Selection and safe use of alternatives to CTC

Textiles Stain Removal

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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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.

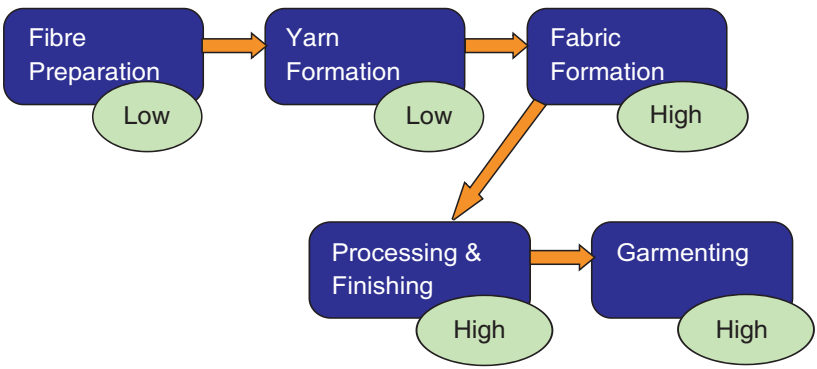
GTZ-Proklima offers technical assistance to industries using up to 10 metric tons or 6,250 litres of CTC per year. In close interaction with affected industries, GTZ-Proklima aims to provide competent guidance in identifying CTC substitutes by addressing environmental, health and safety concerns without compromising on quality and cost effectiveness.

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

2. CTC in Textiles Stain Removal

CTC has many applications along the value chain in the textiles industry. It is typically being used as a cleaning agent for metal and rubber components and as a stain remover for fabric. In the value chain of textiles and clothing the raw material (the fibre) passes through many types of machinery to get converted into finished fabric/garment. Various contaminants like grease, oil, dyes, dust and rust can cause stains in the textile material. The following diagram depicts the basic value chain and the degree of stain occurrence.

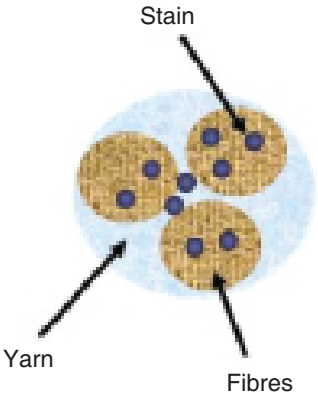
Figure 1:
Textiles value chain

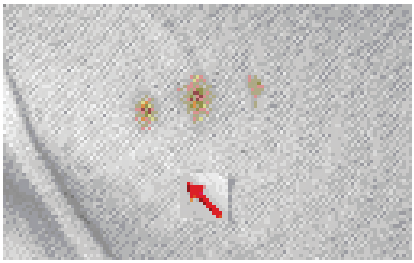


The possibility of occurrence of stains in fibre preparation and yarn formation is low. The chances of stain occurrence in fabric formation, processing & finishing and garmenting are high.

2.1 Stains and their types

A stain is an unwanted colouration or deposition on the fabric. It is a result of physical reaction between the staining agent and the fibres of the fabric. Stains reduce the quality and value of the textile. Stains are broadly classified into two types - organic stains and inorganic stains.





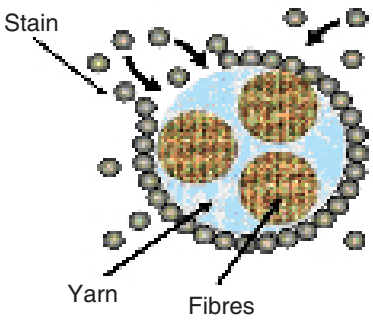
Absorbed Stain

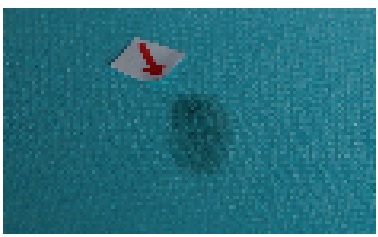
Picture 1: **Absorbed Stain**

Organic stains (absorbed stains) are caused by lubricating oil, grease, dyes, tannin etc. used in textile industry. These substances are generally absorbed into the fabric and fibre structure.

Oils and grease stains are caused by the leakages of these lubricants during the manufacturing process. Dye stains are formed from colour bleeding during washing, dye transfer due to rubbing, spilling of ink, dye or tint marks. Tea and coffee are the common sources of tannin stains.

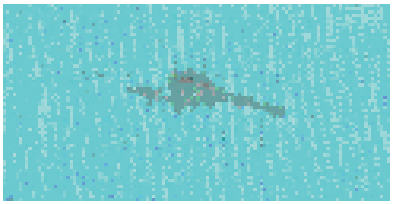
Inorganic stains (adsorbed stains) are caused by muddy soil, inorganic salts and contaminants from storage environment. The staining substances are deposited on the surface of yarn and fabric structure.



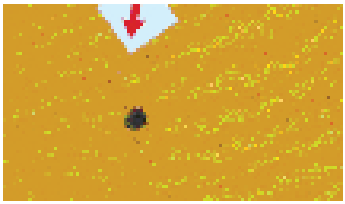


Adsorbed Stain

Picture 2: **Adsorbed Stain**



Picture 3: **Oil Stain**



Picture 4: **Dye Stain**

These types of stains are generated due to poor work practices and improper storage.

Stains that are smaller in size are regarded as spot stains. Some typical organic spot stains are shown in Picture 3.

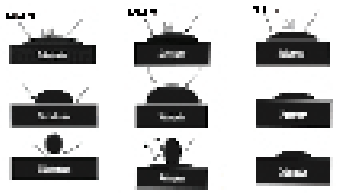
Stains that spread across larger area in the fabric are termed as bulk stains. This is a consequence of poor work practice and storage of material.

Picture 5: **Bulk Stains**

2.2 Mechanisms of stain removal

Most solvents are non-polar in nature which can dissolve organic stains such as oil and grease. Solvents act instantly on these staining substances and remove them by dissolving or entropic swelling. Solvents are volatile in nature and hence do not require separate drying after stain removal. The solvents act on oily substances by the following three mechanisms:

Figure 2:
Stain removal mechanisms



(i) (ii) (iii)

(i) Alcohols roll-up the oily substance and clean from the surface

(ii) Glycol ethers in water clean oil by entropic swelling

(iii) Hydro carbons clean oil by solubilisation

2.3 Relevance of CTC in stain removal

(i) Spot Stain removal in fabrics and garments

The fabrics produced in looms are several hundred meters long to facilitate further chemical processing and finishing operations. During the weaving and allied manufacturing operations the fabric passes through various machinery. The increased manual handling and spillage of lubricants cause most of the stains. The stains are removed in the checking section of the finishing department. A spray gun is popularly used for stain removal in continuous fabrics.

Picture 6: **Solvent in spray gun**

Picture 7: **Solvent in work station**

Garment is a limited length ready-to-use textile material made out of fabric. The stains mostly occur due to spillage of sewing machine oil and poor material handling practices. The solvent is applied through a spray gun as well as with stationary work station to remove the stains. CTC being a powerful de-greasing agent is used to remove the oily and greasy stains.

(ii) Bulk stain removal in synthetic scouring

During the production of synthetic (polyester) fabrics anti-static oil, weighting agents and coning oil (yarn lubricating oil) are applied onto the yarn to achieve a smooth process flow. These ingredients are to be removed once the yarn is converted into fabric, otherwise the pick-up of dyes and finishing chemicals would be impaired. The process of removal of these oily substances and chemicals from the fabric is termed as synthetic scouring.

Besides these chemicals the fabrics also contain handling stains of larger area (bulk stain) due to poor handling & storage practices and spillage of machine lubricating oil. Practically, the chemical impurities and stains are removed in a combined process of scouring.

The process is carried out in high temperature high pressure jet dyeing machines (closed vessel).

Picture 8: **Fabric with bulk stains**

Picture 9: **Fabric with bulk stains**

Picture 10: **Scoured fabric**

The scouring solution contains sodium hydroxide, solvent and non-ionic detergent. CTC is used in the solution mixture as solvent. Sodium hydroxide partially hydrolyses the polyester fabric to yield better softness and hand feel. The solvent initiates the stain removal activity on hard stains in room temperature and as the temperature is raised it turns into vapour state in the machine. The detergent and the emulsion (formed by mixing of detergent and solvent in water) continue the stain removal action at higher temperatures. The stains are removed by solubilisation and degradation.

3 Selecting alternatives to CTC

3.1 Selection criteria

No alternative is ideal in all regards and each one has certain advantages and disadvantages. In order to identify a cost and performance effective substitute for CTC without affecting the environment and health, the substitute should meet the following criteria:

- 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 Assessment of alternatives

GTZ-Proklima has put considerable efforts in assessing various alternatives for stain removal for various types of textile materials like cotton, viscose, silk, wool, polyester and polyester/cotton blend in the industrial environment. The following control measures were adopted during testing:

- The same lubricating (dirty) oil was used to simulate stains in all the samples
- The same operator was engaged through-out the de-staining test

The tests were conducted on white and dyed samples with two time factors i.e. next day and delayed (15 days later). In all the tests the volume of stain remover consumed, time taken for de-staining, efficacy of cleaning and operators comfort were recorded.

The cost of stain removal is the sum of cost of stain remover used, operator's wage, operational cost (power & steam) and depreciation of equipment.

The test results clearly indicate that there are many cost and performance effective solvents available. Table 1 summarises the final results.

Table 1:
Efficacy of alternatives

Name of the alternative	Cotton woven fabric	Silk woven fabric	Wool woven fabric	Viscose woven fabric	Polyester/ Cotton blend woven fabric	Polyester woven fabric
Perchloro ethylene	3	3	3	3	3	3
White petrol	3	3	3	3	3	3
Mineral turpentine oil	3	2	3	3	3	3
Hexane	3	3	3	3	3	2
Xylene	0	3	3	3	0	2
Methyl ethyl ketone	0	0	2	1	2	3
Ethyl acetate	0	1	1	3	0	1
Isopropyl alcohol	1	1	0	0	1	1
Acetone	1	2	0	0	1	0
CTC	3	3	2	3	3	3

Remarks	Efficacy
Stains fully removed	3
Mild traces seen after de-staining	2
Traces seen significantly after de-staining	1
Stains not removed	0

While Perchloro ethylene and White petrol fully remove the stains on all types of fabrics, Acetone and Isopropyl alcohol are not capable of removing the stains satisfactorily on any type of fabric.

Mineral turpentine oil, Hexane and CTC are also effective on most of the fabrics. However, as already mentioned, CTC is very hazardous to health and environment and it will not be legally available after 31st December 2009.

3.3 Viable alternatives

In stain removal the main contaminants are oil and greasy substances. The alternative assessments are made with popular solvents in the textile industrial clusters. However, the capability of any solvent to remove stains can also be assessed by analysing its critical properties.

The most relevant properties of available generic solvents for selecting appropriate alternatives to CTC are:

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.

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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 2:
Properties of selected solvents

Parameters	Flash point-°C	Boiling point-°C	Vapour pressure-mmHg	Dipole moment-Debye	Hansen solubility parameter
Perchloro ethylene	None	121	14	0	20.3
White petrol	-18	50-120	180	-	7.3
Mineral turpentine oil	36-38	146-197	25	-	15.8
Xylene	38	138	6-16	0.6	18.0
Methyl ethyl ketone	-9	79	78	2.8	19.0
Ethyl acetate	-4	77	76	1.8	18.1
Isopropyl alcohol	12	82	33	1.7	23.5
Acetone	-20	56	180	2.9	20.0

4. Process alternatives

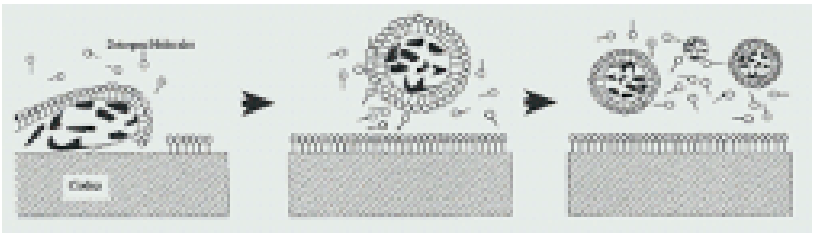
4.1 Detergent stain removers

Detergents are blends of surface acting agents which facilitate removal of material from a surface by reducing the tension between the material and the surface to which it is attached (surfactants). These compounds contain both hydrophobic groups (water repelling ends) and hydrophilic groups (water attracting ends). Therefore, they are soluble in both organic solvents and water.

When the water diluted detergent is applied on oil or grease stain, the molecules of detergent adsorb on to the substance. And the mechanical action (scrubbing or agitation) makes the oily substance to break into tiny droplets. The detergent molecules surround the oil droplets and prevent them from coalescing and re-depositing on the fabric surface.

Picture 11: **Stain removal with detergent**

The detergents are used in diluted form and hence makes de-staining very cost effective. The process requires a workstation consisting of steam and hot air guns as well as a suction pad.



Detergent molecules surround dirt

Dirt separated from cloth

Prevention of re-deposition

Figure 3: **Detergent action**

Steam is used to soften and flush-out the stain. After stain removal the fabric is dried with hot air. There are many detergent based proprietary products available in the market. More details on detergents are available on the project's web site (www.ctc-phaseout.org).

4.2 Solvent and detergent mixtures

There are many pre-mixed solvent and detergent proprietary products available in the market. Mostly glycol ethers (water miscible solvent) and non-ionic detergents (ethoxylates) are mixed in optimised proportions to form a blended stain remover. These substances are suitable for bulk stain removal of synthetic fabrics in a closed vessel at high temperature and pressure.

The compound removes stains by entropic swelling and degradation. The double action of the mixture thoroughly cleans the fabric.

It is also in practice that the synthetic processing industries procure solvents and detergents of their own choice and mix them to act as bulk stain remover.

4.3 Enzymatic stain removers

Enzymes are bio-molecules that catalyse (i.e. increase the rates of) chemical reactions. Almost all enzymes are proteins. During reactions, the enzymes attach with the stain by way of a lock-and-key principle and remove them through degradation. The enzymes are sensitive to pH value and temperature.

Though enzymes require less or no mechanical action for stain removal it takes longer time which can affect the productivity.

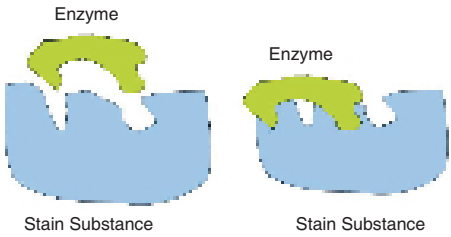


Figure 4 : **Lock-and-key action of enzymes**

The following table-3 summarises the various parameters of stain removers.

Table 3:
Properties of stain removers

Type of stain remover	Parameters				
	Types of stains handled	Evaporation	Mechanism of stain removal	Mechanical action required	Application speed
Solvent	Organic	Fast	Dissolving	Light	Fast
Detergent	Organic and inorganic	No	Dissolving and degradation	Strong	Medium
Enzyme	Organic and inorganic	No	Degradation	Nil	Slow

4.4 Stain removal equipment

There are two types of equipment used for stain removal in textile materials. One is the hand-held spray gun which is used for long fabrics & garments and another is the stationary work station which is used for garments.

The spray gun is popular in textile industry because it is inexpensive and easy to operate. But, the usage is limited to solvents only. Also care should be taken in operation as the spray is powerful.

Picture 12: **Spray gun**

Stationary workstations are equipped with:

- Steam and air spray guns
- Solvent and air spray guns
- Containers for the solvent
- In-built compressor

Picture 13: **Workstation (spotting table)**

Steam is used for stain removal with detergents. The steam and air spray gun makes stain removal very efficient. It separates soils and stains from the fabric. The pressure of the steam helps to break the stain into smaller particles. The heat and moisture present in the steam reduce the electrostatic charge of the particles which are then flushed out from the surface of the fabric.

The solvent and air spray gun is connected with two inlet tubes. One tube is connected with the air compressor and another with the solvent container. The solvent and compressed air are blown through the same gun. Often there are several solvent and spray guns attached to the workstation. This enables the operator to use different stain removers depending on the nature of the stains.

4.5 Suggestions for effective stain removal

- Remove stains while they are fresh. Time delay enhances the fixation of stain with fabric.
- Use a clean white cloth/paper to blot the stain.
- Remove excess solids in the stain by gentle scraping before stain removal as it reduces the volume of stain remover required.
- Ensure stain removers don't affect the colour or finish of the fabric.
- Avoid excessive rubbing of fabric to remove stains as it results in hairy surface.
- Flush the stain from the underside of the fabric.
- Avoid application of heat on stain as it becomes stubborn at higher temperatures.

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. Understanding the properties and risks of alternatives is thus essential for taking informed decisions.

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 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 4:
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

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.

Table 5 shows the hazard ratings of the alternatives discussed in the previous section:

Table 5:
Hazard Ratings of Specific Alternatives

Substance	Inhalation	Skin	Environment	Flammability
Perchloro ethylene	D	C	E	-
White Petrol#	D	C	E	D
Mineral turpentine oil#	C	D	E	C
Hexane	D	C	E	D
Xylene	B	B	-	C
Methyl ethyl ketone	A	A	-	D
Ethyl acetate	A	A	-	D
Isopropyl alcohol	A	-	-	D
Acetone	A	A	-	D
CTC*	D	C	E	-

*For Comparison only. (CTC is no longer available from 1st January 2010)
#These substances are banned by some European textile importers due to excessive aromatic content

Though Perchloro ethylene, White petrol, Mineral turpentine oil and hexane are effective on all fabrics they are toxic to skin and inhalation.

The user is advised to wear a mask and suitable gloves to mitigate the health hazards. These substances are also hazardous to aquatic life and hence discharging the effluent to water body (ground water, river etc.) is to be discouraged. Care should be taken in storage and packing based on the flammability hazard.

5.2 Risk control measures

This guide recommends the following general principles of prevention:

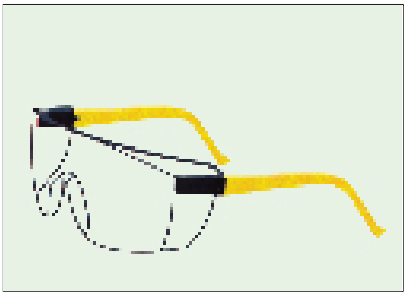
(i) Avoid the need for solvent use;
(ii) Substitute with less hazardous or non hazardous substances;
(iii) Reduce risks at source using technically up to date methods;
(iv) Use measures that give collective protection before considering individual protection;
(v) Ensure appropriate instruction and training of all staff concerned;
(vi) Provide adequate personal protective equipment (PPE) if a significant risk still remains;

5.3 Good practices

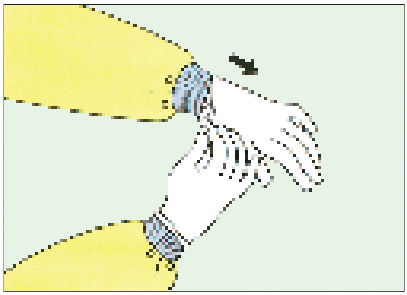
- Prudent substance selection: Select the safest possible substance (see table 5' Hazard Ratings of Specific Alternatives').
- Consult an MSDS: Demand a material safety data sheet (MSDS) of the solvent from the retailer. Study specifically the sections on health risks, fire risks and first aid.
- Limit the quantity: Often the required quantity for cleaning is overestimated. Therefore assess the required quantity carefully and restrict the use accordingly. 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 nitrogen.

- Ensure good ventilation: Many solvents are toxic. 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.

Picture 14: **Local Exhaust Ventilation**



Picture 15: **Safety goggles**



Picture 16: **Protective gloves**

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

- **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.

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 6 guides on the selection of appropriate gloves.

Picture 17 : **Effect of solvent on skin**

Table 6:
Selection of gloves

Chemical	Glove Material
Acetone	Butyl, Nitrile, Neoprene, Laminate film
Hexane or White petrol	Nitrile, Neoprene, Viton
Isopropyl alcohol	Nitrile, Neoprene, Butyl, Viton
Chlorinated solvents	Viton, PVA

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 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.

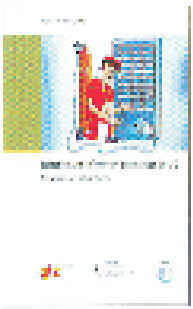
6. Other project publications

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

Notes

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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