Cover Back Page

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CoverPage

National CTC Phase-out Plan

Selection and safe use of alternatives to CTC

Metal degreasing

gtz PROKLIMA

On behalf of
Federal Ministry
for Economic Cooperation
and Development

On behalf of
FFEM

Cover Front Inside

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Disclaimer

Though all care has been taken while researching and compiling the contents provided in this booklet, GTZ Proklima accepts no liability for its correctness.

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.

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

Cover Back Inside

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
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and Development

On behalf of FFEM

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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. UV-B 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 Metal degreasing

Cleaning and degreasing are applied in a variety of industries to remove dirt, sand and grease (sometimes, all these contaminants together are referred to as soil). Cleaning and degreasing are carried out as the final step in manufacturing, as a preliminary step in preparing a surface for further work (like powder coating) or as a periodical cleaning step for machines and components.

Precision cleaning means removal of particulate and/or other inorganic and organic residues from a surface and verifying its cleanliness through analytical methods.

Picture 1: **Fuel injector**

Precision cleaning is used to attain a very high degree of cleanliness. For example brake systems and fuel-injection systems need to be fitted with increasingly smaller diameters and they have to withstand increasingly higher pressures. Therefore even a very minor particle contamination may lead to big problems. Precision cleaning is also used for cleaning electronic parts including PCB, silicon wafers, etc.

Picture 2:
Precision cleaned fuel injector components.

There are various processes being used by many industries for the cleaning application. Some use mechanical means like sand blasting and high pressure jets to flush out insoluble soils. For soluble contaminants, either cold cleaning processes 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.

There are also other cleaning processes like alkaline or acid bath which are beyond the scope of this guide. Hence this booklet only describes solvent cleaning processes and provides information on suitable solvents for those processes.

3 Selecting alternatives to CTC

3.1 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

3.2 Possible alternatives

There are three different types of alternative cleaning agents to replace CTC in metal degreasing:

1. Aqueous agents: pure water, alkaline aqueous solution, neutral aqueous solution (with surfactants), acidic aqueous solution.
2. Semi-aqueous agents: mixtures of water + N-methylpyrrolidone + surfactants, water + glycol ether + surfactants, water + hydrocarbon + surfactants (non-flammable), terpene + surfactants, etc.
3. Non-aqueous agents (solvent based): hydrocarbons, alcohols (ethanol, iso-propanol), silicones, glycol ethers, fluorinates, chlorinates (methylene chloride, trichloroethylene, perchloro ethylene).

This guide is only about alternative solvents and thus the first two alternatives are not dealt in detail here.

The most relevant properties of available generic solvents 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 but higher cleaning efficiency.

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.

For selecting the right alternative, the following eight major parameters are to be taken into account:

Table 1 :
Important factors to find a suitable alternative

	Parameters	Description
1	Properties of the parts to be cleaned	Material composition (steel, aluminium, copper, alloys, etc.), size, weight, geometry, narrow gaps, tiny holes, blind holes
2	Quantity and frequency of cleaning	Large numbers, frequent cleaning batches, etc.
3	Type and amount of contaminant	Solid/liquid, hard/soft, quantity to be removed etc.
4	Further processing; degree of cleanliness	The level of cleanliness required should be clearly defined (critical and non-critical levels)
5	Cleaning agent	This will depend upon local availability, occupational hazards, storage losses etc.
6	Cleaning process	Suitability and affordability of the industries for mechanical cleaning, chemical cleaning, or combination of both, etc.
7	Cleaning equipment	Depends on the process selected. For mechanical cleaning, ball mills, ultrasonic machines etc. are used.
8	Cleaning location	Ventilation, worker safety, etc.

4 Alternatives to CTC

4.1 Cleaning methods

Wiping

Manual cleaning is often the preferred method of cleaning when:

a. The part is too large to fit within a cleaning tank
b. The part is immobile
c. Only portions of a larger assembly, such as electric contacts, require cleaning
d. Some parts of the assembly, such as polycarbonate or plastic components, may be incompatible with certain solvents in the primary cleaning operation.

The solvent is sprayed onto the rags, swabs or brush, and then the metal surface has to be wiped. If this process does not remove the contamination, the solvent should be carefully sprayed directly onto the metal while holding the rag nearby to prevent over-spray. The solvent should remain on the metal briefly and then wiped.

Picture 3: **Wiping**

Advantages: Parts can be cleaned without complete immersion in the cleaning solvent. Additional cleaning equipment, such as wash and rinse tanks, is not necessary. Waste disposal requirements are kept to a minimum.

Limitations: It is a labour-intensive process, which may require additional time to complete. Solvent consumption is higher, as the solvents generally cannot be recycled. There is increased worker exposure to solvents.

Table 2 :
Suitable solvents for Wiping

Sl. No.	Solvent	Sl. No	Solvent
1	Perchloroethylene	4	NC thinner
2	Toluene	5	Petrol
3	Acetone	6	Kerosene

Ensuring Health and Safety

- Don´t dip the rag or brush into the solvent; this will waste a lot of solvent. Use a sprayer to minimise usage and exposure.
- Since all solvents are considered toxic, always protect personnel with gloves and masks to avoid direct skin contact and inhalation.
- Rags or swabs soaked in solvents should be disposed carefully as most solvents are toxic and flammable.

Flushing or spraying


Picture 4: **Spraygun**

Spray cleaning consists of impinging the spray of a solvent upon the components to remove unwanted soil. Machines used for spray cleaning have a pump to pressurise the solvent, a reservoir tank, spray nozzles and a mechanism to move the components.

Advantages; Main advantage is that high production rates are possible, especially with similar shaped components. Clean solvent is directed onto the components´ surfaces, and the high pressure impact improves the cleaning efficiency. Components with a large surface area are best cleaned this way.

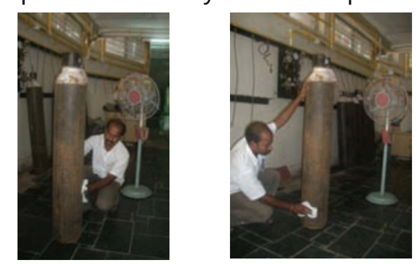
Limitations: Equipment cost is higher than the immersion process. More floor space and maintenance are generally required. Safety considerations limit the use of flammable solvents in spraying.

Table 3 :
Suitable solvents for Wiping

Sl. No.	Solvent	Sl. No	Solvent
1	Perchloroethylene	3	Acetone
2	Toluene	4	NC thinner

Ensuring Health and Safety

- Always use spraying only in very well ventilated area. If the operations are performed in an area where air flow is a factor the work should be performed on the positive side of the flow so that the vapour flows away from the operator.


Picture 5: **Airflow factor**

- Try to avoid flammable solvents. If flammable solvent is unavoidable, eliminate all sources of spark like motors, cigarettes, etc.
- Spraying induces a mist of solvent vapour which can get inhaled. Use of respirator is recommended.
- Never spray solvents into hands to check functioning. Most of the solvents are skin irritants.

Immersion cleaning


Picture 6: **Immersion Cleaning**

This cleaning method is usually used in conjunction with wiping, flushing and ultrasonic cleaning. Immersion cleaning is employed when a large quantity of components needs to be cleaned and where critical cleaning is not required.

It is the process by which the parts to be cleaned are placed in the cleaning solvent to come in contact with the entire surface of the parts.

It is performed in large tanks, drums and barrels either with heated or cold solvents. Installations vary from a single, unheated tank to multi-stage systems having heated and agitated solvents.

Solvents with high flash points are more suitable for immersion cleaning. If solvents with lower flash points are used, then measures to minimise flammable solvent/air mixtures and to eliminate sources of ignition will be essential in addition to flame-proof enclosures.

Advantages: Immersion process is well suited to cleaning castings, welded parts, machined parts, and some sheet metal components. Components in a wide range of sizes, shapes and weights can be processed.

Limitations: Drag-out losses of solvents from immersion equipment can be high, contaminating the water used for subsequent rinsing. Immersion cleaning often requires higher solvent concentrations, higher operating temperatures and longer cycle times than spraying.

Table 4:
Suitable solvents for Immersion Cleaning

Sl. No.	Solvent	Sl. No	Solvent
1	Perchloroethylene	4	NC thinner
2	Toluene	5	Isopropyl Alcohol (IPA)
3	Xylene	6	Methylene dichloride (MDC)*

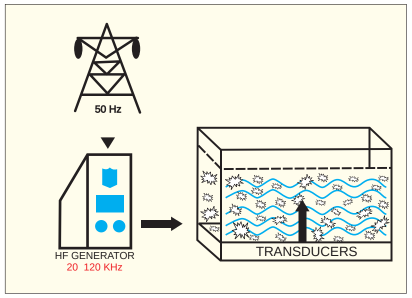
* As MDC has a high vapour pressure, it can be used only in closed systems to minimise evaporation losses.

Ensuring Health and Safety

- Precautions should be taken to avoid spillage when transferring solvents from storage to the immersion tanks.
- Natural ventilation may be adequate in some cases but Local Exhaust Ventilation (LEV) will be needed in most cases. LEV captures the contaminants before they get dispersed in the workplace environment. This system typically consists of hood, duct, air cleaner (to remove toxic contaminants if present), and fan.

- In any enclosed or confined space such as the inside of a tank, even a non-toxic solvent may have anaesthetic or asphyxiating effects if it is used in sufficient quantities. Breathing apparatus and other precautions are required to prevent serious injury or even death.
- Handling and application methods which avoid skin exposure, or the use of suitable protective equipment such as chemical protective gloves and sometimes overalls are required. 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. Solvents may pass through incompatible protective materials in a very short time.

Ultrasonic cleaning



Picture 7: **Ultrasonic Process**

Ultrasonic cleaning uses sound waves passed at a very high frequency through liquid cleaners, which can be alkaline, acid, or even organic solvents.

Ultrasonic cleaning is more efficient as it causes good micro agitation in the solvent tank and cavitations within the liquid. The passage of ultrasonic waves through the liquid medium creates tiny gas bubbles, which provide a vigorous scrubbing action on the parts being cleaned. This action yields very efficient cleaning.

Advantages: It is ideal for lightly soiled work with intricate shapes, surfaces, and cavities that may not be easily cleaned by spray or immersion techniques.

Ultrasonic cleaning is most effective with hard substrates, such as metals, glass, and ceramics, and is not as effective in cleaning soft materials.

Limitations: In most cases, cleaning efficiency decreases with decreasing particle size. A higher frequency – thus higher power consumption – is needed to remove minute particles.

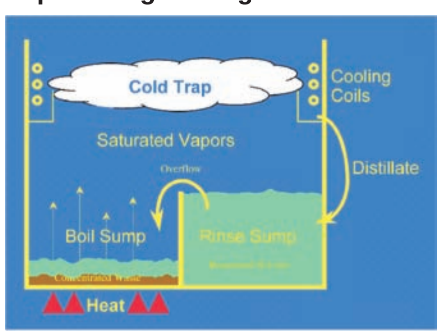
Table 5:
Suitable solvents for Ultrasonic Cleaning

Sl. No.	Solvent	Sl. No	Solvent
1	Perchloroethylene	4	NC thinner
2	Toluene	5	Isopropyl Alcohol (IPA)
3	Xylene		

Ensuring Health and Safety

- Do not place items to be cleaned directly on the bottom of the tank. It is actively vibrating and can abrade the surface of the item. Suspend items in the bath or use the perforated tray made for the purpose.
- Don't handle the equipment when the tank is filled.
- Do not place fingers or hands in the tank while the ultrasonic power is on.
- When using flammable solvents within an ultrasonic environment, flame-proof and spill-proof tanks and equipment must be employed.

Vapour Degreasing



Picture 8: **Vapour Degreasing**

There are two types of Vapour Degreasers. One is a vapour immersion unit which usually has two solvent-filled sumps (the boil sump and the cold sump which is filled with clean, distilled condensate solvent and is often used for rinsing). The other type of degreaser is a vapour-spray unit in which the solvent is boiled in the very bottom of a one-sump degreaser. There is a perforated metal stand just above the boiling solvent. A metal basket filled with dirty parts is placed on this stand. The basket or parts are not immersed in solvent. Instead the solvent vapour encompasses the parts completely and removes the oils and soils. The oils and soils, now diluted into the condensing liquid, will drip back into the boiling solvent below. There is a manual spray wand, which is sprayed under the cooling coils, directly on hard-to-remove soil.

Near the top of either type is a set of cooling coils, that prevents the vapour from escaping out of the unit. It cools and condenses it back to its liquid form so that it can flow back to a clean condensate tank and finally it is routed back to the boil sump or the rinse tank.

The suitable alternatives are limited in this case as the main selection criteria is flammability. Only chlorinated solvents are non flammable.

Table 6:
Suitable solvents for Vapour degreasing

Sl. No.	Solvent	Sl. No	Solvent
1	Perchloroethylene	3	Trichloro ethylene (TCE)
2	Methylene Chloride		

Ensuring Health and Safety

- Locate the degreaser to minimize natural drafts or use baffles to prevent vapours from being disturbed.
- Move the components slowly. Rapid movement of the parts or basket disrupts the vapour zone and causes air to mix in with the vapour.
- Solvent that is not properly drained from parts is immediately lost to evaporation outside the degreaser.
- Avoid inserting oversized items or large baskets into the tank. As a general rule, the cross-sectional area of the work load should not exceed 50 % of the tank's open area.

All tanks should be covered when not in use. All covers should be designed to slide horizontally over the tank top. This movement disturbs the vapour zone less than hinged covers.

In all the above cleaning processes, TCE is being used by many industries. Though technically suitable, GTZ Proklima doesn't recommend TCE as it is a proven Carcinogenic and pollutes ground water.

4.2 Solvent alternatives

Table 7:
Properties of selected solvents

Parameters	Flash point- °C	Boiling point- °C	Vapour pressure- mm_{Hg}	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
Dichloro ethane	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
Mineral turpentine oil	36-38	146-197	25	-	15.8
N-Methyl pyrrolidone	92	204.3	0.42	4.09	22.9
Perchloro ethylene	None	121	14	0	20.3
Toluene	4-7	111	21	0.3	18.2
Trichloro ethylene	None	87	58	0.8	19.0
White petrol	-18	50-120	180	-	7.3
Xylene	38	138	6-16	0.6	18.0

5 Health and Safety

5.1 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. The hazard of electric shock, when coupled with the effects of solvents could be fatal to the personnel.

At the workplace the intake of chemicals occurs mainly through inhalation and skin contact. Another major risk in the electrical systems 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 rates the hazard of each solvent on these four factors.

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 8 :
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	Hazardous	Flammable
B		Harmful	Harmful		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 9 shows the hazard ratings of the alternatives discussed in the previous section:

Table 9 :
Hazard ratings of specific 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
NC Thinner	D	C	E	
N-Methyl pyrrolidone	A	B		
Perchloroethylene	D	C	E	
Toluene	D	C		D
Trichloroethylene	E	E	C	
White petrol	D	C	E	D
Xylene	B	B		C

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.

5.2 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) if a significant risk still remains;

Picture 9: **Effect of solvent on the skin**

5.3 Good practices

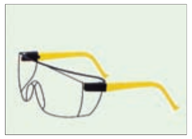
- Prudent substance selection: Select the safest possible substance (see table 13 'Hazard Ratings of Specific Alternatives').
- Consult an MSDS: Demand a material safety data sheet (MSDS) of the solvent from the supplier. Study specifically the sections on health risks, fire risks and first aid.
- Limit the quantity: Often the required quantity for cleaning is overestimated. Therefore assess the required quantity carefully and restrict the use accordingly. It is believed that 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 CO_2.
- All electrical equipment should be properly grounded & de-energised before carrying out cleaning operation. If online operation is inevitable due to equipment design or operational limitations use only insulated hand tools and solvent with low dielectric constant.

- Ensure good ventilation: Many solvents are toxic. While performing the cleaning operation the solvent evapourates 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.

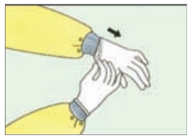

Picture 10 : **Local Exhaust System**

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

- **Wear goggles:** Certain cleaning operations may result in splashing of solvents therefore goggles are required for eye protection.


Picture 11 : **Safety goggles**

- **Wear gloves:** Skin contact with the solvent during cleaning occurs regularly. All solvents remove the fat content of the skin. Gloves can protect the skin adequately.


Picture 12 : **Protective 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 10 guides on the selection of appropriate gloves:

Table 10:
Selection of gloves

Chemical	Glove Material
Acetone	Butyl, Nitrile, Neoprene, Laminate film
Hexane or White petrol	Nitrile, Neoprene, Viton
Chloroform	Viton
Ethyl ether	Nitrile for light exposures (splashes)
Toluene*	Viton, PVA
Xylene	Viton, PVA
Isopropyl alcohol	Nitrile, Neoprene, Butyl, Viton
Methylene dichloride*	Nitrile, for light exposures (splashes) Viton, PVA

*will damage all natural and synthetic glove materials

6 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 water 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).

Dielectric constant: The dielectric constant of a solvent is a relative measure of its polarity.

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 within 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.

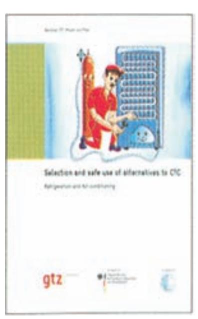
7 Other project publications

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

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