloth to remove the contamination either in assembled condition (**Figure 1**) or in dismantled condition (**Figure 2**).



Figure 1: Cleaning of roller (assembled)



Figure 2: Cleaning of roller (dismantled)

2.2. Stain removal in fabrics and garments

During the weaving and allied manufacturing operations, the fabric passes through various machines that involve a lot of manual handling. Poor work practice causes spillage of sewing machine oil, lubricants and leads to stains on the final product. These stains are removed in the checking section of the finishing department. The solvent application for stain removal is done at a stationary work station with a fixed spray gun (**Figure 3**) or through a portable spray gun in an isolated location (**Figure 4**).



Figure 3: Stain removal by fixed spray gun








Figure 4: Stain removal by portable spray gun

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 the textile sector.

Table 1: Job-hazard-risk profile

Job	Process/Hazard	Risk
	<ul style="list-style-type: none"> • Cleaning of roller on machine. 	<ul style="list-style-type: none"> • Absorption through skin and lungs.
	<ul style="list-style-type: none"> • Cleaning of dismantled roller 	<ul style="list-style-type: none"> • Absorption through skin during wiping process. • Exposure via lungs due to solvent evaporation during cleaning process and from open container and waste cotton/rags kept nearby.
	<ul style="list-style-type: none"> • Rubber cot cleaning 	<ul style="list-style-type: none"> • Absorption through skin
	<ul style="list-style-type: none"> • Stain removal by automated stationary spray gun with suction device. 	<ul style="list-style-type: none"> • Absorption through skin, eye and lungs due to splash and vaporization of solvent.
	<ul style="list-style-type: none"> • Stain removal by portable spray gun 	<ul style="list-style-type: none"> • Exposure via lungs due to solvent evaporation from high pressure spray. • Additional exposure through lungs due to absence of suction device

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 while n-Hexane and MDC levels consistently exceed the permissible exposure limits in most of the cleaning processes, Acetone and MEK do not exceed the permissible exposure limits in most of the cleaning processes, IPA and PCE levels intermediate between MEK and n-Hexane. By using required quantity of solvents for specific cleaning applications, exposure concentrations are reduced significantly. **Box 1** emphasizes the level of reduction in exposure concentration achievable through use of optimal 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 textile sector.

5.1. General Work Practice Guidelines

It is the employer or the managements' responsibility to provide guidance and instructions to workers on environment, health and safety (EHS) management. At the same time it is employees' responsibilities 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		
<ul style="list-style-type: none"> • 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 fitness and performance. • Safety sign boards specific to hazards must be provided and placed at appropriate 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
<ul style="list-style-type: none"> • Labels to be prepared in local language in accordance to MSDS. • Label must contain key information (such as Flammability, Health Risks, etc.) • Hazard symbols must be provided on the label. • Caution words and statements (Danger, Toxic, Irritant, Corrosive etc.) for hazardous chemicals need to be provided. • Damaged or worn out labels must be replaced. • Embossed labels can be requested from the manufacturer. 	<ul style="list-style-type: none"> • Routine implementation of clean up schedule and procedures. • Identification of a responsible and trained person for cleanup activities. • Planning and implementation of periodical maintenance of equipments and accessories. • Deployment of spill control procedures to prevent health and environmental risks. • Provision of appropriate PPEs during cleanup of spills. • Provisions of proper waste disposal protocols. 	<ul style="list-style-type: none"> • Practice of good hygiene practice amongst the workers. • Provision of hand washing facility with adequate soaps and detergents. • Provision of a separate lunch room. • Provision of adequate work cloths. • Provision of shower stations.
Provision of training on		
<ul style="list-style-type: none"> • 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		
<ul style="list-style-type: none"> • Follow storage and handling procedures. • If safe handling procedures are not available, request your supervisor. • Observe safety sign boards for recognizing the hazards. • Handle any new chemicals in the presence of Manager/Supervisor at initial stage. • Learn to use safety equipments. • Use protective device while handling hazardous chemicals. • Request for PPE if not available. • Report any damage or inconsistency of safety equipments to the Manager/supervisor. • Report if chemicals are used beyond expiry dates. • Place back containers at designated location after use. • Transport the containers in closed condition. • Close the containers with air tight fittings to prevent spoiling of chemicals. • Store drinking water separately away from the chemical store. 		
Labeling	Cleanup	Personal hygiene
<ul style="list-style-type: none"> • Request for label and label information in local language • Read the label before using the chemicals. • Care should be taken to prevent label damage while transferring, transporting and handling. • Request to your manager/ supervisor for replacing the damaged label. 	<ul style="list-style-type: none"> • Remove dust, oils and dirt regularly from the machines and floors. • Regularly clean up at end of the shift or end of the day. • Report immediately about the spills to managers/supervisors. • Request for MSDS/instructions in local language for spill cleanup. • Immediately clean the spills according to the instructions and protocol. • Wear appropriate PPEs during cleaning the spills. 	<ul style="list-style-type: none"> • Wash hands before eating. • Use soap for washing the hands. • Avoid smoking and eating at workplaces. • Avoid placing your fingers into mouth, ears and nose while handling chemicals. • Trim the nails periodically to prevent chemical accumulation. • Dress open wounds before handling the chemicals. • Wear clean work clothes. • Change work clothes before leaving the workplace. • Have a shower at the end of the shift (to reduce the dermal exposures and minimize the transportation of the contaminants to home) • Clearly mark the drinking water bottles and always keep them a clean place.
Provision of training on		
<ul style="list-style-type: none"> • Recognizing and understanding the hazardous nature and risk of using chemicals. • Importance of material safety data sheet (MSDS) • Good housekeeping procedures (Storage, handling, labeling and cleanup of chemicals). • Handling the chemical spills and proper disposal methods. • Managing emergency situations – using first-aid, handling fire extinguishers, communications (persons to be contacted, contact phone number) etc. • Checking the functioning of pollution control systems. • Incident or failure reporting systems. • 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 **Tables 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**.



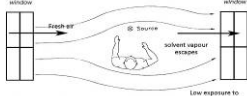


Box 2: Instruction for reading the guidance sheet

**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 in general PCE concentration is moderately lower for short duration process carried out in well ventilated environment. However, in non-ventilated spaces, PCE concentrations may build up over time creating more risks of exposure. The concentrations of MDC consistently exceed the prescribed exposure limits in both ventilated and non ventilated environment. PCE and MDC are reported as suspected carcinogens while the evidence is stronger for PCE.

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 **11**.

Table 4: Job Specific Control Guidance Sheet

Job	Hazards/ Solvents	Risk/ Exposure Situation	Control Measures		
			Engineering	Administrative	PPEs
<p>Cleaning in assembled condition</p>  <p>Cleaning in dismantled condition</p> 	<ul style="list-style-type: none"> • MEK • IPA • n-Hexane 	<p>Inhalation, dermal (skin) and eye contact due to cleaning with bare hands, naked eyes, evaporation from spills, open containers and disposed waste cotton within workplace and in inadequate ventilation.</p>	<ul style="list-style-type: none"> • Select the work location near a window in accordance to the wind direction. • Cleaning area should be well ventilated.  <ul style="list-style-type: none"> • Use mechanical ventilation like local exhaust with flexible duct to dilute solvent vapour in the absence of cross ventilation 	<ul style="list-style-type: none"> • Use optimum quantity of solvent. • Transfer the solvent into small container using funnel to avoid spillage and splash. • Close the container after use. • Do not dip the cotton directly into the container to avoid skin contact. • Treat solvent soaked cotton as hazardous waste. • Remove the spills immediately. • Keep solvents away from ignition sources 	<p>Gloves: MEK: GL 2 IPA: GL 3 n-Hexane: GL 5</p> <p>Goggles/ Spectacles: MEK : GG 1 IPA : GG 1 n-Hexane : GG 2</p> <p>Use power corrected spectacle and goggle if necessary</p>
<p>Cleaning of rubber cot</p> 	<ul style="list-style-type: none"> • IPA • n-Hexane • MDC 	<p>Skin and eye contact due to working with bare hands and naked eye respectively.</p>	<ul style="list-style-type: none"> • Select the work location near a window in accordance to the wind direction. • Cleaning area should be well ventilated. 	<ul style="list-style-type: none"> • Prohibit smoking and place visual sign boards in the workplace to avoid fire hazard 	<p>Gloves: IPA: GL 3 n-Hexane: GL 5 MDC: GL 6</p> <p>Goggles/Spectacles: IPA: GG 1 n-Hexane: GG 2 MDC: GG 2</p>



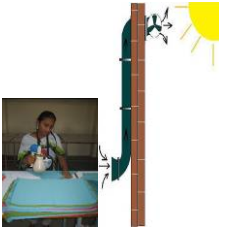












Job	Hazards/ Solvents	Risk/ Exposure Situation	Control Measures		
			Engineering	Administrative	PPEs
Stain removal using fixed spray gun 	<ul style="list-style-type: none"> • Acetone • MEK • IPA • PCE • n-Hexane • MDC 	<p>Lung exposure due to high concentration of solvent vapour in inadequate ventilation condition.</p> <p>Skin and eye contact due to solvent splash and vapour clouds deposition during spraying with bare hands, and naked eyes respectively.</p>	<p>Process isolation: For small units with minimum workload, an isolated and enclosed area along with good ventilation is essential.</p> <p>Suction device: Use the paddle operated suction device to minimize vapour cloud at breathing zone with periodical maintenance.</p>	<ul style="list-style-type: none"> • Avoid spillage of solvent during cleaning. • Optimize the solvent use during spraying process 	<p>Gloves: Acetone: GL 1 MEK: GL 2 IPA: GL 3 PCE: GL 4 n-Hexane: GL 5 MDC: GL 6</p> <p>Goggles/ Spectacles: Acetone: GG 1 MEK: GG 1 IPA: GG 1 PCE: GG 1 n-Hexane: GG 2 MDC : GG 2</p> <p>Respirator: Use R1 if the suction device is not functioning</p>
Stain removal using portable spray gun 	<ul style="list-style-type: none"> • Acetone • MEK • IPA • PCE • n-Hexane • MDC 	<p>Skin and eye contact due to solvent splash and vapour clouds deposition during spraying with bare hands, and naked eyes respectively.</p>	<ul style="list-style-type: none"> • Install Local Exhaust System (LES) for single workstation job. • Ensure the mouth of the duct is positioned near the spraying zone.  <ul style="list-style-type: none"> • For multiple work stations install centralized local exhaust system. 	<ul style="list-style-type: none"> • Provide eye washing bottles or eye cup (E1 or E2) to deal with splash. 	<p>Gloves: Acetone: GL 1 MEK: GL 2 IPA: GL 3 PCE: GL 4 n-Hexane: GL 5 MDC: GL 6</p> <p>In addition to gloves, use CPC1 and R1 in the absence of LES</p> <p>Goggles/ Spectacles: GG 2 for all solvents Use power corrected goggle if necessary</p> <p>Not required if R1 is used</p>

Table 5: Codes and types of personal protective equipments

Sl. No	Code	Recommended protection	PPEs (Gloves/Goggles/Respirator)
1	GL 1	8 hr: Butyl/ latex or rubber gloves	Butyl Latex or Rubber 
2	GL 2	Butyl gloves	Butyl 
3	GL 3	8 hr: Butyl, Nitrile, Viton	Butyl Nitrile Viton 
4	GL 4	Nitrile latex gloves	
5	GL 5	8 hr: Nitrile, PVA, Viton,	Nitrile PVA Viton 
6	GL 6	8 hr: PVA, PE/EVAL, Responder, Trelchem, Tychem 4 hr: Teflon, Barricade	PVA 

Sl. No	Code	Recommended protection	Spectacles/Goggles
1	GG 1	Solvent resistant spectacle	
2	GG2	Solvent resistant goggle	
3	CPC1	Chemical protective clothing (Refer GL1 to GL 6 for type of material)	
Sl. No	Code	Recommended protection	Respirator
1	R1	Full face respirator	
Sl. No	Code	Recommended protection	Other safety equipment
1	E1	Eye washing bottle	
2	E2	Eye cup	

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 Acetone

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)
Ketone	(67-64-1)	ORAL (LD50): Acute: 5800 mg/kg [Rat]. 3000 mg/kg [Mouse]. 5340 mg/kg [Rabbit]. VAPOR (LC50): Acute: 50100 mg/m ³ - 8 hours [Rat]. 44000 mg/m ³ - 4 hours [Mouse].	56 °C	180 mm Hg	0.79 g/cm ³	-20 °C	Highly flammable	2.9 Debye	20.0
Health guidance									
Acute (Immediate) effects	Chronic (Delayed) effects	Target organ affected	Permissible limits of exposure		First aid	Medical Surveillance			
			STEL	TWA					
Irritation of eyes and the respiratory tract and may cause effects on the central nervous system, liver, kidneys and gastrointestinal tract.	Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the blood and bone marrow.	Eyes, skin, respiratory system, central nervous system	1000* 750****	750* 1000** 250*** 500****	Eye: Irrigate immediately Skin: Soap wash immediately Breathing: Respiratory support Swallow: Medical attention immediately	Testing whole blood for acetone at the end of the shift Testing expired air for acetone at the end of the shift Pulmonary Function Tests (PFTs) Testing urine for acetone at the end of the shift			
Safety and environmental guidance									
Incompatible chemicals	Storage condition	Type of fire extinguisher	Spill control			Waste disposal			
Oxidizers, acids	Fireproof Separate from strong oxidants	Powder, alcohol-resistant foam, water in large amounts, carbon dioxide	Improve ventilation. 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. Then wash away with plenty of water (extra personal protection: self-contained breathing apparatus)			Waste must be disposed of in accordance with federal, state and local environmental control regulations			

Table 7: Data Sheet for Methyl Ethyl Ketone (MEK)

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)
Ketone	(78-93-3)	ORAL (LD50): Acute: 2737 mg/kg [Rat]. 4050 mg/kg [Mouse]. DERMAL (LD50): Acute: 6480 mg/kg [Rabbit]. VAPOR (LC50): Acute: 23500 mg/m 8 hours [Rat]	79°C	78 mm Hg	0.81 g/cm ³	-9°C	Highly flammable	208Debye	19.0
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 and the respiratory tract. The substance may cause effects on the central nervous system. Exposure far above the OEL may result in unconsciousness	The liquid defats the skin. Animal tests show that this substance possibly causes toxic effects upon human reproduction	Eyes, skin, respiratory system, central nervous system	300*** 300****	200** 200*** 200****	Eye: Irrigate immediately Skin: Water wash immediately Breathing: Fresh air Swallow: Medical attention immediately	Pulmonary Function Tests Testing urine for Methyl Ethyl Ketone in the end of the shift			
Safety and environmental guidance									
Incompatible chemicals	Storage condition	Type of fire extinguisher	Spill control			Waste disposal			
Strong oxidizers, amines, ammonia, inorganic acids, caustics, isocyanates, pyridines	Fireproof Separate from strong oxidants, strong acids. Keep the storage area and container well closed; Cool	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 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			

Table 8: Data Sheet for Isopropyl Alcohol (IPA)

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)
Secondary Alcohol	(67-63-0)	ORAL (LD50): Acute: 5045 mg/kg [Rat]. 3600 mg/kg [Mouse]. 6410 mg/kg [Rabbit]. DERMAL (LD50): Acute: 12800 mg/kg [Rabbit].	82°C	33 mm Hg	0.79 g/cm ³	12. °C	Highly flammable	1.7Debye	23.5
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. The substance may cause effects on the central nervous system, resulting in depression. Exposure far above the OEL may result in unconsciousness	The liquid defats the skin	Eyes, skin, respiratory system	500*** 200****	400** 400*** 400****	Eye: Irrigate immediately Skin: Water flush Breathing: Respiratory support Swallow: Medical attention immediately	Testing whole blood, expired air and urine for IPA or for the metabolites			
Safety and environmental guidance									
Incompatible chemicals	Storage condition	Type of fire extinguisher	Spill control			Waste disposal			
Strong oxidizers, acetaldehyde, chlorine, ethylene oxide, acids, isocyanates	Fireproof Separate from strong oxidants. Keep the storage area and container well closed; Cool	Powder, alcohol-resistant foam, water in large amounts, carbon dioxide	Collect leaking liquid in sealable containers. Absorb remaining liquid in sand or inert absorbent and remove to safe place. (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 9: 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°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 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 10: Data Sheet for n-Hexane

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)
Hydrocarbon alkane	(110-54-3)	LD ₅₀ - Skin >2 gm/kg rabbit; LD ₅₀ -oral >5 gm/kg rat LC ₅₀ - inhalation >3367 ppm - rat;	63.70 ^o C	124 mm Hg	0.69 g/cm ³	-23 °C	Highly flammable	0 Debye	14.9
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 skin. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. Exposure at high levels could cause lowering of consciousness	Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system peripheral nervous system, resulting in polyneuropathy. Animal tests show that this substance possibly causes toxic effects upon human reproduction	Eyes, skin, respiratory system, central nervous system, peripheral nervous system		500** 50*** 50****	Eye: Irrigate immediately Skin: Soap wash immediately Breathing: Respiratory support Swallow: Medical attention immediately	Testing urine for 2,5-hexanedion in the end of shift at end of workweek			
Safety and environmental guidance									
Incompatible chemicals	Storage condition	Type of fire extinguisher	Spill control			Waste disposal			
Strong oxidizers	Fireproof Separate from strong oxidants Keep the storage area and container well closed	Powder, AFFF, foam, carbon dioxide	Consult an expert. Remove all ignition sources. 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 wash away into sewer. 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 11: Data Sheet for Methylene Chloride

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	(75-09-2)	ORAL (LD50): Acute: 1600 mg/kg [Rat].	40°C	350mm Hg	1.33 g/cm ³	NONE	None	1.6 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. Exposure could cause lowering of consciousness. Exposure could cause formation of carboxyhaemoglobin	Repeated or prolonged contact with skin may cause dermatitis. The substance may have effects on the central nervous system liver This substance is possibly carcinogenic to humans	Eyes, skin, cardiovascular system, central nervous system	125**	25** 50****	Eye: Irrigate immediately Skin: Soap wash promptly Breathing: Respiratory support Swallow: Medical attention immediately	Testing urine for dichloromethane (MDC) in the end of the shift			
Safety and environmental guidance									
Incompatible chemicals	Storage condition	Type of fire extinguisher	Spill control			Waste disposal			
Strong oxidizers; caustics; chemically-active metals such as aluminum, magnesium powders, potassium & sodium; concentrated nitric acid	Separate from metals See chemical dangers food and feedstuffs Keep the storage area cool 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. (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			

* 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