National CTC Phase-out Plan

Selection and safe use of alternatives to CTC

gtz PROKLIMA

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The reader is advised to confirm specifications and health hazards prior to purchase or use of any substance profiled. No claim is made here in respect of the suitability of any solvent as substitute for CTC in any application. Suitability of a product for a particular application requires to be verified through trials prior to any larger-scale application with due consideration of health and safety aspects.

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Table of Contents

1 The Phase-out of CTC

1.1 About CTC

Carbon tetrachloride (CTC) is a solvent and cleaning agent used widely across many industry segments. Its high solvency power, low cost and the fact that it is non-flammable made it popular in many cleaning applications.

Although CTC is very popular, it is an ozone depleting substance (ODS) like chlorofluorocarbons (CFCs). It destroys the stratospheric ozone layer which protects life on our planet from harmful ultraviolet-B (UV-B) rays. It increases the incidence of skin cancer, eye cataract, suppresses the human immune system, reduces crop yields and affects aquatic life. Another adverse impact of CTC is its contribution to global warming. The global warming potential (GWP) of CTC is about 1,400 times higher than that of carbon dioxide (CO_2), the primary greenhouse gas.

At the workplace CTC is an occupational health hazard. CTC is very toxic and is absorbed by the skin and also in the gastrointestinal and respiratory systems. CTC affects the central nervous system (CNS) severely, causing headache, weakness, drowsiness, nausea and vomiting. Inhalation of high levels can permanently damage the liver and kidneys. The severity of the effects depends on the route and frequency of exposure. CTC is proven to cause cancer in animals and is a suspected human carcinogen.

1.2 The Montreal Protocol

To protect the ozone layer, India, along with more than 190 countries has signed the Montreal Protocol to phase out production and consumption of CTC and other ozone depleting substances. Under this agreement India has committed to phase-out the use of CTC as a 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 solvent uses. Given the reduction of supply, the price of CTC has risen substantially making it costlier today than most of its alternatives.

1.3 Role of GTZ-Proklima

For enterprises there is an urgent need to substitute CTC now. But finding suitable alternatives, especially safer ones, is not an easy task. There is no single alternative which can replace CTC in all its applications and in the absence of sufficient information enterprises may substitute CTC with an even more hazardous substance such as Trichloroethylene or Benzene.

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 the Indian textiles and metal cleaning sectors. In addition World Bank, UNIDO and UNDP (on behalf of the Government of Japan) are assisting the country in specific industry sectors with large usage of CTC. These activities are coordinated under the National CTC Phase-out Plan by the World Bank as the lead 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 or 6,250 litres of CTC per year. In close interaction with affected industries, GTZ-Proklima aims to provide competent guidance in identifying CTC substitutes by addressing environmental, health and safety concerns without compromising on quality and cost effectiveness.

GTZ-Proklima maintains strict independence from any branded or proprietary product.

2.1 Selection criteria

No alternative is ideal in all respects; each one has certain advantages and disadvantages.

In order to address environmental, health and safety concerns without compromising on quality and cost effectiveness, any substitute for CTC should meet the following criteria in terms of priority:

- Non-ozone-depleting substance (non-ODS)
- Non-carcinogenic
- Low toxicity
- Non-flammable or low flammability
- Good cleaning efficacy
- Compatible with substrate material (e.g. non-corrosive, non- abrasive)
- Not leaving any residue
- Equal or lower cost compared to CTC
- Locally available
- Can be disposed off easily

2.2 Viable alternatives

Based on the selection criteria presented above, GTZ-Proklima identified a range of alternatives for varied applications, some of which are already in common use by industries. Their suitability has been evaluated in the laboratory or confirmed through industrial trials.

Selection has to be based on the work environment, the individual cleaning practices and the ambient temperature. For example, Methylene dichloride has good solvency power but evaporates very fast due to its low boiling point (40°C) and thus may not be an economical option in warmer climates.

Solvents like Hexane, Toluene and White Petrol are highly flammable and must be used with due precautions to minimise fire risk. If a single solvent does not meet the criterion of stain/soil removal, a mixture/blend could be the solution.

Though Trichloroethylene (TCE) has good cleaning properties and is used by many enterprises, its usage is strongly discouraged because of its inherent cancer risk.

The most relevant properties for selecting appropriate alternatives to CTC are:

- Flash Point
- Boiling Point
- Vapour Pressure
- Dipole Moment
- Hansen Solubility Parameter

Flash point

The flash point (in °C) is the lowest temperature at which a flammable solvent can form an ignitable mixture with air. As a rule of thumb, the higher the flash point temperature the lower is the fire hazard risk. Non-flammable solvents do not have a flash point.

Boiling point

The boiling point (in °C) is the temperature at which the liquid will start boiling. A lower boiling point means higher losses of solvent into the atmosphere.

Vapour pressure

Vapour pressure (in mm Hg) is an indicator for the rate of evaporation under atmospheric conditions. The higher the value the faster the solvent evaporates. If the substance is stored in an open container it can also be considered as a measure of evaporation losses.

Dipole Moment

Dipole moment (in Debye) is a measure of the polarity of a solvent. It determines what type of compounds it can dissolve and with what liquids it is miscible. Typically, polar solvents dissolve polar compounds best and non-polar solvents dissolve non-polar compounds best. Similarly, polar contaminants dissolve best in polar solvents, while non-polar compounds, like oils or waxes, dissolve best in non-polar solvents.

Hansen Solubility Parameter

The Hansen solubility parameter is a numerical value that indicates the relative solvency behaviour of a specific solvent. It is available for every solvent and any liquid or polymer. This number is calculated from the dispersion, polarity and hydrogen bonding properties of the solvent. It is indicative of the forces that hold together the molecules. It should be noted that solvents with Hansen numbers below 17.5 are more effective in cleaning mineral oils, lubricants and greases.

Table : 1

Properties of alternative solvents

Parameters	Flash point °C	Boiling point °C	Vapour pressure mmH_g	Dipole moment Debye	Hansen solubility parameter
Acetone	– 20	56	180	2.9	20.0
Chloroform	None	62	160	1.2	19.0
Cyclohexane	– 20	81	78	0	16.8
Dichloroethane	13	84	64	1.6	18.5
Ethyl acetate	-4	77	76	1.8	18.1
Hexane	– 23	63-70	124	0	14.9
Isopropyl alcohol	12	82	33	1.7	23.5
d-Limonene	43	176	2	2.6	16.6
Methanol	11	64	96	1.7	29.6
Methyl Ethyl Ketone	-9	79	78	2.8	19
Methylene Chloride	None	40	350	1.6	20.3

Parameters	Flash point °C	Boiling point °C	Vapour pressure mmHg	Dipole moment Debye	Hansen solubility parameter
Mineral turpentine	36-38	146-197	25	-	15.8
N-Methyl pyrrolidone	92	204	0.42	4.09	22.9
Perchloroethylene	None	121	14	0	20.3
Toluene	4-7	111	21	0.3	18.2
White petrol	-18	50-120	180	-	7.3
Xylene	38	138	6-16	0.6	18.0
CTC*	None	77	91	0	17.8

***For comparison only (CTC will no longer be available from 1 Jan 2010)**

3 Sector specific alternatives

Cleaning processes used for removing soils and contaminants are varied and their effectiveness depends on the type of contamination, the solvent used, the cleaning procedure, the degree of cleanliness required and subsequent operations to be performed. The selection parameters for each application also differ widely, e.g. in some applications flammability is the most critical parameter while in other applications vapour pressure or the boiling point may be the predominant selection criteria. This section provides information on viable generic solvents for sector specific applications.

3.1 Metal degreasing

Degreasing and precision cleaning are the two main uses of solvents in metal industries. Effective degreasing is important to all industries where the production process includes manufacturing and/or assembling of metal parts. During the various steps of the production process, metal parts must be cleaned of oils, wax, tar and grease.

Various processes have been adopted for this by the industries. Some use mechanical means like sand blasting and high pressure jets to flush out insoluble soils. For soluble contaminants either cold cleaning process like spraying, wiping, rinsing & immersion cleaning, or hot cleaning processes like vapour degreasing are used. It is also possible to combine two processes, as in ultrasonic cleaning, where a solvent is used along with mechanical agitation of parts to do precision cleaning.

Picture 1: **Wiping of equipment**

CTC has been the common solvent that has been used for washing, spraying, dipping or wiping the machined part with it.

In its place now, there are viable other options based on the type of activity undertaken. Some of the easily available alternative solvents are listed in table 2 below.

Table 2 :
Viable alternative solvents in metal degreasing

Sl. No.	Solvent	Sl. No	Solvent
1	Acetone	10	Methyl Ethyl Ketone
2	Chloroform	11	Methylene Chloride
3	Cyclohexane	12	Mineral turpentine
4	Dichloroethane	13	N-Methyl pyrrolidone
5	Ethyl acetate	14	Perchloroethylene
6	Hexane	15	Toluene
7	Isopropyl alcohol	16	White petrol
8	d-Limonene	17	Xylene
9	Methanol		

Precision cleaning

"Precision cleaning" means removal of particulate and/or other inorganic and organic residues from a surface and verifying its cleanliness through analytical methods. Precision cleaning is used to attain a very high degree of cleanliness.

For example, brake systems and fuel-injection systems require very small diameters and have to withstand high pressures. Therefore, even a very minor particle contamination is not tolerable.

Precision cleaning is also used for cleaning electronic parts including PCB, silicon wafers, etc. High purity solvents and solutions are used with various types of cleaning processes such as ultrasonic and jet spray to achieve the desired level of cleanliness. These cleanliness levels cannot be obtained without a clean-room.

Industrial experience has shown that besides CTC, other options are available for performing this task.

Table 3 :
Viable alternative solvents in precision cleaning

Sl. No	Solvent
1	Methylene Dichloride
2	Perchloroethylene
3	Trans - 1,2 - Dichloroethylene (trans)

Particulate analysis of components

In precision component manufacturing and foundries cleanliness specifications are often determined by the original equipment manufacturer (OEM). Residual particle analysis, commonly referred to as the Millipore test, is typically specified to verify the cleanliness achieved.

Picture 2: **Equipment for particulate analysis**

Contaminants are removed from the sample part by rinsing, brushing and/or flushing with a solvent (e.g. CTC). This solution is then vacuum filtered through a membrane filter which collects the contaminants that are greater in size than the grid size of the filter. The quantum of the contaminants thus collected is then compared to the acceptance criteria. Table 4 lists alternatives that have been tested to work successfully.

Table 4 :
Viable alternative solvents in particulate analysis of components

Sl. No	Alternatives to CTC
1	Toluene
2	White petrol
3	Perchloro ethylene (PCE)
4	Isopropyl Alcohol (IPA)

Sampling of raw material:

Picture 3:
Rinsing of scrap materials

In foundries the quantum of wastage in the scrap used as raw material is assessed by using the following method. The sample material is rinsed with solvents like CTC and then dried through heating. The difference in weight of the sample before and after rinsing determines the quantum of wastage. Since the material is dried directly on a source of heat it is important to select a solvent that is non flammable. Alternatives that are suitable for this purpose are given in table 5:

Table 5:
Viable alternative solvents for sampling of raw material in foundries

Sl. No	Solvent
1	Methylene Dichloride (MDC)
2	Perchloroethylene (PCE)

3.2 Jewellery casting

Jewellery usually involves many intricate shapes and designs. These intricate parts are cast through Investment Casting, employing Lost-Wax process.

Picture 4: Finishing of wax pattern

Firms producing jewellery in medium and large quantities employ investment casting method. Carbon Tetrachloride (CTC) is being used in particular to eliminate dimensional irregularities, appearance of parting lines and to finish resized patterns made from wax.Table 6 presents a list of possible alternatives to CTC for finishing wax patterns.

Table 6:
Viable alternative solvents in Jewellery casting

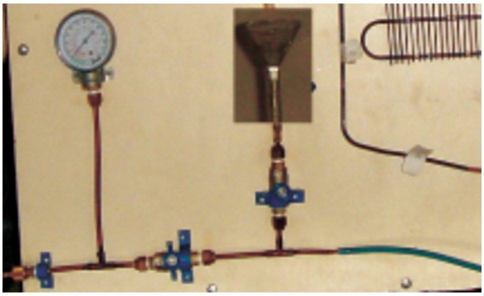
Sl. No	Alternatives to CTC
1	Perchloroethylene (PCE)
2	Toluene
3	Xylene
4	Acetone
5	Isopropyl Alcohol (IPA)

3.3 Refrigeration and Air-Conditioning

During manufacturing/servicing of RAC equipment, circuit components accumulate greasy, oily and solid contamination on their inner surfaces that reacts chemically with the refrigerant and compressor oil combination resulting in the formation of sludge. This in turn deposits on the tubing and causes choking of capillaries which is a major problem in the servicing of refrigeration and air-conditioning systems.

To ensure good system performance the service sector needs to maintain higher system cleanliness. During servicing, the technicians used to pour CTC in the circuitry and flush with nitrogen for the required cleaning purpose.

Picture 5:
Refrigerator system repair



Picture 6:
System for measuring and filling solvent in order to avoid spillage.

Though many enterprises use solvents like petrol and NC thinner, it is not desirable to use these solvents as they can leave residues in the system which in the presence of oil and moisture can later form into sludge. Table 7 presents a list of viable alternatives for refrigeration circuitry cleaning. Hexane and MDC are usually the preferred options.

Table 7:
Viable alternative solvents in RAC

Sl. No	Solvent
1	Hexane
2	Methylene Dichloride (MDC)
3	Perchloroethylene (PCE)
4	Toluene
5	White petrol

3.4 Oxygen systems

In oxygen manufacturing industries CTC is being used for cleaning of nozzles, compressor casings and heat exchangers. During the process other parts such as the outer surface of the cylinders are also cleaned with CTC.

Oxygen can react with most materials and hydrocarbons trapped in an oxygen system can create a fuel that will cause an accidental fire or explosion. The higher the oxygen content and/or pressure in a system, the more vigorous the combustion and it can build up to explosive levels. Hence it is advisable to select only non-flammable solvents for cleaning oxygen systems. However, other parts such as the outer surface of the cylinders do not require solvent cleaning. They can be cleaned instead with water based detergents.

Picture 7: **Oil and grease contaminants**

Trichloroethylene (TCE) is a popular cleaning agent offering good efficacy but its use is strongly discouraged because of its inherent cancer risk.

Table 8:
Viable alternative solvents in oxygen systems

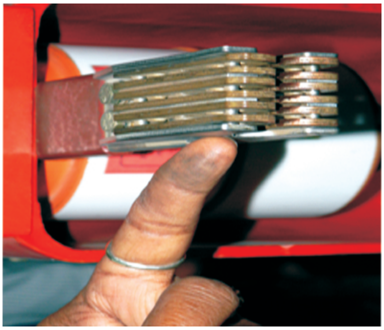
Sl. No	Solvent
1	Methylene Dichloride (MDC)
2	Perchloroethylene (PCE)

MDC is recommended by European standards due to its non-flammability and higher rate of evaporation. PCE may also be used provided proper flushing is carried out to remove all residues.

3.5 Electrical systems

One of the most common uses of CTC that has been identified across the country is in cleaning of electrical applications like contacts, switchgear, high-voltage cables, generators, motors, bushes and breakers.

All electrical switching contacts develop carbon deposits due to the sparking caused during making and breaking contacts. Over time carbon deposits reduce conductivity and result in loss of power and therefore contact cleaning is an integral part of preventive maintenance in every industry.



Picture 8: **Cleaning of contacts**

Due to its non-flammable and insulating properties, CTC has been used to clean impurities and deposits in contacts of small electrical appliances as well as in large electrical distribution networks during offline and online cleaning.

Table 9:
Viable alternative solvents in electrical systems

Sl. No	Solvent
1	Acetone
2	Methylene Dichloride (MDC)*
3	Perchloroethylene (PCE)
4	Isopropyl alcohol

*Only MDC is suggested for online cleaning due to its non-flammability and higher rate of evaporation.

Table 10:
Viable alternative solvents in motor and generator cleaning

	Solvent
1	Mineral Turpentine
2	Perchloroethylene (PCE)
3	White petrol

3.6 Offset printing

The offset printing industry adopted CTC in a variety of printing operations. This includes reviving and cleaning of blanket rollers, cleaning of scanner drums, exposure machines, binding machines and lamination machines.

Picture 9: **Cleaning of astrollen sheet**

CTC is also used for cleaning of film and astrollen sheets to remove dust, handling marks and ink marks. Cello-tapes used for mounting the film leave marks on the astrollen sheet. These could affect the final quality of the print and are therefore removed using CTC.

Table 11:
Viable alternative solvents in offset printing

Sl. No	Solvent	Sl. No	Solvent
1	White Petrol	3	Isopropyl Alcohol
2	n-Hexane	4	Methylene Dichloride (MDC)*

*Whenever there is risk of fire, it is advisable to use only MDC as it is non-flammable. However, one should use it with caution as it may cause some damage to the films and irritation to the eyes.

3.7 Textiles – Stain removal

Stains are unwanted coloration in fabric/garment caused by external sources. The textile materials are processed in series of machineries from raw material (fibre) stage to finished product (garment) during which oily and handling stains can occur.

By spraying a suitable solvent, like CTC, on the material the stains are dissolved and removed. Alternatively, detergent solutions also exist, however these require some additional time for drying process at the end of the stain removal exercise. There are many cost and performance effective solvents and detergents available. Solvents are popular in industry due to its fast action and quick natural drying.

Picture 10: **Stain removal in textiles**

Extensive studies have been conducted with simulated and industrial stains under different conditions. The most common solvents are listed in Table 12.

Table 12:
Viable alternative solvents in stain removal*

Sl. No	Solvent
1	Perchloro ethylene
2	White petrol*
3	Hexane
4	Mineral turpentine oil*
5	Acetone

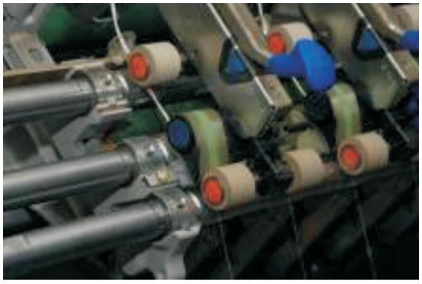
*These substances are banned by some European textile importers due to excessive aromatic content

*For a complete list of solvents and water based detergents please visit www.ctc-phaseout.org

Spinning mills

CTC is used in this sector mainly for the cleaning of rubber cots and aprons of drawing machines, combing machines and ring-frames.

Cots and aprons used in spinning mills are in continuous contact with fibre. Due to this contact, static electricity builds up on the surface of the cot. This attracts fibre to the cot's surface and results in lapping. Other reasons for lapping are humidity, cotton wax, honeydew and cotton seed-oil.



Picture 11: **Rubber cots/ aprons in spinning**

Table 13:
Viable alternative solvents for spinning mills

Sl. No	Solvent	Sl. No	Solvent
1	Perchloro ethylene	4	Ethyl acetate
2	Mineral turpentine oil*	5	Methyl ethyl ketone
3	NC thinner	6	Xylene

*These substances are banned by some European textile importers due to excessive aromatic content

Water can also be used for this application but it may increase downtime.

3.8 Activated Carbon testing

Activated carbon (AC) is a form of carbon that is activated by a carefully controlled oxidation process to develop a porous structure, generally characterized by a very large surface area. CTC is being used to determine the porosity of the activated carbon. In this process, measured quantity of CTC is passed through the AC. The porosity is determined on the basis of the quantity of CTC adsorbed by the AC.

Table 14:
Viable alternative in activated carbon testing

Sl. No	Alternative
1	n-Butane

The Butane activity test is the only internationally accepted alternative test method for measuring the porosity of the activated carbon. This test is similar to the one explained for CTC above, except that Butane is in gaseous form when used. The butane activity is the ability of the activated carbon to adsorb butane from a mixture of dry air and butane under specific conditions. The mass of Butane adsorbed at saturation is noted and calculated as mass of Butane per unit mass of carbon.

Since Butane is extremely flammable and can cause an accidental fire or explosion, additional precautions need to be taken.

4 Health and safety

4.1 Hazard potential of alternatives

Any solvent is a potential hazard for health and safety. Most solvents are toxic but the degree of hazard varies from one substance to another. Understanding the properties and risks of alternatives is thus essential for taking informed decisions on what to use and how to use it.

At the workplace the intake of chemicals occurs mainly through inhalation and skin contact. Another major risk on the shop floor level is flammability. While these hazards affect directly and immediately the workplace, the environmental hazards like contamination of air and ground water are rather indirect effects, not only at the workplace but also on a global scale. Thus this guide provides the hazard rating of each solvent on these four criteria.

Each hazard has been further classified into six grades and each grade is characterized through a corresponding colour shade. The least risk is marked in green, followed by shades of yellow and orange. Red represents the most severe risk.

Table 15:
Hazard Rating

Group	Risk	Inhalation	Skin	Environment	Flammability
E	high	Severely Toxic	Severely Toxic	Very hazardous	Extremly flammable
D		Very toxic	Very toxic		Highly flammable
C		Toxic	Toxic		Flammable
B		Harmful	Harmful	Hazardous	Combustible
A		Irritant	Irritant		Possibly combustible
-	low	none	none	not classified	Non-flammable

*For details on the hazard classification methodology please visit www.ctc-phaseout.org

Table 16 shows the hazard ratings of the alternatives discussed in the previous sections:

Table 16:
Hazard Ratings of Specific Solvent Alternatives

Substance	Inhalation	Skin	Environment	Flammability
Acetone	A	A	-	D
Chloroform	D	C	-	-
Cyclohexane	B	-	-	C
Dichloromethane/ ethylene dichloride	E	E		D
Ethyl acetate	A	A		D
Hexane	D	C	E	D
Isopropyl alcohol	A	-		D
d-Limonene	C	D	E	C
Methanol	C	C		D
Methyl Ethyl Ketone	A	A		D
Methylene Chloride / dichloromethane	D	C		-
Mineral turpentine	D	C	E	D
N-Methyl pyrrolidone	A	B		A
Perchloroethylene	D	C	E	-
Toluene	D	C		D
Trichloroethylene	E	E	C	-
White petrol	C	D	E	D
Xylene	B	B		C
CTC*	D	C	E	-

*for comparison only

Solvents like Perchloroethylene that are rated as "very hazardous" to the environment are toxic to aquatic organisms and may cause long-term adverse effects in the aquatic environment. Hence care must be taken for safe disposal of used solvents and solvent soaked wastes.

The selection of a solvent should be made so as to minimize the hazard. As is apparent from the ratings above, most of the substances are classified as "very toxic" for "Inhalation" and "toxic" under "Skin". Safe use can therefore not be ensured by a prudent selection alone. The following section introduces measures to safeguard health and safety while using hazardous solvents.

4.2 Risk control measures

This guide recommends the following general principles of prevention:

I. Avoid the need for solvent use;

II. Substitute with less hazardous or non hazardous substances;

III. Reduce risks at source using technically up to date methods;

IV. Use measures that give collective protection before considering individual protection;

V. Ensure appropriate instruction and training of all staff concerned;

VI. Provide adequate personal protective equipment (PPE).

4.3 Good practices

When deciding on the use of any solvent the following steps should be followed:

- **Prudent substance selection:** Select the safest possible substance (see table 16 'Hazard Ratings of Specific Solvent Alternatives').

- **Consult an MSDS:** Demand a material safety data sheet (MSDS) of the solvent from the retailer. Study specifically the sections on health risks, fire risks and first aid.

- Limit the quantity: Often the required quantity for cleaning is overestimated. Therefore assess the required quantity carefully and restrict the use accordingly. Solvent exposure can be reduced significantly by this measure alone.

- Purge with inert gases: Purging with air should be completely avoided as a mix of the solvent with contaminants could prove to be explosive in some cases. Therefore, always use only inert gases like nitrogen.

- Ensure good ventilation: While performing the cleaning operation the solvent evaporates into the surroundings. If the cleaning personnel experiences drowsiness or nausea, it is an indication that concentration of solvent vapours is above tolerable limits in the surroundings and there is a need for better ventilation of the cleaning area. The possible options include:

  Shift cleaning operations to an area with high ceilings and cross-ventilation.

  - If there is a perceivable flow of air, clean downwind so that the air first reaches the cleaning personnel and then the part being cleaned.

  - If none of these prove sufficient, consider the installation of local exhaust ventilation (LEV). LEVs capture contaminants before they disperse into the air of the workplace. Such systems consist of a hood, a duct and an air cleaner. LEVs cannot be bought off the shelf and they have to be sized by experts to meet the specific requirements.

  - By providing proper ventilation the vapour level can be reduced significantly.

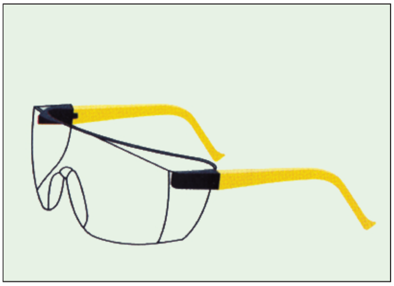
Picture 12: **Local Exhaust Ventilation**

4.4 Personal protection equipment

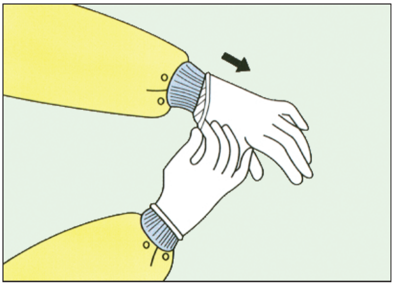
Different types of personal protective equipment exist.

- **Masks**: Masks can help to filter the vapours to a limited extent.

- **Goggles:** Goggles protect the eyes against inadvertent splashes of solvents.
- **Face Shields:** Protect the whole face against inadvertent splashes.
- **Gloves:** Most solvents remove the fat content of the skin. Gloves can protect the skin adequately. The next section provides more details on proper selection of gloves.
- **Respirators:** In any enclosed or confined space such as the inside of a tank, even a non-toxic solvent may have anesthetic or asphyxiating effects if it is used in large quantities. Breathing apparatus or respirators with a reservoir of oxygen may be required to prevent serious injury or even death.



Picture 13: **Safety goggles**



Picture 14: **Protective gloves**

Picture 15: **Effect of solvent on skin**

4.5 Selection of gloves

Care should be taken in selecting gloves and other protective clothing as different solvents affect the materials from which they are made in different ways. Some solvents may, for example, pass through some glove materials in a very short time. Table 17 guides on the selection of appropriate gloves:

Table 17:
Selection of appropriate gloves

Solvent	Glove Material
Acetone	Butyl, Nitrile, Neoprene, Laminate film
Chloroform*	Viton
Ethyl Ether	Nitrile for light exposures (spalshes)
Hexane	Nitrile, Neoprene, Viton
Isopropanol	Nitrile, Neoprene, Butyl, Viton
Methanol	Butyl, Viton, Laminate film
Methylene dichloride*	Nitrile, for light exposures (splashes), Viton, PVA
Toluene*	Viton, PVA
Xylene	Viton, PVA
*will damage all natural and synthetic glove materials	

5. Glossary

This glossary defines terms likely to be encountered in material safety data sheets (MSDS)

Acute effect: The effect caused by a single short term exposure to a high amount of concentration of a substance.

Aerosols: Liquid droplets or solid particles dispersed in air that are of fine enough particle size (0.01 to 100 microns) to remain dispersed for a period of time.

Alkali: Any of a class of substances that liberates hydroxide ions in and have a pH of more than 7. Strong alkalis in solution are corrosive to the skin and mucous membranes. They are also called bases and may cause severe burns.

Anhydrous: Does not contain water (e.g. anhydrous lime).

Asphyxiation: A condition whereby oxygen in the air is replaced by an inert gas such as nitrogen, carbon dioxide, ethane, hydrogen or helium to a level where it cannot sustain life. Normal air contains 21 percent of oxygen. If this concentration falls below about 17 percent, the human body tissue will be deprived of supply of oxygen, causing dizziness, nausea and loss of coordination. This type of situation may occur in confined work places.

Auto-ignition temperature: The minimum temperature at which a material ignites without application or a flame.

Boiling point: The temperature at which liquid changes to a vapour state at a given pressure (usually 760 mm of Hg or one atmosphere).

Caustic: The ability of an alkali to cause burns.

Chronic (health) effect: An adverse effect on a human body with symptoms developing slowly over a long period of time.

Chronic toxicity: A chronic effect resulting from repeated doses of or exposure to a substance over a relatively prolonged period of time.

Confined space: Any area that has limited openings for entry or exit that would make escape difficult in an emergency, has a lack of ventilation, contains known and potential hazard, and is not normally intended or designed for continuous human occupancy (e.g. a storage tank, manhole of collection conveyances systems in effluent treatment plants).

Explosion proof-equipment: Apparatus or device enclosed in a case capable of withstanding an explosion of specified gas or vapour and preventing the ignition of specified gas or vapour surrounding the enclosure by sparks, flash or explosion and operating at an external temperature so that surrounding flammable atmosphere will not be ignited.

Flammable: A flammable liquid is defined as a liquid with a flash point between 21 and 55 degrees Celsius. It may catch fire on contact with a source of ignition.

Flammable/ explosion limits: Flammable / explosion limits produce a minimum and a maximum concentration of gases/ vapours/fumes in air that will support combustion. The lowest concentration is known as the lower flammable/explosion limit (LEL), the highest concentration is known as upper flammable/explosion limit (UFL).

Flash point: Minimum temperature at which, under specific conditions, a liquid gives off sufficient flammable gas/ vapour to produce a flash on contact with a source of ignition.

General exhaust/ventilation: A system for exhausting or replacing air containing contaminants from a general work area.

Hansen solubility parameter: A numerical value that indicates the relative solvency behaviour of a specific solvent. This number is calculated (based on volume percentage) from the properties dispersion, polarity and hydrogen bonding of the solvent. Hansen solubility parameter is available for every solvent, any liquid or polymer.

Hazard: A potential to cause danger to life, health, property or the environment.

IDLH (Immediate danger to life and health): The maximum concentration from which one could escape with in 30 minutes without any escape-impairing symptoms or irreversible health effects. Usually used to describe a condition where self contained breathing apparatus (SCBA) must be used.

Incompatible: Condition of materials that could cause dangerous reactions from direct contact with one another. Particularly relevant when storing different substances in the same place.

Local exhaust: A system or device for capturing and exhausting contaminants from the air at the point where the contaminants are produced (e.g. dust in shaving and buffing).

MSDS (Material safety data sheet): Consolidated information on specific identity of hazardous chemical substances, also including information on health effects, first medical aid, chemical and physical properties, emergency measures etc.

OEL (Occupational exposure limit): An exposure level established by a regulatory authority (e.g. OSHA, NIOSH).

Poisoning: Normally the human body is able to cope with a variety of substances within certain limits. Poisoning occurs when these limits are exceeded and the body is unable to deal with a substance (by digestion, absorption or excretion).

Risk: The measured probability of an event to cause danger to life, health, property or the environment.

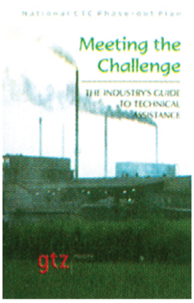
TLV (Threshold limit value): A concentration threshold in the atmosphere which is set specially for each pollutant. It refers to the limit accepted in the atmosphere of working area.

TLV-STEL (TLV short term exposure limit): Concentration threshold in an atmosphere contaminated with a specific type of pollutant for a 15 minute exposure (if not otherwise specified).

TLV-TWA (TLV time weighted average): Concentration threshold in an atmosphere contaminated with a specific type of pollutant, usually for a continuous eight hour exposure.

Toxicity: The inherent potential of a chemical substance to cause poisoning.

6. Other project publications

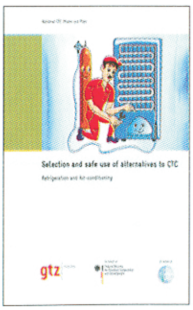


Meeting the Challenge provides essential information on the National CTC Phase-out Plan and industry sectors most affected by it. The publication elaborates on 'applications' across sectors affected by the phase-out of CTC and also GTZ-Proklima's mandate, approach and technical assistance to affected industries.

Languages: English, Hindi, Gujarati, Kannada and Malayalam

Solvent Alternatives is a compilation of technical information on a variety of CTC alternatives that are in use in industry across different sectors and applications. The advisory elaborates on the use and potential risks involved therein, with regard to profiled substances.

Language : English



Industry specific guidelines for the substitution of CTC in specific sectors are available. These guidelines inform of alternatives to CTC and their safe use.

Language: English

All publications are available for free download at our website
www.ctc-phaseout.org

Notes

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Ozone Cell, Ministry of Environment and Forests, Government of India, is the central agency coordinating the phase-out of CTC. The cell has established the regulatory framework and national phase-out plan. It ensures that domestic CTC production and import progressively decrease in compliance with national targets.

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH is an international cooperation enterprise for sustainable development with worldwide operations. GTZ-Proklima is a sectoral program which implements bilateral and multilateral projects in order to assist partner countries in fulfilling their obligations under the Montreal Protocol. With more than 130 projects, GTZ-Proklima is the largest bilateral partner of the Multilateral Fund of the Montreal Protocol. GTZ-Proklima, on behalf of the Government of Germany and under the overall coordination of Ozone Cell, Ministry of Environment and Forests, provides support to Indian industries for smooth transition to a CTC-free world. In the current project GTZ-Proklima holds an additional mandate on behalf of the Government of France which provides financial support through its French Global Environment Facility (FFEM). GTZ-Proklima does not promote any particular product or brand but provides technical assistance to CTC consuming industries.

On behalf of
Federal Ministry
for Economic Cooperation
and Development

On behalf of

National CTC Phase-out Plan

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