# Selection and safe use of alternatives to CTC

## Textiles – Spinning Mills

gtz PROKLIMA

On behalf of
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and Development

On behalf of
FFEM

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*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.*

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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.

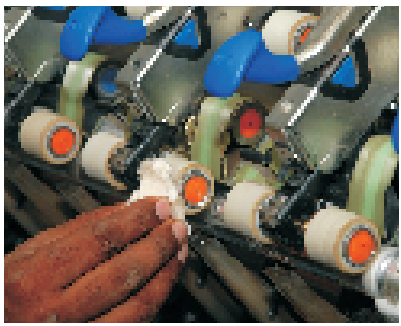
GTZ-Proklima maintains strict independence from any branded or proprietary product.

# 2. CTC in Textiles Spinning Mill Sector

CTC is used in the sector mainly for cleaning the rolling elements in textile machinery to avoid lapping. Lapping is an unwanted process in which the fibres get rolled up on the cots/rollers of the draw-frame, comber, simplex and ring-frame machines.

This results in increased mending time and affects the operator productivity.

Picture 1: **Lapping**

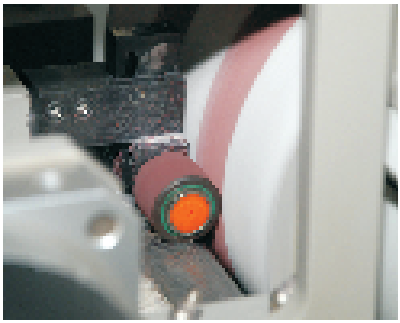


Picture 2: **Cots Cleaning**

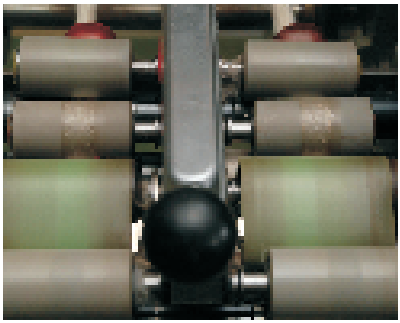
In the simplex and ring-frame machines, the cots are cleaned once in a month with CTC and are sent for buffing once in two months. Buffing removes the grooves and surface irregularities of the cots. There are some additional surface treatment processes like acid cleaning and berkolisation practiced by some mills.

There are three main reasons for lapping:

- Static charge: Cots and rollers 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 which results in lapping. Static charge is not an issue with cottons but does apply to polyester for which antistatic agents are required.



Picture 3: **Cot buffing**



Picture 4: **Honeydew on the cots**

- Humidity: High humidity results in more frequent lapping because of the increased moisture on the surface of the cots and rollers.
- Contamination deposits: Cotton wax, honeydew and cotton seed oil can all cause lapping because of their adhesive nature.

To rectify this lapping, CTC is applied on to the surface of cot/roller and wiped with a cloth to remove the contamination. The draw-frame and combers stop automatically when lapping happens. The operator then needs to open up the machine and to clean the rollers in situ. Hot water is also used for cleaning in some mills. The water evaporates very quickly because of the high temperature of the cots. In the simplex and ring-frame machines the cots are removed from the machine and then cleaned. Cleaning may also be carried out in situ.

Picture 5: **Cleaning of rollers in comber**

Picture 6: **Cleaning of rollers in Drawframes**

# 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 the 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)
- Not leaving any residue
- Equal or lower cost compared to CTC
- Locally available
- Can be disposed off easily

## 3.2 Viable alternatives

Solvents

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 through industrial trials. The industrial trial was conducted with the following control conditions:

- All alternatives were tested with the same lot of cotton mixing (hank of sliver = 0.13).
- Humidity in the department was maintained at ± 2%
- For all the detergents, the concentration level was 5%.
- All alternatives were tested with the same machine by the same operator to avoid variations in performance.

During the tests, the volume of alternatives consumed and the time taken for each cleaning were measured and recorded since cost and time are the most important considerations for an industry. The results for the draw-frame and the comber are presented in chart 1 and 2.

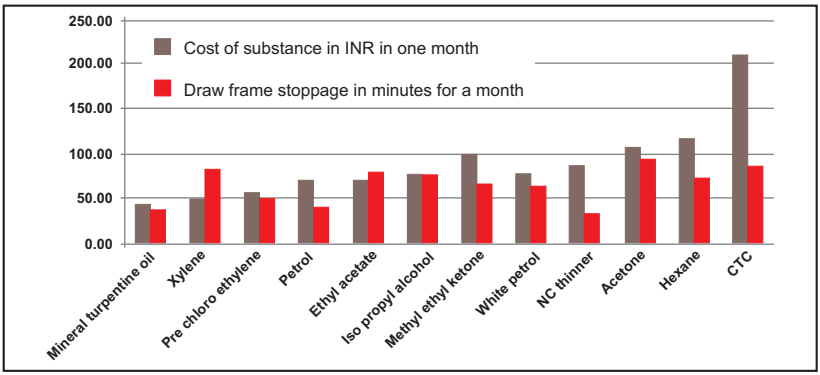



Chart 1: **Test results for Draw-frame machine**

Chart 1 clearly demonstrates the performance of the alternatives on the two main criteria: machine stoppage time which is directly influenced by the drying time and the cost of the alternative. It can be seen that Mineral Turpentine Oil is the ideal substitute as it dries fast and costs less. Other suitable alternatives are Xylene, Perchloro ethylene, Petrol, Ethyl acetate and Isopropyl alcohol in that corresponding order.

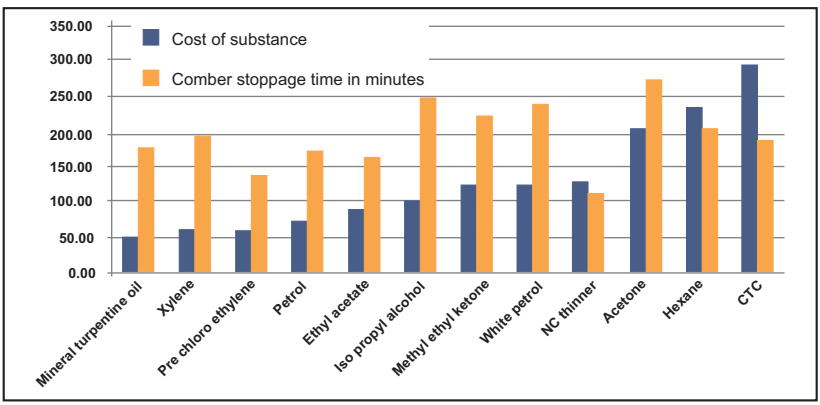



Chart 2: **Test results for comber machine**

Chart 2 shows the results for the comber machine. The stoppage time is higher here as there are more number of rollers that need to be cleaned. These results are consistent with that of the results of draw-frame machine; same alternatives in the same order are found to be suitable as the roller material is the same on both machines.

Though a few proprietary detergents have good cleaning properties and are used by many enterprises, their usage is limited by the fact that they take longer time to dry resulting in higher idle machine time. The details of these products are available in the project's website (www.ctc-phaseout.org).

Selection has to be based on the work environment, the individual cleaning practices and the ambient temperature. For example, Acetone and Hexane have good solvency power but evaporate very fast due to their low boiling point (40°C) and thus may not be an economical option for many mills. Solvents like Hexane, Isopropyl alcohol (IPA) 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 criteria of stain/soil removal, a mixture/blend could be the solution.

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.

### 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.

Table1
**Properties of selected solvent**

| Parameters | Flash point - °C | Boiling point - °C | Vapour pressure - mmHg | Dipole moment - debye | Hansen solubility parameter |
|---|---|---|---|---|---|
| Acetone | -20 | 56 | 180 | 2.9 | 20 |
| Petrol | -40 | 35-215 | 465 | 0.3 | 18 |
| 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 |
| Methyl ethyl ketone | -9 | 79 | 78 | 2.8 | 19 |
| Mineral turpentine Oil | 36-38 | 146-197 | 25 | - | 15.8 |
| Perchloro ethylene | None | 121 | 14 | 0 | 20.3 |
| NC thinner | -4 | 90-112 | 40 | - | 17.6-17.8 |
| White petrol* | -18 | 150-120 | 180 | - | 7.3 |
| Xylene | 38 | 138 | 16 | 0.6 | 18 |

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

### Alternative materials for Cots

New materials which are anti-static in nature like Nitrile, are increasingly used for cots manufacture. This reduces the lapping tendency and hence the frequency in cleaning.

# 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.

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 2 :
**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 3 shows the hazard ratings of the alternatives discussed in the previous section:

Table 3
**Hazard ratings of specific alternatives**

| Substance | Inhalation | Skin | Environment | Flammability |
|---|---|---|---|---|
| Acetone | A | A | | D |
| Ethyl acetate | A | A | | D |
| Hexane | D | C | E | D |
| Isopropyl alcohol | A | | | D |
| Methyl ethyl ketone | A | A | | D |
| Mineral turpentine | D | C | E | D |
| Perchloro ethylene | D | C | E | |
| White petrol | D | C | E | D |
| Xylene | B | B | | C |

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.

## 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;

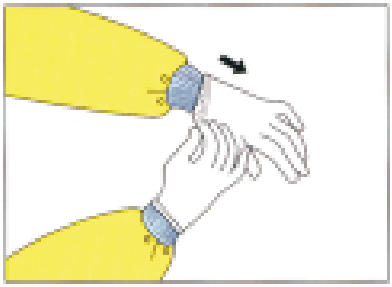
(iv) Use measures that give collective protection before considering individual protection;

(V) Ensure appropriate instruction and training of all staff concerned;

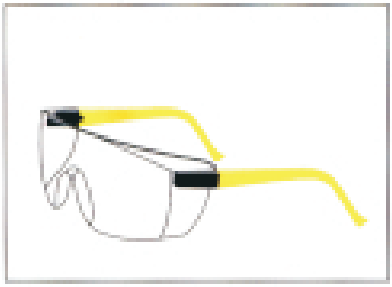
(vi) Provide adequate personal protective equipment (PPE) if a significant risk still remains.

## 4.3 Good practices

- Prudent substance selection: Select the safest possible substance (see table 3 '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 7: **Protective gloves**



Picture 8: **Safety goggles**

- **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.

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

Table 4
**Selection of gloves**

| Chemical | Glove Material |
|---|---|
| Acetone | Butyl, Nitrile, Neoprene, Laminate film |
| Ethyl acetate | Neoprene, Butyl |
| Hexane | Nitrile, Neoprene, Viton |
| Perchloro ethylene | Nitrile, Neoprene |
| Xylene | Viton, PVA |

# 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).

**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.

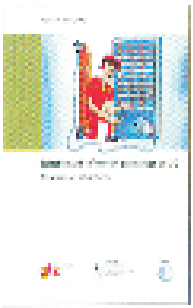
# 6. Other project publications


***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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