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




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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 ***Offset Printing*** 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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We acknowledge the cooperation from Print India, Bengaluru and Choose Graphics, Chennai in granting us access to their facilities to execute the study.

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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
IPA	Isopropyl alcohol
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
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
TCE	Trichloroethylene
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

Offset printing has become a very popular method with nearly 40% of all printing jobs being performed with this technique. Offset printing is widely followed because of the rapid advances in the quality of paper, inks, and plates, used for the job. This has led to fast execution of high volume jobs, high quality printing, and improvements in the stability of printing plates. Offset printing is commonly used for newspapers, books periodicals and other reading materials and also in the packaging industry for consumer goods.

Many types of paste inks are employed in offset printing and each one is used somewhat differently. Examples include heat-set, cold-set, and energy-curable (or EC), such as ultraviolet (or UV) curable, and electron beam (or EB) curable inks. In this industry, chemicals are used to clean the ink deposits on the sheets, films, plates etc. Historically, acid based solutions were used for this purpose and later replaced by alkaline solutions. In recent times, these have been replaced with solvents due for several reasons ranging from perceived health hazards to objectionable odour and cost of previous methods.

The offset printing industry uses CTC mainly to clean the films and astrollen sheets. CTC is also found to be of use in reviving and cleaning of blanket rollers, cleaning of scanner drums, machines used for exposure, binding and lamination. Ink residues and dust accumulate onto the films due to improper handling and storage. Cellotapes used for mounting the film also leave residues on the astrollen sheet. All these stains could affect the final quality of the print and are, therefore, removed.

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 OFFSET PRINTING SECTOR

White Petrol, n-Hexane and Isopropyl Alcohol are the most widely used solvents for cleaning the astrollen sheets:

2.1. Cleaning of astrollen sheet

It is common to find solvents being directly used from inappropriate containers which results in surplus use and spillage of solvent. The solvent are decanted on to a cotton swab, and the contaminants on the sheet are removed by wiping. The solvent container is kept open throughout the cleaning process (**Figure 1**).

Figure 1: Cleaning of astrollen sheet by wiping

2.2. Cleaning of glass sheet

After each process, the glass sheets are cleaned by wiping using a cotton swab. Usually, two individuals are involved in cleaning process, with one worker holding the glass sheet and the other engaging in cleaning the sheet (**Figure 2**).

Figure 2: Cleaning of glass sheet

2.3. Ventilation conditions

Almost always the cleaning processes seem to be performed under poor ventilation conditions, for e.g. in front of the wall (**Figure 3**). This leads to trapping of solvent vapours and accumulation of the same resulting in high solvent exposures.

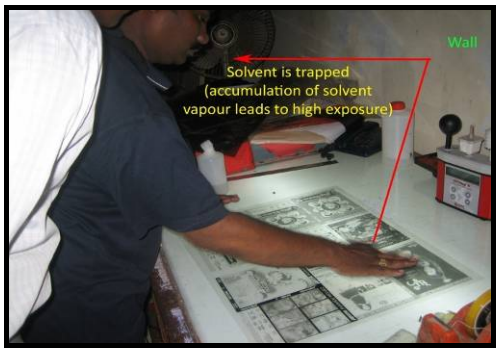


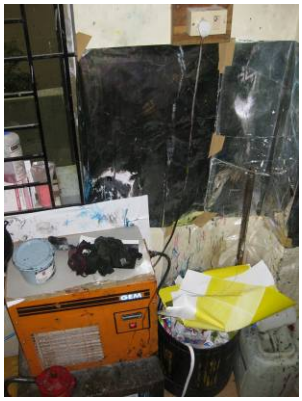
Figure 3: Cleaning of astrollen sheet in confined space

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 offset printing sector.

Table 1: Job-hazard-risk profile

Job	Process/Hazard	Risk
Cleaning of Astrollen Sheet 	• Cleaning of dust, inks and cello tape residues by wiping.	• Absorption through skin from direct contact with solvent soaked cotton. • Exposure via lungs due to solvent evaporation from cleaning process and open container.
Cleaning of glass sheet 	• Cleaning of glass sheet by wiping.	• Absorption through skin from direct contact with solvent soaked cotton. • Exposure via lungs and eyes due to solvent vaporization. • Enhanced lung absorption through excessive inhalation of trapped solvents and poor body posture.
Cleaning of Rollers 	• Cleaning of paint pigments by wiping.	• Absorption through skin from direct contact with cotton soaked solvent. • Exposure via lungs and eyes due to solvent vaporization.
Disposal of cotton waste 	• Disposing and storing cotton waste within the workplace	• Exposure via lungs due to solvent evaporation from used cotton waste when stored in open container within the work place. • Risk of fire at the place of cotton waste disposal due to storage of cotton waste near the electrical equipments and solvent container.

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 levels consistently exceed the permissible exposure limits in most of the cleaning processes, IPA levels are usually lower than the permissible limits. 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 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 offset printing 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 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
• 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.	• 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.	• 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

- 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.
- 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
• 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.	• 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.	• 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

- 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. This is provided in **Table 4** and **5** below. 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**.

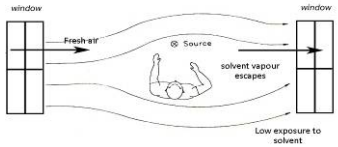
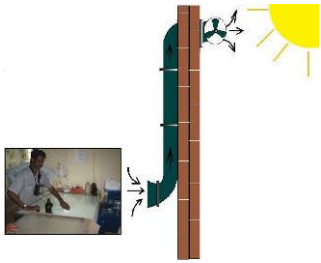
Box 2: Instruction for reading the guidance sheet

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, exposure concentration of IPA is lower than n-Hexane. The same trend has been observed during cleaning of astrollen sheets, rollers and glass sheets by wiping process. The exposure concentration of n-hexane is found to be higher than TLV-TWA but lower than the PEL value. Whereas for IPA, both TLV-TWA and PEL values are lower than the permissible limits.

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** and **7**.

Table 4: Job Specific Control Guidance Sheet

Job	Hazards/ Solvents	Risk/ Exposure Situation	Control Measures		
			Engineering	Administrative	PPEs
Cleaning of Astrollen Sheet 	• Isopropyl Alcohol (IPA) • n-Hexane	Inhalation, dermal (skin) and eye contact due to cleaning with bare hand, naked eyes; evaporation from spills; inadequate ventilation and  Open/partially closed containers  	• Cleaning area should be well ventilated. • Select the work location near a window in accordance to the wind direction.  • Use mechanical ventilation like exhaust fan  Or local exhaust system to dilute the solvent vapour. 	• Use optimum quantity of solvent. • Transfer the solvent into small container using funnel to avoid spillage and splash. • Close the container after use.  • • Restrict the presence of coworkers nearby, during the cleaning process. • Avoid dipping the cotton directly into the container to avoid skin contact and solvent contamination. • Treat solvent soaked cotton as hazardous waste. • Collect the solvent soaked cotton wastes in a bin with lid.  • Then follow proper disposal procedures. • Keep solvents away from ignition sources. • Remove the spills immediately. • Prohibit smoking and place visual sign boards in the workplace to avoid fire hazard.	**Gloves:** IPA: GL 1 n-Hexane: GL 2 **Spectacles:** GG1 Use power corrected Spectacles with side shields

Job	Hazards/ Solvents	Risk/ Exposure Situation	Control Measures		
			Engineering	Administrative	PPEs
Cleaning of Rollers 		Inhalation, dermal (skin) and eye contact due to cleaning with bare hand, naked eyes; solvent evaporation from wiping; poor ventilation (re-circulated air)in case of air conditioned environment and open/partially closed containers	**For non air conditioned environment.** • Use local exhaust system to dilute the solvent vapour.  **For air conditioned environment.** • Connect a flexible duct to the air conditioning exhaust during cleaning and keep close to roller. • Avoid re circulating cool air for long duration. Vent out the cool air periodically by exchanging fresh air.	• Collect the solvent soaked cotton wastes in a bin with lid.  • Then follow proper disposal procedures. • Keep solvents away from ignition sources. • Remove the spills immediately. • Prohibit smoking and place visual sign boards in the workplace to avoid fire hazard. • Rotate the workers for cleaning process, not more than four times in a day for each worker.	**Goggles:** GG2 Use power corrected goggle if necessary Not required if R1 is used **Respirator:** Use R1in the absence of LES. Check with manufacturer for appropriate chemical cartridge.

Job	Hazards/ Solvents	Risk/ Exposure Situation	Control Measures		
			Engineering	Administrative	PPEs
Cleaning of Glass sheet 		Inhalation, dermal (skin) and eye contact due to cleaning with bare hand, naked eyes, and working in confined space.	• Local exhaust system with flexible duct.  • Use a mechanical device (pole) to hold the glass sheet to avoid exposure of co-worker during cleaning.	• Restrict the presence of coworkers nearby, during the cleaning process. • Handle the solvent safely by using PPE. • Collect the solvent soaked cotton wastes in a bin with lid.  • Treat solvent soaked cotton as hazardous waste and dispose in proper manner.	**Goggles:** GG2 Use power corrected goggle if necessary Not required if R1 is used **Respirator:** Use R1in the absence of LES. Check with manufacturer for appropriate chemical cartridge.
	Fire hazard 	Risk of fire due to storage of solvent soaked cotton waste near the electrical equipments and solvent containers		• Store the cotton waste away from the fire sources. • Dispose the cotton waste in safe manner and according to standard protocol. • Solvents should be stored in separate storage area. • Keep the electrical equipment away from the solvent container and waste cotton bin.	**Firefighting equipment** Class B and C firefighting equipment (refer Part I manual).

Table 5: Codes and types of personal protective equipments

Sl. No	Code	Recommended protection	PPEs (Gloves/Goggles/Respirator)
1	GL 1	8 hr: Butyl, Nitrile, Viton	Butyl Nitrile Viton 
2	GL 2	8 hr: Nitrile, PVA, Viton,	Nitrile PVA Viton 
Sl. No	**Code**	**Recommended protection**	**Spectacles / Goggles**
1	GG 1	Solvent resistant spectacle	
2	GG2	Solvent resistant goggle	
Sl. No	**Code**	**Recommended protection**	**Respirator**
1	R1	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 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].	82^0C	33 mm Hg	0.79 g/cm^3	12^0C	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 7: Data Sheet for 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)	**LD50 – Skin** >2 gm/kg rabbit; **LD50 -oral** >5 gm/kg rat LC50 – **inhalation** >3367 ppm - rat;	63.70^0 C	124 mm Hg	0.69 g/cm 3	-23 ^{0}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	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

* 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