UNEP
UNITED NATIONS ENVIRONMENT PROGRAMME
INDUSTRY AND ENVIRONMENT

UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY

Technologies for Protecting the Ozone Layer

Catalogue

Specialized Solvent Uses

SOURCE BOOK

Technologies for Protecting the Ozone Layer

Catalogue Specialized Solvent Uses

June 1994

Multilateral Fund for the Implementation of the Montreal Protocol
1800 McGill College Avenue, 27th Floor
Montreal, Quebec H3A 3JC
Canada

UNEP

United Nations Environment Programme
Industry and Environment Programme Activity Centre
39-43 Quai André Citroën
75739 Paris Cedex 15
France

United States Environmental Protection Agency
Stratospheric Protection Division
6205J
401 M Street, SW
Washington, D.C. 20460
United States

Printed on Recycled Paper

SOURCE BOOK

Trademarks

All trademarks or servicemarks used in this catalogue are the trademarks or servicemarks of their respective companies.

Reproduction of this Document

UNITED NATIONS PUBLICATIONS	
Sales N°	94-III-D8
ISBN N°	92-807-1429-5

Disclaimer

The United Nations Environment Programme (UNEP), the United States Environmental Protection Agency (USEPA), the International Cooperative for Ozone Layer Protection (ICOLP), and ICF Incorporated do not endorse the performance, worker safety, or environmental acceptability of any of the technical options discussed. Every industrial operation requires consideration of worker safety and proper disposal of contaminants and waste products. Moreover, as work continues -- including additional toxicity testing and evaluation -- more information on health, environmental, and safety effects of alternatives and replacements will become available for use in selecting among the options discussed in this document.

While the information contained herein is believed to be accurate, it is summarized and does not present all relevant details on alternatives. Implementing alternatives presented in this document requires careful consideration of a wide range of situation-specific parameters, many of which may not be addressed by this document. Responsibility for implementation and the resulting impacts rests exclusively with the individual or entity choosing the alternative.

UNEP, USEPA, ICOLP, and ICF in furnishing or distributing this information, do not make any warranty or representation, either expressed or implied, with respect to the accuracy, completeness, or utility of the information presented in this document; nor do they assume any liability of any kind whatsoever for events resulting from the use of, or reliance upon, any information, material, or procedure contained herein, including, but not limited to, any claims regarding health, safety, environmental effects or fate, efficacy, performance, or cost.

Mention of any company, association, or product in this document is for informational purposes only and does not constitute a recommendation of any such company, association, or product, either, expressed or implied, by UNEP, USEPA, ICOLP, ICF or the reviewers of this document and the companies and organisations that employ them.

The reviewers listed in this document have reviewed an interim draft of this document, but have not reviewed this final version. These reviewers are not responsible for any errors which may be present in this document or for any effects which may result from such errors.

Table of Contents

Foreword

Mounting scientific research has implicated chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs) and methyl bromide in the depletion of the stratospheric ozone layer, that segment of the earth's atmosphere which protects animal and plant life from the damaging effects of ultraviolet radiation. In September 1987, nations concerned about this crisis signed the Montreal Protocol, a landmark agreement that identified the major ozone-depleting substances (ODSs) and established a timetable for the reduction and eventual elimination of their use. Under the Protocol and its amendments, ODS production and consumption of the controlled substances are to be reduced and eliminated through the development of chemical substitutes and alternative manufacturing processes. Information exchange is crucial in order to realize this global phaseout.

As an Implementing Agency of the Multilateral Fund for the Implementation of the Montreal Protocol (MF), one role of the United Nations Environmental Programme (UNEP) is to provide Article 5 (i.e., developing) countries with the latest technical information to assist their expeditious phaseout of controlled ODS. Through various regular feedback mechanisms with the concerned countries, UNEP's Industry and Environment Programme Activity Centre (UNEP IE/PAC) has perceived the broad information needs of Article 5 countries to be:

- *what are the technical options that currently exist to eliminate ODS;*
- *who are the suppliers of the technologies, equipment and products required for each technical option; and*
- *how can a company assess, select, and implement an alternative technology.*

In response to each of these demonstrated needs, UNEP IE/PAC's OzonAction programme under the Multilateral Fund is producing a series of technical reference publications and guidelines that will assist industry in developing countries to make the transition from ODS to non-ODS alternatives, including the development of ODS phase-out projects. As part of the series of sector-specific *Catalogues of Technologies for Protecting the Ozone Layer,* this publication is intended to assist industry and governments in Article 5 countries with:

- identifying alternative technologies in the aerosols, sterilants, carbon tetrachloride, and miscellaneous uses sectors; and
- initiating related ODS phase-out projects.

Assistance Available to Article 5 Countries from UNEP IE/PAC

Technical Options

To address the need to understand the available technical options, UNEP IE/PAC has produced a series of easy-to-read brochures that provide an overview of the options available to companies and organizations seeking to eliminate their ODS use. The *Protecting the Ozone Layer* technical brochure series is based on the UNEP Technical Options Committee reports, which are also available to developing countries through UNEP IE/PAC.

The brochures are designed for decision-makers in government and industry, and make an excellent introduction to the alternatives in the aerosols, foams, halons, solvents, and refrigeration sectors.

Technology suppliers

Once the technical options are understood, the next step a developing country must face is to select an appropriate option and then identify the wordwide suppliers of the alternative technologies and equipment. In response to this need, UNEP IE/PAC is producing a series of *Catalogues of Technologies for Protecting the Ozone Layer* for the major ODS use sectros (aerosols, foams, solvents, and refrigeration). These technical references provide descriptions of the current ODS uses in the sector, an overview of what ODS alternatives currently exist, and contacts for the suppliers of the alternative technologies. These catalogues are being developed with the cooperation of the UNEP Technical Option Committees, and one has been co-produced with USEPA and industry associations such as ICOLP.

These sector-specific catalogues are targeted at plant engineers and managers responsible for identifying, evaluating, and implementing these alternatives. It is also expected that the governments ODS officers in the national ozone units in developing countries will use them as they work with their industry, Implementing Agencies, and others to develop ODS phase-out projects.

Assessment and Implementation

The next step a company or government must take after the technology is selected and the suppliers are identified is to successfully implement the chosen technology. UNEP IE/PAC is assisting the process through two publications:

- *Practical Guide to Policy Guidelines for Industry on Management of Phase-out of ODS.*
  The guide is a practical document whose objective is to help industry in developing countries, specifically small and medium-sized enterprises (SMEs), to better manage and accelerate their phase-out of ozone depleting substances controlled under the Montreal Protocol. It is intended to be a "management guideline" document for business managers.

- *Elements for Establishing Policies, Strategies and Institutional Framework for Ozone Layer Protection.* This manual will provide governments in developing countries with guidelines for establishing an ODS phase-out policy and strategy, including the supporting actions, in particular the establishment of an "ozone office" in developing countries.

Acknowledgements

This catalogue was prepared by the United Nations Environment Programme (UNEP) and the United States Environmental Protection Agency (USEPA) in conjunction with the International Cooperative for Ozone Layer Protection (ICOLP), and with the input of a number of individuals and organizations.

The catalogue was researched and written by the following team at ICF Incorporated in Washington, D.C., USA:

Mr. Michael Zatz
Ms. Jennifer Ketzis
Ms. Megan Rush
Mr. Sudhakar Kesavan

The project was managed, and the catalogue was reviewed for technical accuracy and comprehensiveness, by:

Dr. Stephen O. Andersen
Deputy Director, Stratospheric Protection Division, United States Environmental Protection Agency; Chair, UNEP Solvents, Coatings, and Adhesives Technical Options Committee

Mr. John Sparks
Project Manager - Methyl Chloroform Phaseout, Program Outreach Section, Stratospheric Protection Division, United States Environmental Protection Agency

Ms. Nina Bonnelycke
Solvents Substitutes Analyst, Analysis and Review Branch, Stratospheric Protection Division, United States Environmental Protection Agency

The following technical representatives also provided technical review:

Husamuddin Ahmadzai, *Swedish Environmental Protection Agency, Sweden*
Bryan Baxter, *British Aerospace (retired), United Kingdom*
Jay Baker, *Ford Motor Company, ICOLP Technical Committee Chairman, USA*
Pakasit Chanvinij, *Thai Airways International, Thailand*
Jorge Corona, *Consultant, Mexico*
Brian Ellis, *Protonique S.A., Switzerland*
Steve Evanoff, *Lockheed Fort Worth Company, USA*
Joe Felty, *Texas Instruments, ICOLP Board Member, USA*
Don Hunt, *United States Air Force, ICOLP Affiliate, USA*

Steve Newman, *National Aeronautics and Space Administration (NASA), USA*
Patrice Rollet, *DEHON S.A., France*
Yoshihide Shibano, *JACET, Japan*
Darrel Staley, *Boeing Defense and Space Group, USA*
John Stemniski, *Charles Stark Draper Laboratory, USA*
Jane Yang, *Ford Motor Company, ICOLP Member, USA*

UNEP IE/PAC staff involved in the production of this catalogue were:

Mme. J. Aloisi de Larderel, *Director, UNEP IE/PAC*
Mr. Rajendra Shende, *Coordinator, UNEP IE/PAC OzonAction Programme*
Mr. James Curlin, *Consultant, UNEP IE/PAC OzonAction Programme*
Ms. Trude Tokle, *Consultant, UNEP IE/PAC OzonAction Programme*

The USEPA, UNEP and ICOLP wishes to thank all of the contributors and their employers for helping to make this catalogue possible.

Getting Started

The following is a step-by-step guide to using this document. Taking these steps will ensure that the reader makes the best possible use of the catalogue.

Step 1: Read the "Disclaimer"

The disclaimer provides important information about the nature of the information presented in the catalogue.

Step 2: Read the "Introduction" section

Read the brief introduction at the beginning of the catalogue. It provides a summary of the problem of ozone-depletion, the relevant international regulations driving the phaseout of ozone-depleting substances, and the content of the catalogue.

Step 3: Read the "Methodology" section

The methodology section provides information on how specialized uses and alternatives were selected for inclusion in the catalogue and describes the methods used for researching the alternatives presented in the datasheets.

Step 4: Read the User's Guide

All readers should carefully read the User's Guide which describes the complete set of criteria that should be considered in the evaluation of alternative technologies.

Step 5: Read the "Summary of Specialized Uses" section

Those sections of the Summary of Specialized Uses which apply to the relevant use of ozone-depleting substances -- mould release agents, printed circuit boards, aerosol dusters, etc. -- should be read next. Each section summarizes the information presented in the datasheets.

Step 6: Identify and read relevant datasheets

Use the Table of Contents to identify datasheets of relevance. Read these datasheets and identify alternatives about which additional information is desired.

Step 7: Gather additional information on potential alternatives

Readers may wish to use the list of vendors provided at the end of each datasheet and the addresses in Annex E to gather additional information on alternatives. Trade publications, industry experts, conferences, and in-house staff may also be good sources of information. Additional information may also be available from UNEP IE/PAC's OzonAction Information Clearinghouse database. Refer to Annexes A and C for more information.

Introduction

Background and Overview

The Montreal Protocol and the Multilateral Fund

In 1974, Sherwood Rowland and Mario Molina of the University of California claimed that the man-made chemicals known as chlorofluorocarbons (CFCs) were damaging the stratospheric ozone layer. Subsequent research supported the theory, and it is now established that the stratospheric ozone layer -- which protects the earth from dangerously high levels of ultraviolet radiation from the sun -- is being destroyed by human activity. Ozone depleting substances (ODSs) including CFCs and carbon tetrachloride are used in the manufacture and operation of thousands of products, including aerosol products, sterilants, solvent applications, and miscellaneous uses.

The Montreal Protocol on Substances that Deplete the Ozone Layer was drawn up under the guidance of the United Nations Environment Programme (UNEP) in September 1987. The Protocol identified the main ODSs, and set specific limits on their production and consumption levels in the future. Exhibit 1 lists the 134 countries that have ratified the agreement as of May 1994. Universal ratification is quite probable in the near future.

London Amendments to the Montreal Protocol

It is intended that the Protocol be continually updated as necessary to reflect the changing scientific evidence and technological developments. In June 1990, the Parties to the Protocol met in London to consider the implications of new scientific evidence that showed that the ozone layer was being depleted even faster than originally thought. The London meeting agreed to phase out the consumption and production of CFCs and halons by the year 2000, and to control other chemicals, namely carbon tetrachloride and 1,1,1-trichloroethane.

The London Amendments acknowledged the financial and technical assistance that developing countries would need, and to meet this need the Parties established the Multilateral Fund (MF) as part of a financial mechanism. The MF serves all countries that operate under paragraph 1 of Article 5 of the Protocol (known as "Article 5 countries"). United Nations Development Program (UNEP), the United Nations Development Programme (UNDP), and the World Bank were chosen to be the Fund's original implementing agencies, with the United Nations Industrial Development Organization (UNIDO) being added later. UNEP's responsibility as an implementing agency is to conduct research, gather data, and to provide a clearinghouse function.

Copenhagen Amendments to the Montreal Protocol

At their fourth meeting in Copenhagen, Denmark (November 1992), the Parties took decisions that advanced the phaseout schedules in non-Article 5 (i.e., developed) countries for several ODSs, included methyl bromide and HCFCs as new controlled substances, and continued the financial mechanism to assist Article 5 countries.

The London and Copenhagen Amendments were ratified by the required number of parties, and both amendments have entered into force.

Exhibit 1

PARTIES TO THE MONTREAL PROTOCOL

Algeria
Antigua and Barbuda
Argentina
Australia
Austria
Bahamas
Bahrain
Bangladesh
Barbados
Belarus
Belgium
Benin
Bosnia & Herzegovina
Botswana
Brazil
Brunei Darussalam
Bulgaria
Burkina Faso
Cameroon
Canada
Central African Republic
Chile
China
Colombia
Congo
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Denmark
Dominica
Ecuador
Egypt
El Salvador
EEC
Fiji
Finland
France
Gambia
Germany
Ghana
Greece
Grenada
Guatemala
Guinea
Guyana
Honduras
Hungary
Iceland
India
Indonesia
Iran
Ireland
Israel
Italy
Jamaica
Japan
Jordan
Kenya
Kiribati
Kuwait
Lebanon
Libyan Arab Jamahiriya
Liechtenstein
Luxembourg
Malawi
Malaysia
Maldives
Malta
Marshall Islands
Mauritania
Mauritius
Mexico
Monaco
Morocco
Myanmar
Namibia
Netherlands
New Zealand
Nicaragua
Niger
Nigeria
Norway
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Portugal
Romania
Republic of Korea
Russian Federation
St. Kitts and Nevis
Saint Lucia
Samoa
Saudi Arabia
Senegal
Seychelles
Singapore
Slovakia
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Sudan
Swaziland
Sweden
Switzerland
Syrian Arab Republic
Tanzania
Thailand
The former Yugoslav Republic of Macedonia
Togo
Trinidad & Tobago
Tunisia
Turkey
Turkmenistan
Tuvalu
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
Uruguay
Uzbekistan
Venezuela
Viet Nam
Yugoslavia
Zambia
Zimbabwe

Date: May, 1994

Bangkok Meeting of the Parties

At their fifth meeting in Bangkok, Thailand (November 1993), the Parties approved a budget of US$510 million for the MF for the 1994-96 period. In light of the availability of banked halons and the efficiency of technical alternatives to halons, the Parties decided that in 1994 no exemptions for production of halon for essential uses were necessary for developed countries. The Parties also agreed, inter alia, that information on HCFC and methyl bromide alternatives and substitutes be updated annually.

Signatories to the Protocol have agreed to reduce and eliminate the use of the controlled ODSs even though substitutes and alternatives technologies were not yet fully developed. Industries and manufacturers are starting to replace the controlled ODSs with less damaging substances, but a major obstacle in the conversion process is a lack of up-to-date, accurate information on issues relating to ODS substitutes and ODS-free technologies. UNEP is meeting this challenge through its OzonAction programme (see Annex A).

Phaseout Efforts in the United States

As amended in 1990, the U.S. Clean Air Act (CAA) contains several stratospheric ozone protection provisions. Ozone-depleting substances are grouped into Class I or Class II substances. Class I substances include all fully halogenated CFCs, three halons, 1,1,1-trichloroethane, and carbon tetrachloride. Class II is comprised of all hydrochlorofluorocarbons (HCFCs). Several key sections of the CAA ozone protection provisions of relevance to users of ODSs in specialized applications are:

- ***Section 604 and Section 605: Phaseout of Production and Consumption of Class I and Class II Substances.***
  In response to the Copenhagen Amendments to the Montreal Protocol and earlier announcements by former President Bush, the USEPA recently accelerated the phaseout schedule for ODSs. The revised schedule includes an accelerated phaseout for both Class I and Class II substances. Class I substances will be phased out of production by December 31, 1995. Phaseout dates for HCFCs vary according to chemical. The new schedule also includes provisions for a phaseout of methyl bromide by the year 2001.

- ***Section 610: Nonessential Products Containing Chlorofluorocarbons***
  This section directs the USEPA to promulgate regulations that prohibit the sale or distribution of certain "nonessential" products in aerosol and foam applications that use Class I and Class II substances. The phaseout date for these products was January 1, 1994. However, the USEPA is granting limited exemptions.

- ***Section 611: Labelling***
  This section of the CAA directs the USEPA to promulgate regulations requiring labelling containers not only of Class I and Class II substances but also products manufactured with these substances. The label must read "Warning: Contains or manufactured with [*insert name of substance*], a substance which harms public health and environment by destroying ozone in the upper atmosphere." For easy recognition by average consumers, the label must clearly identify the ODS by chemical name, and must be placed so that it is clearly legible and conspicuous. This regulation took effect on May 15, 1993.

- ***Section 612: Safe Alternatives Policy***
  Section 612 requires the USEPA to evaluate the overall environmental and human health impacts of alternatives to ozone-depleting chemicals. This policy ensures that ODSs will be replaced by substitutes that reduce overall risks to human health and the environment. The USEPA expects to issue final lists of approved substitutes by March 1993 and will evaluate new substitutes on an on going basis after that date.

As a further incentive to reduce the production and consumption of ODSs, the U.S. Congress placed an excise tax on ODSs manufactured or imported for use in the United States. The tax is based on each chemical's ozone-depletion potential. These taxes were recently increased as a part of the U.S. Congress' 1992 comprehensive energy bill. The following table shows the tax rates:

Calendar Year	Tax Amount Per Kilogram (US$)	
	CFC-113	1,1,1-Trichloroethane
1991	$2.416	$0.302
1992	$2.945	$0.368
1993	$5.908	$0.465
1994	$7.672	$0.959
1995	$9.436	$1.179

Accelerated Phaseout Efforts in Europe

Under the Single European Act of 1987, the twelve members of the European Community (EC) are subject to environmental directives. The members of the EC are Belgium, Denmark, Germany, France, Greece, Great Britain, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Council Regulation number 594/91 of March 4, 1991 provides regulatory provisions for the production of substances that deplete the ozone layer. The EC phaseout schedule for CFC-113 production is more stringent than the Montreal Protocol. It calls for an 85 percent reduction of CFC-113 by January 1, 1994 and a complete phaseout by January 1, 1995. For 1,1,1-trichloroethane, the production phaseout schedule calls for a 50 percent cut in production by January 1, 1994 and a complete phaseout by January 1, 1996. While all members must abide by these dates, Council Regulation number 3322/88 of October 31, 1988 states that EC members may take even more stringent measures to protect the ozone layer.

The European Free Trade Agreement (EFTA) countries of Austria, Finland, Iceland, Norway, Sweden, and Switzerland have each adopted measures to completely phase out fully halogenated ozone-depleting compounds. Austria, Finland, Norway, and Sweden will phase out the use of newly-produced CFC-113 in all applications by January 1, 1995 with possible exemptions for essential uses. Sweden also plans an aggressive phaseout date of January 1, 1995 for 1,1,1-trichloroethane. In addition, some of the EFTA countries have sector-specific interim phaseout dates for certain solvent uses. Austria is planning to phase out CFC-113 in a number of solvent cleaning applications by January 1, 1994. Sweden and Norway already eliminated their use of CFC-113 in all applications except textile dry cleaning on January 1, 1991 and July 1, 1991, respectively.

Phaseout Efforts in Canada

Environment Canada, the federal environmental agency responsible for environmental protection in Canada, has proposed a reduction program that is more stringent than the Montreal Protocol. Environment Canada has also announced a series of target dates for the phaseout of CFCs in specific end uses. For solvent cleaning applications, such as metal and precision cleaning, it mandates a production and import phaseout of CFC-113 by the end of 1994. Under the proposed schedule, production, imports, and exports of CFCs are to be eliminated by January 1, 1996, with a 75 percent reduction by January 1, 1994. For carbon tetrachloride, the phaseout date is January 1, 1995 -- one year earlier than that mandated by the Montreal Protocol. Production, imports, and exports of 1,1,1-trichloroethane will be halted by January 1, 1996, with interim reductions of 50 percent by January 1, 1994, and 85 percent by January 1, 1995.

Phaseout Efforts in Japan

On May 13, 1992, the Ministry of International Trade and Industry (MITI) of Japan requested its 72 Industrial Associations to phase out CFC and 1,1,1-trichloroethane production and imports by the end of 1995. The recent Japanese Ozone Layer Protection Act gives MITI the authorization to promulgate ordinances governing the use of ozone-depleting compounds. MITI and the Environmental Agency have established the "Guidelines for Discharge Reduction and Use Rationalization." Based upon these guidelines, various government agencies provide administrative guidance and advice to the industries under their respective jurisdictions. Specifically, MITI is working with the Japan Industrial Conference for Ozone Layer Protection (JICOP) to prepare a series of manuals which provide technical information on alternatives to CFC-113 and 1,1,1-trichloroethane. The manuals prepared are:

- Manual for Phasing-Out 1,1,1-Trichloroethane;
- Manual for Reduction in the Use of Ozone-Depleting Substances.

MITI also encourages industry to reduce consumption of ozone-depleting compounds through economic measures such as tax incentives to promote the use of equipment to recover and reuse solvents.

Purpose of the Catalogue

This catalogue is intended to assist users in making a transition from ODSs to alternatives that do not threaten the ozone layer. It is targeted primarily at plant engineers and managers responsible for identifying, evaluating, and implementing these alternatives. It is expected that government policy makers will also find the catalogue useful as they work with industry, bilateral agencies and agencies of the Multilateral Fund responsible for implementing the Montreal Protocol. This catalogue will also be useful to large commercial businesses and retailers that currently purchase and use ODS-containing products. The catalogue provides these businesses with an overview of the available alternatives and identifies some of the suppliers of these alternatives.

While ODSs are used in a wide range of applications, this document focuses only on specialized uses, including especially those applications or processes in which the amount of ODS used is relatively small, compared to the use of ODSs in refrigeration or foam blowing.[1]

Content of the Catalogue

This document is divided into four sections. The first section discusses the methodology used to prepare the catalogue. The second section provides a set of criteria to be considered in the evaluation of alternative

[1] *General uses of ozone-depleting solvents in bulk metal cleaning and electronics cleaning, and alternatives such as aqueous cleaners, semi-aqueous cleaners, and no-clean soldering, have been addressed at length in other USEPA and UNEP publications. Several of these publications are discussed on page 99 of this document.*

technologies. The third section presents the uses addressed in this document and describes each of the specialized use sectors included in the catalogue. The fourth section of this document presents a series of datasheets on specific technical alternatives. For example, one datasheet addresses the use of petroleum distillates as solvents in fabric protectants while another focuses on using non-solvent mould release agents in lieu of a process that uses CFC-11, CFC-113, or 1,1,1-trichloroethane. As new information becomes available, the datasheets will be updated, and new datasheets will be added.

A key feature of the datasheets is the list of suppliers around the world who offer the technology. In addition, the datasheets provide the following types of information:

- Category of use
- Name of the alternative technology and the ODSs to be replaced
- General description of the alternative, including performance characteristics
- Environment, health, and safety concerns such as toxicity, VOC classification, ozone-depletion potential, and global warming potential
- Materials and equipment changes
- Associated costs
- Current use and availability

It is important to note that the information in the datasheets is summarized and, therefore, does not present all relevant details on alternatives. In addition, the available alternatives change continuously. Because suppliers are working constantly to develop and offer new technologies, the information contained herein may be superseded over time.

Users of ODSs are advised to use this document as a starting point in their search for alternatives. Suppliers and other potential sources of information are included in this document to assist users of ODSs in their search for alternatives. The search should also include review of available technical literature, consultations with several suppliers and trade associations, testing and evaluation of multiple alternatives, and careful review and consideration by in-house engineers and managers. Such an approach can maximize the opportunity for a successful and cost-effective transition away from use of ODSs.

Request for Information

The documents are **"living"** documents that will be updated on a regular basis to reflect technological advancements, new products, and changing control measures.

Information is welcome both on alternatives to uses covered in the catalogue as well as on alternatives not discussed. The USEPA and UNEP request that companies or individuals with such information use the form in Annex D to supply this information to:

United Nations Environment Programme
Industry and Environment Programme Activity Centre
39-43 Quai André Citroën
75739 Paris Cedex 15
France
Fax: (33) 1 44 37 14 74

or

Stratospheric Protection Division, 6205J
U.S. Environmental Protection Agency
401 M Street, NW
Washington, D.C. 20460
United States
Fax: (1) 202 233 9577

1. Methodology for Preparing the Catalogue

1. Methodology for Preparing the Catalogue

This section describes the method used to prepare this catalogue. It begins by discussing the sources used to identify uses and their alternatives. It then presents the criteria used to select uses for inclusion in the catalogue. The section concludes with a description of the methods used to gather technical information on the alternatives presented in the catalogue.

Sources of Information

In preparing this catalogue, several sources were consulted. Written materials such as conference proceedings and trade journals were reviewed first. These sources were supplemented with information from industry organizations and experts in the field. Many of these experts are members of the UNEP Solvents, Coatings, and Adhesives Technical Options Committee and the UNEP Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride Technical Options Committee set up under the Montreal Protocol. These industry experts were asked to complete a data form identifying specialized uses of ODSs and providing information on alternatives and their manufacturers. A copy of the data form sent to these individuals is presented in Annex D. Technical data on the alternatives (e.g., performance, health, environmental, and safety concerns, equipment changes, etc.) were supplemented from a wide variety of sources, including trade journals, industry organizations, product literature, and suppliers.

Selection of Specialized Uses

After compiling the list of specialized uses, the next step was to select those specialized uses to be addressed in this catalogue. The original list of specialized uses was narrowed down using the following four major criteria:

- Availability of alternatives
- Quantity of ODS consumption in the use sector
- Worldwide prevalence of the use
- Existing literature on alternatives

A brief description of each of the criteria follows.

Availability of Alternatives. For each specialized use, a number of potential alternatives may exist. Some of these alternatives are commercially available worldwide, while others are still in the development or testing stages and are not yet commercially available. To make the catalogue as current and useful as possible, only those uses with alternatives that are commercially available worldwide were included in the catalogue.

Quantity of ODS Consumption in the Use Sector. Of the numerous specialized uses identified, some consume relatively large amounts of ODSs, while others require small quantities of ozone-depleting chemicals. The purpose of this catalogue is to effect the large-scale elimination of ODSs from manufacturing and maintenance operations. Therefore, the uses that consume larger quantities of ODSs relative to other specialized uses were considered candidates for the catalogue.

Worldwide Prevalence of the Use. Many of the specialized uses identified are prevalent worldwide, while others are found only in specific countries or geographic regions. In addition, while some of the uses are relevant to a large number of manufacturers or users, others apply only to a very few companies. Since the intent of this catalogue is to provide the greatest amount of information about alternatives that are relevant to the largest number of companies and individuals, those specialized uses whose use is limited either by location or by the number of interested parties are not addressed in this catalogue.

Existing Literature on Alternatives. Because this catalogue is meant to supplement, rather than to repeat, already existing information, a large number of specialized uses were eliminated from consideration early in the evaluation process. General uses such as bulk metal cleaning and electronics cleaning and alternatives such as aqueous cleaners, semi-aqueous cleaners, and no-clean soldering have been addressed at length in other USEPA and UNEP publications (several of these publications are discussed on page 99 of this document). Therefore, they are not included in this catalogue. The specialized uses and alternatives addressed in this catalogue are those for which little, if any, published material currently exists.

After selecting uses to discuss in the catalogue, each use was placed into one of three categories. The first category consists of those specialized uses for which alternatives are currently on the market; for each use in this category, there are alternative technology datasheets and use sector descriptions included in this catalogue. The second category consists of those uses for which no known alternatives exist. These specialized uses are described in a use sector description but no alternative technology datasheets are included in this catalogue. The third category consists of those uses no longer of commercial interest. No datasheets on alternatives to these uses are included in the catalogue, although a brief description of the specialized use sector is provided.

Research on Technology Datasheets

For many of the uses addressed, there are a large number of technically feasible alternatives commercially available on the international market. The list of alternatives was narrowed to include only those alternatives that are new to the market and those most likely to be used worldwide. These alternatives were then researched in-depth and Alternative Technology Datasheets were compiled.

For those uses included in the catalogue, the full range of alternatives was investigated. Existing literature and contact with industry experts served as primary sources for this information. A number of vendors and users were also interviewed. For example, to gather information on aerosol mould release agents, a number of manufacturers were contacted, as were a number of users of mould releases.

2. User's Guide for Selecting Non-ODS Alternatives

2. User's Guide for Selecting Non-ODS Alternatives

Introduction

Plant managers should consider a variety of criteria when selecting an alternative technology to replace CFCs, carbon tetrachloride, and 1,1,1-trichloroethane in specialized use applications. These criteria may be categorized as follows:

- Organizational
- Regulatory
- Economic
- Environment, Health, and Safety
- Technical

This section discusses the various criteria that fall into each of these five groups.

Organizational Considerations

When undertaking efforts to phase out ozone-depleting substances (ODSs), company decision-makers and plant managers must carefully consider the relation between the organization's phaseout efforts and its other activities and priorities. Clearly, a company's phaseout of ODSs is greatly facilitated if its management is fully committed to achieving such a goal. Other important organizational factors that may have a bearing on the choice of a non-ODS technology include:

- ***Compatibility with corporate environmental policy.*** Some non-ODS alternatives generate other forms of emissions, effluents, or other wastes that are subject to the company's own environmental policies. In addition, if the company is a subsidiary of a foreign-owned corporation, the parent company's environmental policies may restrict the use of certain alternatives.

- ***Compatibility with other corporate objectives.*** Corporate policies may pose obstacles to implementing certain non-ODS technologies. In all cases, conflicts between such policies and the need to phase out ODSs must be reconciled, with priority being given either to the old directive or to the demands of a phaseout. For example, a company may eliminate certain alternative technologies based on concern over product quality or performance, or it may decide that the change in quality or performance is acceptable given the impact of the new technology on its consumption of ODSs.

- ***Feasibility given existing organizational structure.*** Any requirements of conversion projects must be compatible with the organizational structure of the firm. For example, if converting to a non-ODS technology requires that a plant be shut down temporarily while retrofits or full conversions are made the firm must have the ability to either accept the temporary loss of production capacity (e.g., by building up and then depleting product stocks) or match the loss in productive capacity at one plant with increases in production at other plants, or at the facility of a contract filler.

- ***Availability of capital.*** Perhaps the single greatest factor that impacts the ability of a plant to implement non-ODS technologies is the willingness of company management to devote the necessary capital resources. Again, the costs of converting to alternative technologies must be reconciled with competing demands for capital within the firm, and finally, they must be reconciled with the amount that management decides it is willing to spend on conversion projects. The availability of financing from the Montreal Protocol Multilateral Fund to cover the incremental costs of conversion projects in Article 5 (developing) countries is intended to eliminate this impediment.

Regulatory Considerations

Plant managers must evaluate potential alternative chemicals or processes as to their compliance with a variety of government regulations. Alternatives should conform to the specific regulations that apply in the country where the alternative will be implemented. This may include both national and local regulations. In the United States, for example, alternatives must be evaluated vis-a-vis relevant sections of the 1990 Clean Air Act Amendments, as well as against state and local regulations that may deal with environmental aspects of alternatives such as emissions of volatile organic compounds (VOCs) or effluents from process wastewater. In Europe, "best available technology" (BAT) guidelines have been developed to control VOC emissions from certain types of ODS using processes. Exporters must be aware of relevant regulations in the countries to which they are exporting.

Economic Considerations

Process economics is a key factor in the selection of alternative technologies. Initial costs associated with an alternative process include capital cost of equipment, possible costs associated waste treatment/handling equipment, and costs for permit changes for new construction or new operating procedures. In addition, operating cost calculations incorporate costs for material, labour, maintenance, and utilities. Cost estimates for an alternative process can be developed through preliminary process design. One simple approach is to calculate the net present value (NPV) based on the discount rate and period of investment used by the company. The NPV is calculated as follows where (n) is the number of years, and (i) is the discount rate.

$$NPV = Cost_0 + Cost_1/(1+i) + Cost_2/(1+i)^2 + ... + Cost_n/(1+i)^n$$

While traditional economic considerations such as rate of return and payback period are important, the ODS reduction program may be justified on the basis of environmental protection and on the reliability of the ODS supply. It is important to recognize that the price of ODSs will rise rapidly as supplies dwindle. If cost savings that result from reduced ODS consumption are taken into consideration, then some alternative processes or substitute chemicals are likely to be significantly cheaper than the processes currently being used.

Environment, Health, and Safety Considerations

Unfortunately, there are no perfect substitutes for ODS use. Plant managers may often have to make tradeoffs on environmental, health, and safety issues. Such issues must be considered by plant managers as they choose between often imperfect ODS substitutes. In particular, they should consider the following:

- ***Ozone depletion and global warming.*** Each alternative must be evaluated for its contribution to ozone depletion as well as global warming. In some cases, it might be considered unacceptable to replace a high ozone depletor with a non-ODS that has a high global warming potential (GWP). The focus during the phaseout of ozone-depleting substances should be on finding substitutes which do not contribute significantly to other environmental problems.

- ***Volatile organic compounds (VOCs).*** Alternative chemicals that are classified as VOCs are photochemically reactive, and thus contribute to the formation of tropospheric ozone (smog). Chemicals that are VOCs may have national and/or local regulations concerning their use.

- ***Energy efficiency.*** The energy efficiency of an alternative cleaning process will have direct impacts on both the cost of maintaining a process as well as on the environment (e.g., global warming concerns).

- ***Toxicity and worker safety.*** Alternatives should minimize occupational exposure to hazardous chemicals. Personal Exposure Limits (PELs) such as those determined by the Occupational Health Safety Administration (OSHA) in the United States. should be considered before selecting alternatives. Personal protective equipment, such as gloves, safety glasses, and shop aprons, should be reviewed for compatibility with alternatives. Work procedures and practices should be reviewed and modified to accommodate the properties of the alternative.

- ***Flammability.*** Fire and explosion hazards are very important considerations. In some instances, changes in a material or process will require the review of fire protection engineers and insurance carriers . Flammability should be evaluated and adequate fire control measures should be implemented before switching to an alternative that involves potentially flammable substances. In some cases, relocation of a plant may be necessary.

- ***Recyclability of solvent.*** It is economically and environmentally beneficial to find alternative solvents whose waste product can be recaptured and reused. For example, spent solvent can often be treated and returned to the facility for reuse.

- ***Ground water pollution.*** In order to avoid potentially expensive cleanup procedures in the future, plants should plan for the proper disposal of leftover solvent. If possible, solvent should be handled on a well-lined concrete floor. If spillage occurs, the solvent should be recovered immediately to the maximum extent possible.

Technical Considerations

The technical feasibility of an alternative process or chemical substitute must be evaluated on a case-by-case basis, and depends on a number of important considerations. These considerations will vary greatly from facility to facility, and will depend on, among other things, plant location and product function.

3. Summary of Specialized Uses

3. Summary of Specialized Uses

Definition of Specialized Use

Ozone-depleting substances (ODSs) are used in a large number of major applications such as refrigeration, foam blowing, bulk parts cleaning, and fire protection. Because of the large quantities of ODSs used in these major applications, much information about alternative technologies is available to the general public. However, many applications use only a small amount of an ODS. For the purposes of this catalogue, "specialized use" was defined as any use that, although it may be widespread, requires relatively small quantities of CFC-113, 1,1,1-trichloroethane, carbon tetrachloride, and/or other ODSs in comparison to historical uses of ODSs in applications such as refrigeration, foam blowing, or fire extinguishing. This catalogue provides information on alternative technologies for these widely used, specialized applications. USEPA and UNEP publications that address general uses of ozone-depleting solvents are discussed on page 99 of this document.

List of Uses Addressed in the Catalogue

The catalogue discusses the following specialized uses of ODSs:

- Aerosol mould release agents
- Printed circuit board "freeze sprays"
- Aerosol dusters
- Aerosol cleaners/flux removers
- Fabric protectants
- Film cleaning
- Aircraft windshield sprays and coatings
- Fumigants
- Typing and writing correction fluids
- Mobile air conditioner flushing agents
- Use in semi-conductor manufacturing processes
- Aerosol pesticides

A use sector description follows for each of these uses. In addition, one or more alternative technology datasheets are included in the catalogue for nine of the uses listed above. Alternatives to ODS use as flushing agents, in semi-conductor manufacturing, and in pesticides are not included in this catalogue due to lack of information on alternatives, cessation of commercial use, or controls on reformulation that preclude the use of substitutes without extensive regulatory review.

Aerosol Mould Release Agents

Aerosol mould release agents, which are sprayed on mould surfaces prior to the injection of the substance to be moulded, are used in a wide variety of manufacturing and maintenance applications. Their use allows the moulded product to be easily removed from the mould when the process is completed.

Aerosol mould release agents generally consist of three primary components: solvent, active ingredient, and propellant. In traditional formulations, the solvent is often 1,1,1-trichloroethane, and the propellant is often CFC-12 or HCFC-22. The active ingredient in aerosol mould releases varies depending on the intended application. Common active ingredients are silicone oils, fluoropolymers, and waxes. None of the active ingredients has an ozone-depletion potential, and therefore none are being changed.

In formulations of mould release agents that are solvent-based, the active ingredient is solubilized and forced from the can by the propellant. Upon contacting the surface of the mould, the solvent volatilizes and leaves a uniform coating of the active ingredient on the mould. Desirable characteristics in an aerosol mould release agent include uniform spray patterns, fast evaporation rate, easy release of the product from the mould, minimal transfer of release agent to the part being moulded, and low flammability.

There are several alternatives to the use of ODSs in aerosol mould release agents that are currently available worldwide. Three of these will be addressed in this catalogue: non-solvent formulations, water-based products, and HCFC-based products.

Printed Circuit Board "Freeze Sprays"

Printed circuit board freeze sprays are used in the manufacture and repair of most printed circuit boards in a procedure known as thermal stress testing. This procedure determines the location of faulty components in failed circuit boards. Once identified, the faulty component, rather than the entire circuit board, can be repaired or replaced.

Thermal stress testing freeze sprays are single component aerosols in which the propellant is also a refrigerant. Traditionally, CFC-12 had been used, but many manufacturers of these products have recently switched to HCFC-22. To check a component, the refrigerant is sprayed directly on the component, resulting in the component being cooled to approximately -51°C.

The alternatives to CFC-12 and HCFC-22 in printed circuit board freeze sprays are relatively limited, but widely available. The two most prevalent alternatives, HFC-134a and liquid nitrogen, are discussed in this catalogue. Carbon dioxide is another new alternative, but at the present time it is not widely used.

Aerosol Dusters

Aerosol dusters remove dust and other particulates from the inside of computers, cash registers, and any other locations in which particulates tend to accumulate. Excessive amounts of dust and particulate build-up may affect the ability of a machine to function properly.

Aerosol dusters are single component aerosols in which the force of the propellant removes the dust and particulates from the surface or space being cleaned. The most important factor for a good duster is that the gas have a high vapour pressure so that it will be expelled from the can with a great deal of force. Traditionally, both CFC-12 and HCFC-22 have been used as aerosol dusters.

By far the most commonly used alternative to these substances in dusters is HFC-134a or HFC-152a. The catalogue discusses these products in detail. Carbon dioxide is another potential alternative, but much of the testing performed to date has shown that it is unacceptable due to the large pressure drop that occurs in the can as the product is being dispensed. Because it is not likely to be widely used in aerosol duster applications, carbon dioxide as an alternative is not addressed in this catalogue.

Aerosol Cleaners and Flux Removers

Aerosol cleaners and flux removers remove oil, grease, flux, and other contaminants from a wide variety of electronic and electric parts including printed circuit boards. These are general cleaners used at various stages in almost all manufacturing and repair processes. Cleaners are used prior to, during, and after some assembly and repair processes as well as prior to the final production process.

Aerosol cleaners and flux removers contain two general components, the solvent and the propellant. The solvents used in these formulations are described in this catalogue. Traditionally, the same solvents used in bulk cleaning and flux removal applications have been used in aerosol products. These are CFC-113 and 1,1,1-trichloroethane. The desirable characteristics for an aerosol cleaner or flux remover include good solvency, fast residue-free evaporation, and nonflammability.

Alternative aerosol cleaners and flux removers are often a blend of several solvents, rather than a single component. There are dozens of different formulations currently available worldwide from a number of suppliers. The catalogue presents three of the popular alternatives: terpene-based, alcohol-based, and hydrocarbon-based cleaners. Several other alternatives, including those that are water-based and HCFC-based, are available, but since they are not widely used, they are not addressed in the catalogue.

Fabric Protectants

Fabric protectants are applied to textiles either by retailers, by consumers, or at mills. They prevent and remove stains. Fabric protectants previously contained 1,1,1-trichloroethane as the solvent because it is nonflammable and an excellent dispersant for the active ingredient, usually a fluorochemical mixture.

Retailer- and consumer-applied fabric protectants or stain repellents are usually sold in aerosol formulations for treating products such as ties, apparel, upholstery, and carpets. The aerosol products provide a fluorochemical barrier against absorption of oil-based and water-based stains. Nonaerosol products are also available. However, because it is usually more difficult to obtain an even coverage with nonaerosol products, they have traditionally been used almost exclusively by retailers. Advanced nonaerosol pump sprays have recently been developed that provide better coverage of the product being protected. These are expected to be used by some consumers.

Mill-applied fabric (textile) protectants are nonaerosol products applied during the production process. The current use of 1,1,1-trichloroethane in these applications is limited. More common are aqueous products and solvent-based products using petroleum distillates and trichloroethylene.

Alternatives to 1,1,1-trichloroethane-based fabric protectants include water-, petroleum distillate-, and trichloroethylene-based products. According to some mill applicators, solvent-based products are uncommon but would be used in situations where the cloth could not be exposed to water. No manufacturers of mill-applied petroleum distillate- and trichloroethylene-based products could be identified. Therefore, the only datasheet for mill-applied fabric protectants in this catalogue addresses water-based alternatives.

Film Cleaning

The film cleaning market remains at a fairly constant size and utilizes approximately 1,600 film cleaning units worldwide to clean film of all types. These automatic units are typically used in a film laboratory or film-to-videotape transfer facility, each of which usually operates two units with an annual solvent usage of about 3,125 litres. The solvent traditionally used in these automatic film cleaning units is 1,1,1-trichloroethane.

Until recently, there were only two film cleaning machine manufacturers worldwide. Film cleaning machines manufactured by Lipsner Smith are the most prevalent. The other existing manufacturers are CTM in France and Radio Frequency Company, Incorporated and Technology Film Systems in the United States, with the latter two companies being relatively new to the film cleaning industry. Until recently, 1,1,1-trichloroethane had been used in all Lipsner Smith machines. Cleaning machines from CTM also operate using 1,1,1-trichloroethane, while those made by Radio Frequency Company, Incorporated and Technology Film Systems are water-based.

There are two commercially available alternatives to the use of 1,1,1-trichloroethane in film cleaning systems: perchloroethylene (PERC) and water-based cleaning. In addition, Du Pont has proposed the use of HFC-43-10. In some cleaning systems, PERC can be used as a virtual drop-in replacement for 1,1,1-trichloroethane, but in others, the system must first be modified. Water-based cleaning systems were introduced to the market in late 1993. The third alternative, HFC-43-10, is a virtual drop-in replacement according to Du Pont. It is currently in the testing stage and should be on the market in one to two years for use in all Lipsner Smith Film Cleaning systems. Since it is currently not available, a datasheet is not included in the catalogue.

Aircraft Windshield Sprays and Coatings

Sprays on airplanes remove grease and dirt from the windshield, thereby allowing water to run off. This maintains clear visibility by preventing water build-up and the subsequent icing that might occur. Aircraft windshield sprays traditionally contain CFC-113 and are applied by small nozzles much like those used in automobiles. A delivery system sprays the CFC-113-based formulation onto the windshield and wipers remove it.

A windshield coating can be used as an alternative to CFC-113-based spray systems. Unlike CFC-113 sprays, the windshield coating system is applied during scheduled aircraft maintenance rather than in-flight. More information on this alternative is offered in the datasheet.

Fumigants

Carbon tetrachloride has been used for two primary purposes in fumigants. First, it has been used by itself as a spot fumigant for grains and seeds. Second, it has been used as a diluent to reduce the flammability or explosivity of other fumigants such as carbon disulphide and acrylonitrile. When combined with carbon disulphide, it is used to treat grains and, in some cases, to control pests in soil. When combined with acrylonitrile, it is used to control dry wood termites and other structural pests.

Extensive research on the use of 1,1,1-trichloroethane as an alternative to carbon tetrachloride has been conducted in the United Kingdom. However, 1,1,1-trichloroethane was never a registered alternative. No current uses of 1,1,1-trichloroethane in fumigants are known to exist.

Many countries have banned carbon tetrachloride as a fumigant and in fumigant mixtures. However, it may still be used as a grain treatment to a small extent in some countries, especially in Africa. In these situations it is most likely used because of pest infestation in storage facilities rather than as a quarantine treatment. Therefore, likely alternatives to carbon tetrachloride would be phosphine gas and/or controlled/modified atmospheres. There are many other pest control methods for stored grain; however, because the prevalence of this specialized use sector could not be verified, only datasheets on the most likely alternatives -- phosphine gas and controlled/modified atmospheres -- are included in the catalogue.

Typing and Writing Correction Fluids

Coloured opaque correction fluids for covering typing and writing errors have traditionally contained 1,1,1-trichloroethane. 1,1,1-Trichloroethane has not been used in products for photocopied material because of its incompatibility with the copier ink. The primary advantages to 1,1,1-trichloroethane in correction fluids are that it easily covers print, is nonflammable, and dries quickly.

The two most prevalent alternatives to 1,1,1-trichloroethane in correction fluids are petroleum distillates and water. Petroleum distillate-based correction fluids can be used on pen and ink, copies, and typing, but have the potential disadvantage of being flammable. Water-based correction fluids can be used on photocopies and typing. Depending on the formulation, water-based fluids may be effective on pen and ink, although some formulations will require several coats before covering the ink and each coat may require up to 50 seconds to dry. Water-based correction fluids are nontoxic and nonflammable. These two alternatives are discussed in datasheets in the catalogue.

Mobile Air Conditioner Flushing Agent Applications

After the removal of coolant in automobile and other mobile air-conditioning systems, CFC-113 has been used as a flushing agent to remove debris. CFC-113 was selected because of its compatibility with the CFC-12 refrigerant. It was dispensed in aerosol form or from a pressurized cylinder, flushed through the system, and then vented to the air. It was often used after a compressor or desiccant bag failure -- events which could cause metal or other debris to become lodged in the air conditioner.

As an alternative to CFC-113, liquid CFC-12 is currently used as a flushing agent. After flushing, the liquid CFC-12 is then filtered to remove any debris, and recycled. Liquid CFC-12 is compatible with air-conditioning systems that use either CFC-12 or HFC-134a. However, because CFC-12 production will be phased out on the same schedule as CFC-113, a nonozone-depleting alternative to CFC-12 is needed.

Since almost all mobile air-conditioning systems are being manufactured or changed to use HFC-134a, any alternative flushing agent must be compatible with HFC-134a. At the present time, no such alternative flushing agents exist. In addition, CFC-113 is not a viable flushing agent for HFC-134a systems because residues from its use are not compatible with the lubricants used in these systems. Until a better alternative is available, HFC-134a is being flushed with the liquid form of HFC-134a, just as CFC-12 systems were flushed with the liquid form of CFC-12.

Alternatives to CFC-113 as a flushing agent are not included in this catalogue for one primary reason: CFC-12 and CFC-113 are no longer being widely used because systems are now being manufactured with HFC-134a. Consequently, CFC-12 is no longer needed as a flushing agent because liquid HFC-134a is adequate, and the use of CFC-113 will be eliminated because it is not compatible with HFC-134a.

Use in Semi-Conductor Manufacturing Processes

Three major semi-conductor manufacturing processes -- plasma etch processing, oxide growth processing, and photolithographic processing -- use CFC-113 or 1,1,1-trichloroethane. Due primarily to the significant differences in these processes at different facilities, little information on alternatives to the use of CFC-113 and 1,1,1-trichloroethane is available.

However, the following are potential alternatives for each process:

> Plasma etch processing -- CFC-113 could be replaced with FC-14, CHF_3 or C_2F_6. In addition, several mixtures of fluorocarbons (FCs) and hydrofluorocarbons (HFCs) are being tested as alternatives. Another process, Magnetron Reactive Ion Etching (RIE), is being developed as an alternative to CFC use in etching. A switch to any of these alternatives would likely result in high conversion costs or loss in yields. In addition, FCs are subject to regulation in some countries due to their high global warming potential.

Oxide growth processing -- At the present time, no alternatives to the use of 1,1,1-trichloroethane in oxide growth processing have been identified.

Photolithographic processing -- There are a few potential alternatives to the use of ODSs in semiconductor wafer fabrication. However, since present processes and equipment are designed around the solvents to be used, the alternatives would require new processes or new equipment. Potential alternatives include lasers and dry photoresist methods or aqueous chemistry photoresists.

Aerosol Pesticides

Many pesticides formulated as aerosols contain 1,1,1-trichloroethane as a solvent. Common pesticides formulated with 1,1,1-trichloroethane include total release indoor foggers (TRIF), household roach and ant sprays, and wasp and hornet sprays. Usually, 1,1,1-trichloroethane is the solvent of choice to decrease flammability or to make the products nonflammable. In many cases, it is essential that pesticides be nonflammable in order to meet certain regulations such as those set by the World Health Organization (WHO) to regulate flammability in pesticides used in aircraft. In some cases, pesticide formulations must meet local criteria such as those set by the USEPA to regulate and determine flammability limits for pesticides used in residential settings.

Flammability is of particular concern for TRIF products which are designed to be dispensed in relatively large rooms. Often, the risk of fire is increased because TRIF products are applied incorrectly by consumers (e.g., they are released in small rooms or closets, or are set too close to ovens). Prior to the late 1970s, petroleum distillates, methylene chloride, and 1,1,1-trichloroethane were used as the solvents in TRIF products. Because of flammability concerns associated with petroleum distillates and the removal of methylene chloride due to human health concerns, the amount of 1,1,1-trichloroethane in a typical formulation was increased. It currently accounts for up to 60 to 65 percent of the formula on average.

Alternative formulations are now being investigated and one option for decreasing flammability is to replace highly flammable propellants with less flammable propellants. Many pesticides used hydrocarbon blend propellants. The hydrocarbons may be replaced with blends of HFC-134a, HFC-152a, dimethyl ether (DME), and/or HCFC-22. At this time, the use of DME is the most popular option. Substitution of HCFC-22 is not considered a long-term solution because it is subject to a phaseout under the Montreal Protocol due to its ozone-depletion potential.

There are several options for replacing 1,1,1-trichloroethane as a solvent in TRIF products and pesticide sprays. First, it could be replaced with de-ionized water in the form of an oil-out emulsion system. This method would be the least expensive approach, but the efficiency of the product could be decreased because of the larger particle size that would be produced with a water system. Two other options are to use either HCFC-123 or HCFC-141b as the solvent. Both of these methods, however, would be more expensive than the use of 1,1,1-trichloroethane.

Another alternative to pesticides containing 1,1,1-trichloroethane would be to remove these pesticides from the market and use other currently available, registered pesticides that do not contain 1,1,1-trichloroethane. Such pesticides include slightly flammable aerosol products, baits, and aqueous formulations. This alternative replacement method could be viable for most applications. However, in situations such as pesticide sprays for use on or near high tension power lines or in aircraft, these formulations may not be viable alternatives. In these cases, the 1,1,1-trichloroethane containing pesticide would have to be reformulated to meet the required application criteria.

4.Alternative Technology Datasheets

For each of the specialized uses identified, datasheets have been prepared providing details on alternative technologies.

See Annex D for Alternatives and Uses Information Submission Form

See Annex D for Alternatives and Uses Information Submission Form

Alternative Technology Datasheet

4.1 Aerosol Mould Release Agents

User: Aircraft, automobile, and a variety of other equipment manufacturer

ODS(s) to be Replaced: CFC-11, CFC-113, 1,1,1-trichloroethane

Alternative: ***Non-Solvent Mould Release Agents***

Description of the Alternative:

In non-solvent mould release agent formulations, no solvent is used to dissolve the active ingredient. The release agent is dispensed from the can by the propellant only. Removing solvent from the formulation may result in increased performance because there is no risk of the solvent attacking plastics or metals. However, because of the lack of diluent in the formulation, some clouding of the release agent has been observed upon application. In addition, the lack of solvent may result in uneven application of the active ingredient on the surface of the mould. No dry time is associated with the use of non-solvent mould release agents since there is no solvent to evaporate.

The propellants most often used in non-solvent formulations are HFC-134a, HFC-152a, dimethyl ether (DME), and hydrocarbons. Typical formulations often contain a blend of two or more of these propellants. With some propellant blends, the propellants used will not be miscible and will therefore separate within the package. In these cases, especially where flammable propellants are involved, it is important that users shake the can vigorously prior to depressing the valve and releasing the product. Failure to do so could result in a cloud of flammable gas being dispensed.

Use and Availability:

Non-solvent mould release agents are new products that are used in a limited but growing number of applications at the present time. They are currently manufactured and distributed by several companies in the United States. Several types of non-solvent release agents are available, including general purpose silicones, lecithin, silicone-free paintables, fluorotelemer, and a number of others.

Environmental, Health, and Safety Considerations:

Depending on the propellant or propellant blend used in the formulation, there may be worker health and safety or environmental impacts associated with the use of non-solvent mould release agents.

With all of the propellants mentioned except for HFC-134a, flammability is a concern. Care must be taken to ensure that the release agents are used in open, well-ventilated areas so that the risk of fire with flammable formulations is minimized. Some formulations contain blends of flammable and nonflammable propellants in appropriate concentrations so that the propellant mixture is nonflammable.

Emissions of volatile organic compounds (VOCs) are another environmental concern associated with the use of some non-solvent mould release agents.[2] In traditional CFC-based release agents, the propellant comprises approximately three percent of the product formulation. In non-solvent formulations, however, the propellant can account for more than 95 percent of the formulation. The move away from CFCs and 1,1,1-trichloroethane has resulted in the introduction of VOCs into the release agent formulation. DME and hydrocarbons are considered VOCs, and their emissions may be strictly regulated in some states and localities. The introduction of VOCs, coupled with the increased volume of propellant used in non-solvent formulations, may result in a significant increase in the emissions of VOCs from aerosol mould release agents. Potential users should consult local regulations to determine the acceptability of using products containing VOCs.

Global warming potential (GWP) is an important factor to consider in a switch to HFC propellants. On a 100-year basis, HFC-134a has a very high GWP of 1,200 as compared with CO_2, which has a GWP of 1. The GWP of HFC-152a is substantially lower at 150.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

The cost of a non-solvent mould release agent depends primarily on the type of propellant used. Propellants such as DME, hydrocarbons, and HFC-152a will be relatively inexpensive, while HFC-134a will be more expensive. In addition, the type of can required may differ with each formulation, thereby impacting the cost of the product. In general, non-solvent release agent formulations using DME, hydrocarbons, and/or HFC-152a have a cost substantially lower than CFC-based release agents. The cost of an HFC-152a/DME non-solvent release agent can be as much as 30-40 percent less than a comparable CFC-based formulation. This price differential is due primarily to the taxes now levied on CFCs. Formulations using HFC-134a are substantially more expensive and can cost over 50 percent more than CFC-based release agents. In this case, the price differential is a result of the relative scarcity of HFC-134a for use in aerosol applications.

[2] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Suppliers of Alternative Materials and/or Equipment:

George Mann & Co.
Micro Care Corp.
Percy Harms Corp.
Zip-Chem Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on non-solvent mould release agents.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Aerosol Mould Release Agents

User: Aircraft, automobile, and a variety of other equipment manufacturers

ODS(s) to be Replaced: CFC-11, CFC-113, 1,1,1-trichloroethane

Alternative: ***HCFC-Based Mould Release Agents***

Description of the Alternative:

One method of eliminating the use of CFCs as solvents in mould release agents is to reformulate the products using HCFC solvents. From the user's standpoint, this reformulation should have a minimal effect on the technique for using/applying the product because the HCFCs have properties similar to the solvents they are replacing. However, performance should be tested and confirmed both in the lab and on the production line. In most cases, the nonflammability of HCFCs is a major important factor in their being chosen as alternatives for other ozone-depleting substances.

When the world began to eliminate the use of CFC solvents, many manufacturers of mould release agents reformulated their products to use HCFC-141b as a substitute solvent. Currently, many of these products still use HCFC-141b, although some manufacturers are reformulating their products so that they use no ozone-depleting solvents.

Use and Availability:

Mould release agents using HCFC-141b as a solvent are readily available worldwide. However, due to regulations in the United States and elsewhere limiting the use of HCFCs in aerosol applications, many manufacturers are reformulating their products to eliminate HCFC-141b solvents. Consequently, the supply of HCFC-based mould release agents is likely to decrease over the next few years. Several types of HCFC-141b-based release agents are available, including general purpose silicones, lecithin, silicone-free paintables, fluorotelemer, and a number of others.

Environmental, Health, and Safety Considerations:

There are no major worker health and safety impacts associated with the use of HCFC-141b as a solvent in mould release agents. HCFC-141b is nonflammable and exposure levels encountered during everyday work do not pose any threat to worker health.

While flammability is not a concern with HCFC-141b, it is possible that the formulation of a mould release agent as a whole may be flammable. Other components of the product formulation such as propellants or additional solvents may be flammable and can have an impact on the overall flammability of the product.

However, most manufacturers using HCFC-141b do so to maintain a nonflammable product, and would therefore be unlikely to include flammable solvents or propellants in concentrations high enough to impact the product's overall flammability.

The primary concern with HCFC-141b is its contribution to depletion of the stratospheric ozone layer. CFC-113 has an ozone-depletion potential (ODP) of 0.7. HCFC-141b has an ODP of approximately 0.12, comparable to the ODP of 1,1,1-trichloroethane, a chemical which is being phased out by January 1, 1996. A switch from CFC-113 to HCFC-141b reduces the ozone depletion by a factor of 3, but will continue to result in ozone layer depletion. Furthermore, HCFC-141b production will be phased out in much of the world by the year 2030. In the United States, HCFC-141b is scheduled to be phased out by the year 2003, and by the year 2015 in the European Community.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

HCFC-based mould releases on average cost approximately the same as CFC-based formulations. As the supply of CFCs becomes scarcer in the coming years, HCFC-based releases can be expected to become cheaper than their CFC-based counterparts. However, as the number of companies using HCFCs in their release agents is reduced, it is expected that the cost of HCFC-based products will increase, although not as rapidly as CFC-based products.

Suppliers of Alternative Materials and/or Equipment:

GSI Exim America
Gunze Sangyo Group
McGee Industries
Miller-Stephenson Chemical Company, Inc.
Newgate Simms, Ltd.
Percy Harms Corp.
Price-Driscoll Corp.
Sprayon Products Industrial Supply
Stoner Inc.

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on HCFC-based mould release agents.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Aerosol Mould Release Agents

User: Aircraft, automobile, and a variety of other equipment manufacturers

ODS(s) to be Replaced: CFC-11, CFC-113, 1,1,1-trichloroethane

Alternative: ***Water-Based Mould Release Agents***

Description of the Alternative:

In order to eliminate the use of ozone-depleting substances as solvents in aerosol mould release agents, products can be reformulated using water in place of the ozone-depleting solvent. In some products, a small amount of another solvent (such as an alcohol) is also included in the formulation. Water-based release agents are produced both in bulk and in aerosol formulations, although bulk products are more common. In both cases, the product is applied in the same manner as traditional release agents, but a post-application drying step will probably be required since water evaporates at a much slower rate than the solvents being replaced in the formulations. In order to speed the drying process, it may be necessary to expose the surface to which the agent was applied to heat for a period of 10 or more minutes following application. However, even with a drying step, the drying time may be significantly longer with water-based products than with traditional mould release agents.

In addition, the relatively high surface tension of water as compared with other solvents often results in less efficient wetting of the mould surface. Ease of release from the mould will vary depending on the product being moulded, but tests have shown that water-based release agents can release easier than traditional solvent-based products in many applications. Furthermore, tests have shown that, in some applications, contamination resulting from the transfer of release agent from mould to product is no worse with water-based agents than with solvent formulations.

Use and Availability:

Water-based mould release agents are currently available worldwide and are being used in a variety of manufacturing operations. They are most popular in rubber moulding applications, in large part because rubber moulding is performed at extremely high temperatures. At these temperatures, the water in the release agent formulation evaporates very rapidly, thus providing similar results to those that would be achieved using a fast-evaporating formulation based on another solvent. The effect is that there is no appreciable increase in drying time when using a water-based release agent at these high temperatures.

Environmental, Health, and Safety Considerations:

From a worker health and safety standpoint, water-based mould release agents are most likely the safest option currently available. Water-based formulations are nonflammable (alcohol or other solvents are sometimes present in low concentrations, but do not affect the overall flammability of the product), and there are no exposure limits associated with the use of water. Furthermore, VOC-emissions are significantly reduced in water-based mould release agents in comparison to their solvent-based counterparts. Finally, since all of the release agent is evaporated, there is no bulk waste disposal and therefore no need for water treatment.

Materials and Equipment Changes Required:

No changes are required for the user. However, to avoid problems such as corrosion, it is necessary to check the mould itself and the moulded materials for compatibility with water-based release agents.

Associated Materials Costs:

The cost of water-based mould release agents is significantly lower than similar CFC-based products. Manufacturers have estimated the price differential at approximately 20 percent on a per unit basis. This difference in cost is the result of three principal factors. First, the material cost of water is much lower than for any chemical solvent. Second, the taxes on ozone-depleting substances are avoided by using water-based products. Finally, the production of water-based release agents is cheaper than the production of CFC-based formulations. These cost savings can then be passed on to the consumer in the form of lower product prices.

Suppliers of Alternative Materials and/or Equipment:

Dexter Corporation
GSI Exim America
Gunze Sangyo Group
McGee Industries
Newgate Simms, Ltd.
Rheinchemie
Releasomers, Inc.

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Rigby, Michael. "Working with Water-Based Mold Releases," Rubber & Plastics News, 25 November 1991, pp. 37-39+.

Contact any of the suppliers listed above for more information on water-based mould release agents.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.2 Printed Circuit Board "Freeze Sprays"

User: Printed circuit board manufacturers and repair facilities

ODS(s) to be Replaced: CFC-12, HCFC-22

Alternative: ***HFC-134a Sprays***

Description of the Alternative:

Printed circuit board freeze sprays can be reformulated to replace CFC-12 or HCFC-22 with a hydrofluorocarbon (HFC) refrigerant. The HFC used in these applications is HFC-134a. Since HFC-134a functions both as a refrigerant and as an aerosol propellant, no additional chemicals are required in the alternative formulation. HFC-134a freeze sprays are capable of cooling components to approximately -50°C. This is slightly warmer than the temperatures achievable with HCFC-22 freeze sprays. However, -50°C is sufficient for the testing requirements of most users.

Anti-static formulations of HFC-134a freeze sprays which contain approximately 99.25 percent HFC-134a and 0.75 percent of an antistatic agent are available.

Use and Availability:

Currently, there is a shortage of HFC-134a. This is especially true in the aerosols sector because the majority of the HFC-134a produced is being purchased for the refrigeration and air conditioning use sectors. Despite this shortage, a number of companies currently offer HFC-134a printed circuit board freeze sprays. These products are available and are currently in use worldwide.

Environmental, Health, and Safety Considerations:

Worker health and safety is not a problem since HFC-134a is nonflammable and nontoxic. However, there is one potential environmental impact associated with the use of HFC-134a printed circuit board freeze sprays. This is their global warming potential (GWP). On a 100-year basis, HFC-134a has a very high GWP of 1,200 as compared with CO_2, which has a GWP of 1. As more countries begin to regulate chemicals with high GWPs, it is possible that the use of HFC-134a in emissive uses such as freeze sprays might be restricted.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

At the present time, HFC-134a is extremely expensive because of low levels of production and the high demand for the product in a variety of use sectors. HFC-134a printed circuit board freeze sprays may be more expensive than other alternatives as well as more expensive than CFC- or HCFC-based products. Estimates indicate that the cost of a typical HFC-134a freeze spray is 10 - 25 percent higher than a HCFC-22 spray. A price comparison with CFC-12 freeze sprays was not available because no suppliers of CFC-12 freeze sprays could be identified.

Suppliers of Alternative Materials and/or Equipment:

Chemtronics, Inc.
Micro Care Corp.
Miller-Stephenson Chemical Company, Inc.
Zip-Chem Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on HFC-134a printed circuit board freeze sprays.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Printed Circuit Board "Freeze Sprays"

User: Printed circuit board manufacturers and repair facilities

ODS(s) to be Replaced: CFC-12, HCFC-22

Alternative: ***Liquid Nitrogen Freeze Sprays***

Description of the Alternative:

Printed circuit board freeze sprays using CFC-12 or HCFC-22 can be replaced with a not-in-kind liquid nitrogen freeze spray. Liquid nitrogen freeze sprays, whose cooling ability has been measured at approximately -196°C, can cool individual components to a much lower temperature than either CFC-12, HCFC-22, or other currently available alternatives.

Tests have shown that liquid nitrogen sprays have a faster overall cooling rate than CFC-12 and that, despite the extremely low temperatures, there is minimal frost build-up on the components. However, it is possible that the excessively low temperatures resulting from nitrogen use may cause some components to temporarily fail, even though they are not actually defective. Therefore, it may be necessary to develop a temperature control strategy when using liquid nitrogen sprays with certain types of components.

One major benefit associated with the use of a liquid nitrogen freeze spray is the reduction in the electrostatic discharge given off during testing. Tests have shown that when using liquid nitrogen, the electrostatic discharge is about 1-2 percent of that which occurs with CFC or HCFC refrigerants. Since high levels of electrostatic discharge can damage circuit boards, this low discharge is a major benefit.

Use and Availability:

Liquid nitrogen freeze spray equipment for use on printed circuit boards is currently available worldwide, but only one manufacturer of such equipment is known. The liquid nitrogen itself is also available worldwide from almost any industrial gas supplier. These freeze spray systems are being used successfully in a variety of applications by a number of companies. Some examples of its current use include major airlines (American Airlines and KLM Royal Dutch Airlines), aircraft manufacturers (Hughes Aircraft Co. and McDonnell Douglas Aerospace), electronics manufacturers (General Electric, IBM Canada Ltd., Magnavox Electronic Systems, Motorola, and Northern Telecom), and others.

Environmental, Health, and Safety Considerations:

Proper handling of the material is a major worker health and safety issue that must be considered when evaluating a switch to liquid nitrogen freeze sprays. Liquid nitrogen is a cryogenic liquid that can freeze human tissue almost instantly, producing frostbite on exposed skin or eye tissue. This is an especially important concern in the transfer of liquid from the storage tank into the spray gun, as well as when spraying the component to be cooled. In addition, workers must be careful not to touch any uninsulated pipes or storage vessels that contain liquid nitrogen. Doing so may result in the skin sticking to the pipe or vessel and tearing when it is removed. Workers must wear adequate protective clothing and exercise caution when handling liquid nitrogen.

Nitrogen gas generated by liquid nitrogen is an asphyxiant because of its ability to displace oxygen in the area around its use. However, this is not likely to be a major issue in the case of freeze sprays because of the relatively small amount of nitrogen used at any given time.

Materials and Equipment Changes Required:

Because liquid nitrogen freeze spray systems do not rely on the standard disposable aerosol can, several pieces of equipment must be acquired before it can be used. There are three general components of a liquid nitrogen system: the holding tank, the withdrawal equipment, and the freeze spray "gun."

In order to make the process more economical, liquid nitrogen is stored on-site in bulk containers and withdrawn as needed to fill the spray gun (a dewar flask). In most cases, suppliers of the liquid nitrogen will provide cylinders for bulk storage of the nitrogen at little or no cost. However, the facility must ensure that there is adequate space and an appropriate location for placement of the tanks.

The second piece of required equipment is the withdrawal device. This device is used to remove liquid nitrogen from the storage tank and transfer it to the smaller spray guns. Finally, it will be necessary to purchase one or more spray guns for dispensing the liquid nitrogen onto the printed circuit board. These guns come in varying sizes, but the most popular ones hold approximately 0.5 litre of liquid nitrogen. The spray guns are made of stainless steel and have a number of interchangeable nozzles designed for different applications.

Associated Materials Costs:

There are three primary costs to consider in evaluating a liquid nitrogen freeze spray system. First is the material cost for the nitrogen. Although the cost of liquid nitrogen varies from supplier to supplier and from region to region, a typical price is US$0.25 per litre. The second cost is that of the withdrawal equipment. There are very few manufacturers of this equipment and the price will depend primarily on the size required. A typical piece of such equipment costs approximately US$300. Finally, the cost of the spray gun itself must be considered. Again, this cost will depend on the size of spray gun purchased. However, a typical 0.5 litre dispenser with several interchangeable spray nozzles costs approximately US$650.

Because all of the dispensing equipment used in liquid nitrogen systems is reusable, the long-term cost of such a system will be significantly less than the cost of using freeze sprays in disposable aerosol cans. One study estimated that, when comparing liquid nitrogen with CFC-12 aerosols, the cost of a spray gun will be paid back after testing just 95 printed circuit boards.

Suppliers of Alternative Materials and/or Equipment:

Brymill Corporation

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Compressed Gas Association, Inc.
1725 Jefferson Davis Highway
Arlington, VA 22202-4102
USA
Tel: (1) 703 412 0900
Fax: (1) 703 412 0128

Compressed Gas Association, Inc. Safe Handling of Cryogenic Liquids. Publication CGA P-12-1993.

Schmitt, Stephen and Robert Olfenbuttel. "Electronic Component Cooling Alternatives: Compressed Air and Liquid Nitrogen," Draft Project Summary prepared by Battelle (Columbus, Ohio, USA) for the U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Office of Research and Development, April 1993.

Contact the supplier listed above for more information on liquid nitrogen printed circuit board freeze sprays.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.3 Aerosol Dusters

User: General maintenance and repair facilities for precision instruments

ODS(s) to be Replaced: CFC-12, HCFC-22

Alternative: ***HFC-134a and HFC-152a Sprays***

Description of the Alternative:

Aerosol dust removers can be reformulated to replace CFC-12 or HCFC-22 with a hydrofluorocarbon (HFC) propellant. Simple products, aerosol dusters are used in the periodic maintenance of electronic, electrical, or precision instruments to remove microscopic dust and other particles from vital contact surfaces. The formulation is 100 percent propellant, and the particles are removed when they are dislodged by the force of the propellant. Therefore, the most important characteristic of an aerosol duster is that it maintain a high pressure in the canister throughout its lifetime.

Two HFCs, HFC-134a and HFC-152a, are being marketed as replacements for CFC-12 and HCFC-22 in aerosol dusters. Both function equally well, but have significant differences in worker health and safety and in environmental impacts.

Use and Availability:

Currently, there is a shortage of HFC-134a, particularly in the aerosols sector because the majority of the HFC-134a produced is being purchased for the refrigeration and air conditioning use sectors. Despite this shortage, a number of companies currently offer HFC-134a aerosol dusters. These products are available and are currently in use worldwide.

HFC-152a is available in larger quantities than HFC-134a. Despite this availability and its significantly lower cost, HFC-152a is used relatively infrequently in aerosol dusters, primarily because of flammability concerns.

Environmental, Health, and Safety Considerations:

Worker health and safety is not a problem with HFC-134a because it is nonflammable. However, there is one potential environmental impact associated with the use of HFC-134a in aerosol dusters. This is its global warming potential (GWP). On a 100-year basis, HFC-134a has a very high GWP of 1,200 as compared with CO_2, which has a GWP of 1. As more countries begin to regulate chemicals with high GWPs, it is possible that the use of HFC-134a might be restricted.

In comparison, HFC-152a is flammable and must be used only in well-ventilated areas in which there are no hazardous ignition sources. Although HFC-152a also has a relatively high GWP of 140 on a 100-year basis, this is substantially lower than that of HFC-134a.

Both HFC-134a and HFC-152a are nontoxic and have relatively high worker exposure limits of 1000 parts per million (ppm).

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

At the present time, HFC-134a is extremely expensive relative to HFC-152a, HCFC-22, and other potential ingredients of aerosol dusters. Its high cost is a result of low levels of production and high demand for the product in a variety of use sectors. Therefore, HFC-134a aerosol dusters are likely to be significantly more expensive than HFC-152a dusters as well as more expensive than CFC- or HCFC-based products. Estimates place the cost of a typical HFC-134a aerosol duster at approximately 25 percent higher than the cost of a HCFC-22 spray.

Suppliers of Alternative Materials and/or Equipment:

Chemtronics, Inc.
Micro Care Corp.
Miller-Stephenson Chemical Company, Inc.
Zip-Chem Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on HFC-134a and HFC-152a aerosol dusters.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.4 Aerosol Cleaners/Flux Removers

User: General cleaning of parts and printed circuit boards during manufacture and repair

ODS(s) to be Replaced: 1,1,1-Trichloroethane, CFC-113, HCFC-141b

Alternative: ***Terpene-Based Aerosols***

Description of the Alternative:

One method of eliminating the use of ozone-depleting substances in aerosol cleaners and flux removers is by reformulating the product with terpenes. Terpenes are naturally occurring chemicals produced by plants that have inherent cleaning abilities. One of the most commonly used terpenes in cleaning and flux removal products is d-limonene, although other terpenes have recently been introduced in blends. Terpenes are capable of removing a variety of contaminants including flux, tape residues, greases, oil, and tar from a number of products. They are generally compatible with metals, painted surfaces, ceramics, fibreglass, and most plastics. However, terpenes may remove some conformal coatings used on printed circuit boards. The appropriate testing should be performed if conformal coatings are used. Alternative cleaners and flux removers may contain only terpenes, or the terpenes may be combined with other solvents such as hydrocarbons.

Most terpene cleaners require no rinsing and usually leave no residue; all completely evaporate from the surface of the part with no wiping or drying. However, there is one major disadvantage associated with terpene cleaners -- their relatively slow evaporation rate. This results in increased drying time and a corresponding reduction in throughput.

Use and Availability:

Several major manufacturers of aerosol cleaners and flux removers now offer terpene-based alternatives worldwide. Most of these formulations are based on d-limonene, but some also include other solvents such as petroleum distillates and naphtha. Terpene-based aerosol products are available with several different propellants.

Environmental, Health, and Safety Considerations:

Worker health and safety is not a major concern with terpene-based cleaners. In general, terpenes are noncarcinogenic and nontoxic. As a result, most have no established worker exposure limits. Terpenes typically used in aerosol cleaners and flux removers have a distinctive citrus odour which may be strong and can cause some minor discomfort to workers exposed to high concentrations of the vapour.

Terpene-based aerosols are flammable and typically have flash points in the range of 38°C to 66°C. Therefore, they must be handled with care and should only be used in areas where there are no potential ignition sources.

Due to the risks associated with odours and flammability, terpene-based aerosol cleaners and flux removers should be used in well-ventilated areas whenever possible.

From an environmental standpoint, there are two major issues to consider when using terpene-based products. First, terpenes are considered volatile organic compounds (VOCs) and their use is restricted in some areas.[3] Potential users should consult with local environmental officials before implementing a terpene-based product. Second, terpenes are believed to be toxic to aquatic life. While this is not a major concern in most aerosol applications because there is no bulk use of terpenes in liquid form, it may be an issue if a water rinse is used. In these cases, terpenes will be removed from the part being cleaned and transported in the rinsewater to a receiving source. If the terpenes are present in high enough concentrations, this could cause potential problems of aquatic toxicity.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

The cost of a terpene-based aerosol will vary depending on the amount of terpene present and the propellant used. In general, formulations using HFC-134a as a propellant will be slightly more expensive than those in which carbon dioxide, hydrocarbons, HFC-152a, or most other propellants are used. Terpene-based alternatives are significantly less expensive than aerosol cleaners and flux removers containing CFC-113. The difference in price between these two products can be more than 50 percent. The price differential is large due primarily to taxes on CFC-113, as well as a shortage of products containing CFC-113. Despite taxes on 1,1,1-trichloroethane, terpene-based products appear to be comparable in price to cleaners and flux removers based on 1,1,1-trichloroethane. It is likely that 1,1,1-trichloroethane-based products will become more expensive in the near future because of a decrease in the amount of its production that will occur as the developed country phaseout date approaches. Finally, the price of terpene-based products is generally lower than that of products based on HCFC-141b.

Suppliers of Alternative Materials and/or Equipment:

Chemtronics, Inc.
LPS Laboratories, Inc.
Micro Care Corp.
Zip-Chem Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

[3] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Sources of Information:

Gallagher, Scott R. "Terpenes as Replacements for Restricted Solvents," Spray Technology and Marketing, January 1993, pp. 32-34+.

Contact any of the suppliers listed above for more information on terpene-based aerosol cleaners and flux removers.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Aerosol Flux Removers

User: General cleaning of printed circuit boards during manufacture and repair

ODS(s) to be Replaced: 1,1,1-Trichloroethane, CFC-113, HCFC-141b

Alternative: ***Alcohol-Based Aerosols***

Description of the Alternative:

One method of eliminating the use of ozone-depleting substances in aerosol flux removers is by reformulating the product with alcohols. Alcohols are generally excellent for removing flux residues. They have been used for flux removal for many years in hand-wipe applications, and have recently been introduced in vapour degreasing applications. Alcohols are effective at removing almost all types of flux from a variety of board materials. Testing may be required, however, to determine compatibility with plastics.

Alcohols dry without any wiping or rinsing and leave little residue on the printed circuit board, but quite often the time needed for the alcohol to evaporate is significantly longer than that needed for CFC or HCFC-based products. Therefore, users of aerosol alcohol flux removers may experience a decrease in processing time and throughput. In order to speed the drying process, many suppliers of alcohol-based cleaners recommend using compressed air or manually wiping with a clean cloth or swab.

Several types of alcohols, including isopropanol, ethanol, certain non-linear alcohols, and numerous blends of alcohols, can be used in aerosol flux removers. Each formulation has a different flash point, cleaning ability, and evaporation rate and therefore must be evaluated individually to determine acceptability in a particular cleaning operation.

Use and Availability:

Alcohol-based aerosol flux removers are relatively new alternatives that, because of their flammability, are used on a limited basis. Very few manufacturers of aerosol cleaners and flux removers currently offer alcohol-based alternatives worldwide. Those that are offered are usually based either on blends of traditional alcohols such as isopropanol and ethanol or on blends of nonlinear alcohols. On some occasions, other nonalcohol solvents will be included in the formulation to enhance the cleaning ability and/or reduce the overall flammability of the product. Alcohol-based aerosol products are available with several different propellants, although nonflammable propellants such as HFC-134a are usually used.

Environmental, Health, and Safety Considerations:

The primary worker health and safety consideration associated with alcohol-based aerosol flux removers is their flammability. In general, alcohol-based cleaners have low flash points and are therefore extremely flammable, especially when atomized in an aerosol application. However, the flammability varies from product-to-product, and commercially available cleaners currently have a range of flash points from approximately 12°C (isopropanol) to more than 82°C (a proprietary blend of nonlinear alcohols). Because of their generally high flammability, it is important that alcohol-based products be used only in well-ventilated areas where there are no potential ignition sources. In addition, workers should be trained thoroughly in the safe handling and use of these products.

Alcohol-based aerosol flux removers are generally noncarcinogenic and nontoxic, and most have relatively high worker exposure limits in the United States. For instance, isopropanol has a threshold limit value (TLV) of 400 part per million (ppm), equal to that of ordinary rubbing alcohol. Another product, a high flash point blend of nonlinear alcohols has no worker exposure limits, and yet another blend (isopropanol and ethanol) has a TLV of 568 ppm.

The primary environmental consideration associated with the use of alcohol-based aerosol flux removers is that alcohols are considered volatile organic compounds (VOCs) and their use is restricted in some areas.[4] Potential users should consult with local environmental officials before implementing an alcohol-based product.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

The cost of an alcohol-based aerosol will vary depending primarily on the choice of propellant. In general, formulations using HFC-134a as a propellant will be slightly more expensive than those in which carbon dioxide, hydrocarbons, HFC-152a, or most other propellants are used. The relatively low cost of alcohols will result in a significantly lower cost for alcohol-based products than for products containing CFC-113, 1,1,1-trichloroethane, or HCFC-141b. For example, according to one manufacturer, an alcohol-based flux remover costs only about half as much as a similar product containing CFC-113. The same alcohol-based product costs approximately one-third less than an HCFC-based product, and slightly less than a product based on 1,1,1-trichloroethane.

Suppliers of Alternative Materials and/or Equipment:

Chemtronics, Inc.
Micro Care Corp.

See Annex E for complete addresses, telephone numbers, and fax numbers.

[4] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Sources of Information:

Contact any of the suppliers listed above for more information on alcohol-based aerosol flux removers.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use:

Aerosol Cleaners/Flux Removers

User:

General cleaning of parts and printed circuit boards during manufacture and repair

ODS(s) to be Replaced:

1,1,1-Trichloroethane, CFC-113, HCFC-141b

Alternative:

Hydrocarbon-Based Aerosols

Description of the Alternative:

One method of eliminating the use of ozone-depleting substances in aerosol flux removers is by reformulating the product with mixtures of hydrocarbons. In most hydrocarbon formulations, aliphatic hydrocarbons are mixed with alcohols or other oxygenated hydrocarbons such as acetone. Hydrocarbon-based aerosols are noncorrosive and are suitable for use on all types of electronics and on many metals.

A rinse is not required when using hydrocarbon-based aerosol cleaners. These cleaners can be applied using a trigger pump or an aerosol can, generally dry at a slightly slower rate than isopropyl alcohol, and leave no residue. In an aerosol, hydrocarbon blends can be used with a variety of propellants, although nonflammable propellants such as carbon dioxide and HFC-134a are most popular.

Use and Availability:

Hydrocarbon-based cleaners and flux removers are manufactured by several companies and are available worldwide in several different formulations in both spray and aerosol packaging. Aerosols produced by different manufacturers may use different propellants.

Environmental, Health, and Safety Considerations:

The primary worker health and safety consideration associated with hydrocarbon-based aerosol cleaners and flux removers is their flammability. Because hydrocarbons are themselves flammable and are often combined with alcohols in a cleaner formulation, most of these formulations have relatively low flash points. However, the flammability varies from product-to-product, and commercially available hydrocarbon-based aerosol cleaners have a range of flash points from approximately -18°C (blend with acetone) to 44°C (a proprietary blend of aliphatic hydrocarbons and alcohols). Because of their generally high flammability, it is important that hydrocarbon-based products be used only in well-ventilated areas where there are no potential ignition sources. In addition, workers should be trained thoroughly in the safe handling and use of these products.

Because of the wide variety of chemical constituents used in hydrocarbon-based aerosol cleaners, worker exposure limits vary widely: some cleaners may have low limits while others may be higher. In general, however, the permissible exposure limits (PELs) of these products vary around 100 ppm.[5] Odour is generally not a problem with hydrocarbon-based aerosol cleaners because many have only a slight odour.

The primary environmental consideration associated with the use of hydrocarbon-based aerosol cleaners and flux removers is that all of the hydrocarbons and alcohols that make up the cleaners are considered volatile organic compounds (VOCs).[6] As such, their use may be restricted in some areas. Potential users should consult local environmental officials before implementing a hydrocarbon-based product.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

The cost of a hydrocarbon-based aerosol cleaner or flux remover varies depending on the formulation and the propellant used. In general, formulations using HFC-134a as a propellant are slightly more expensive than those in which carbon dioxide, hydrocarbons, HFC-152a, or most other propellants are used.

Suppliers of Alternative Materials and/or Equipment:

Chemtronics, Inc.
LPS Laboratories, Inc.
Micro Care Corp.
Zip-Chem Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on hydrocarbon-based aerosol cleaners and flux removers.

Date of Datasheet Completion:

May 1, 1994

[5] According to the United States Occupational Health and Safety Administration and one major manufacturer of hydrocarbon cleaners.

[6] VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.

Alternative Technology Datasheet

4.5 Aerosol Fabric Protectants

User: Retailer-applied fabric treatment and home fabric maintenance

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Petroleum Distillate-Based Fabric Protectants***

Description of the Alternative:

In order to eliminate 1,1,1-trichloroethane in fabric protectants, petroleum distillates can be substituted as the principal solvent. Petroleum distillates are a type of organic solvent which are derived from the fractional distillation of petroleum products. While they function satisfactorily as replacements for 1,1,1-trichloroethane in aerosol fabric protectants, manufacturers must considered two major factors. First, due to their lower vapour pressure, formulations containing petroleum distillates may require an increased amount of drying time. Second, petroleum distillates do not function as well as 1,1,1-trichloroethane as carriers of the active ingredient in the product. This can result in a decrease in the adhesion quality of the protectant to the fabric. In order to account for this potential deficiency, it may be necessary to treat the fabric at more frequent intervals than would be needed with a 1,1,1-trichloroethane-based formulation.

Use and Availability:

Several types of aerosol petroleum distillate-based fabric protectants, including fabric, carpet, auto, and leather protectants, are currently used. Petroleum distillate-based fabric protectants are manufactured and distributed by a number of companies worldwide.

Environmental, Health, and Safety Considerations:

There may be consumer and worker health and safety or environmental impacts associated with the use of petroleum distillates as a solvent. These impacts and the potential risks they pose depend on the level of consumer and retailer awareness concerning the differences between products previously used and the newly formulated products.

The primary safety concern associated with the new formulations is flammability. Previous formulations containing 1,1,1-trichloroethane were nonflammable. Petroleum distillate-based formulations, however, have flash points ranging from 28°C to over 60°C. In some specialty petroleum distillate formulations, flash points are as low as -46°C. However, if the user is made aware of the potential risks and provided with adequate training, these products can be used safely.

Another health and safety consideration is the strong odour of some petroleum distillate-based products. While these odours are not dangerous, they may result in significant discomfort for workers or consumers using these products. To reduce the concentration of the product in the air and thereby to reduce the odour, products with strong odours should be used only in well-ventilated areas. It should be noted that some companies are producing retailer applied fabric treatments with odourless mineral spirits, thereby eliminating this potential problem.

Emissions of volatile organic compounds (VOCs) are the most important environmental concern associated with the use of petroleum distillates in fabric protectants.[7] Due to its exempt (non-VOC) status, the use of 1,1,1-trichloroethane in formulations did not add to VOC emissions. However, because petroleum distillates are considered VOCs, the new product formulations may contain as much as 96 percent VOCs by weight. Emissions of VOCs may be strictly regulated in some geographic regions. Potential users should consult local regulations to determine the acceptability of using products containing VOCs.

Materials and Equipment Changes Required:

In some cases, equipment may have to be adjusted so that it is explosion proof. In addition, the increased drying time could make it necessary for users in the retailer applied fabric treatment industry to reconfigure their treatment facility so that the number of pieces being treated does not decrease. The increased drying time could also result in delays in shipping and delivery times (e.g., retailers may not always be able to guarantee overnight delivery if drying times exceed the current period and pieces cannot be processed as fast as in the past).

To address the risk of flammability and odour discomfort, users may need to make changes to ventilation systems and take other precautions, all of which could increase overhead costs.

Associated Materials Costs:

Because of taxes on ozone-depleting substances in the United States, 1,1,1-trichloroethane formulations are generally more expensive than petroleum distillate-based formulations. However, if the taxes are not considered, the products may have similar prices, but in some cases, the petroleum distillate-based products will be more expensive.

Suppliers of Alternative Materials and/or Equipment:

Fiber Shield Industries Inc.
S.A. MICA Isolamentos S.A.
Sentry Chemical Co., Inc.
Specialty Chemicals
3M Consumer Specialties Division

See Annex E for complete addresses, telephone numbers, and fax numbers.

[7] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Sources of Information:

Contact any of the suppliers listed above for more information on petroleum distillate-based aerosol fabric protectants.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Aerosol Fabric Protectants

User: Retailer-applied fabric treatment and home fabric maintenance

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Aerosol Water-Based Fabric Protectant***

Description of the Alternative:

In water-based solvent fabric protectants, 1,1,1-trichloroethane is replaced as the main solvent with water. While they function satisfactorily as a replacement for 1,1,1-trichloroethane in aerosol fabric protectants, manufacturers must consider three major factors when switching to water-based formulations. First, due to the very low vapour pressure of water, formulations containing large amounts of water are likely to require a significantly longer drying time, especially in humid environments. Second, in fabric protectant products, water does not function as well as 1,1,1-trichloroethane as a carrier of the active ingredient. This can result in a decrease in the adhesion quality of the protectant to the fabric. In order to account for this potential deficiency, it may be necessary to treat the fabric at more frequent intervals than would be needed with a 1,1,1-trichloroethane-based formulation. Third, water may damage (shrink, discolour) certain fabrics, depending on the method of application.

Use and Availability:

Very few companies manufacture and distribute aerosol water-based fabric protectants. However, several types of aerosol water-based fabric protectants, including fabric, carpet, auto, and leather protectants, are currently available. These types of products are relatively new to the market and their market share is yet to be determined.

Environmental, Health, and Safety Considerations:

There are no significant consumer and worker health and safety impacts associated with the use of aerosol water-based fabric protectant formulations.

Although water itself is nonflammable, flammability is still a concern with some water-based aerosol formulations. Due to the presence of flammable constituents in water-based formulations, the product as used may be flammable. Previous formulations containing 1,1,1-trichloroethane were nonflammable. While most of the water-based products currently available are nonflammable, some of those containing flammable components have flash points in the neighbourhood of 57°C.

From an environmental standpoint, the only notable issue is that of volatile organic compound (VOC) emissions from some aerosol water-based products.[8] Water is not considered a VOC, but these products may contain small quantities of volatile organic compounds (VOCs) as propellants. These VOC propellants decrease the particle size of the protectant when it is dispensed.

Materials and Equipment Changes Required:

No changes are required for the user. However, the increased drying time required for water-based protectants could make it necessary for users in the retailer-applied fabric treatment industry to reconfigure their treatment facility so that the number of pieces being treated is not decreased. In some cases, sources of heat and fans could assist in shortening the drying time. The increased drying time could also result in delays in shipping and delivery times (e.g., retailers may not always be able to guarantee overnight delivery if drying times exceed the current period and pieces cannot be processed as fast as in the past).

In the few cases where flammability is a concern, users may need to make changes in ventilation systems and take other precautions that could increase overhead costs.

Associated Materials Costs:

Because of taxes on ozone-depleting substances (ODSs) in the United States and the extremely low cost of water, water-based formulations are significantly less expensive than 1,1,1-trichloroethane formulations. The same is believed to be true in most of the world, whether or not taxes on ODSs are present.

Suppliers of Alternative Materials and/or Equipment:

3M Consumer Specialties Division

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on water-based aerosol fabric protectants.

Date of Datasheet Completion:

May 1, 1994

[8] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Alternative Technology Datasheet

Use: Aerosol Fabric Protectants

User: Retailer-applied fabric treatment and home fabric maintenance

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Nonaerosol Water-Based Fabric Protectant***

Description of the Alternative:

Nonaerosol water-based fabric protectants, which are liquids that are dispensed manually rather than from an aerosol container, are a replacement for aerosol 1,1,1-trichloroethane-based fabric protectants. A common method for dispensing the protectant is via a finger- or trigger-pump spray. Water-based protectants can also be applied by retailers using an air pressure system -- a system in which a bulk container of the protectant is pressurized and the product is dispensed through a spray wand.

In nonaerosol applications, the formulation is dispensed as a mist and consists of larger drops than an atomized aerosol spray. The result is that, upon application, the fabric may become wet due to the larger drops. This, as well as the low vapour pressure of water may result in significantly longer drying times as compared to traditional fabric protectants, especially in humid environments. In addition, the nonaerosol application may, in some cases, result in an uneven distribution of the product on the fabric being treated.

In general, water may not always function as well as 1,1,1-trichloroethane as a carrier of the active ingredient in fabric protectant products. This can potentially decrease the adhesion quality of the protectant to the fabric. In order to account for this potential deficiency, it may be necessary to treat the fabric at more frequent intervals than would be needed with a 1,1,1-trichloroethane-based formulation. Also, water may damage (shrink, discolour) certain fabrics, depending on the method of application.

Use and Availability:

Nonaerosol water-based fabric protectants for use by retailers and consumers are new to the market and can be used on many different types of fabric. They are currently manufactured and distributed by several companies worldwide.

Environmental, Health, and Safety Considerations:

There are no significant consumer and worker health and safety impacts associated with the use of water-based fabric protectant formulations. However, due to the presence of flammable constituents in water-based formulations, the product as used may, in some cases, be flammable.

Materials and Equipment Changes Required:

Spraying apparatus may need to be made corrosion-resistant. Also, the increased drying time required for water-based protectants could make it necessary for users in the retailer-applied fabric treatment industry to reconfigure their treatment facility so that the number of pieces being treated does not decrease. The addition of heat sources and fans could potentially assist in decreasing the drying time. If the drying time is not decreased, delays in shipping and longer delivery times could occur (e.g., retailers may not always be able to guarantee overnight delivery if drying times exceed the current period and pieces cannot be processed as fast as in the past).

Associated Materials Costs:

Because of taxes on ODSs in the United States and the extremely low cost of water, water-based formulations are significantly less expensive than 1,1,1-trichloroethane formulations. The same is believed to be true of most of the world, whether or not taxes on ODSs are present.

Suppliers of Alternative Materials and/or Equipment:

Du Pont de Nemours
F.H. Engel S.A.
Fiber Shield Industries Inc.
3M Consumer Specialties Division

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on water-based nonaerosol fabric protectants.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.6 Mill-Applied Fabric Protectants

User: Textile mills

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Nonaerosol Water-Based Fabric Protectant***

Description of the Alternative:

Nonaerosol water-based fabric protectants are a replacement for 1,1,1-trichloroethane-based mill-applied fabric protectants. In the production mill, nonaerosol water-based fabric protectants are applied by dipping the fabric into vats of the liquid protectant. The fabric is then drawn through rollers to remove excess water, after which it is heat-cured. This treatment process requires a longer processing time than that normally associated with the use of 1,1,1-trichloroethane mill-applied fabric protectants.

Due to the need to heat-cure the fabric after treatment, users must ensure that the fabric being protected is capable of withstanding the heat of the curing process, which can be as high as 149°C to 177°C. In addition, some fabrics such as acrylics and olefins may experience increased shrinkage or dye loss when protected with water-based treatments. Therefore, it may be necessary to perform heat and water compatibility tests on the fabric.

Use and Availability:

Water-based fabric protectants are currently manufactured and distributed by several companies. They are becoming the predominant type of protectants used in mills and are used on many textiles, including apparel fabric, carpet, and upholstery.

Environmental, Health, and Safety Considerations:

There are no significant consumer and worker health and safety impacts associated with the use of water-based fabric protectant formulations.

Depending on the concentration of each of the constituents, products that contain flammable constituents may be flammable as used. Previous formulations containing 1,1,1-trichloroethane were nonflammable. While most of the water-based products currently available are nonflammable, some of those containing flammable components have flash points ranging from -3°C up to 100°C.

Some of the constituents in water-based formulations are considered volatile organic compounds (VOCs).[9] For

[9] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

example, acetone and ethylene glycol are often found in water-based formulations. The resulting formulation, not including the water, contains approximately 250 grams of VOCs per litre of product. These chemicals can also be problematic because of their odour. Users should consult with regional authorities on local VOC regulations.

Materials and Equipment Changes Required:

Depending on the production processes currently used in the mill, equipment changes may be required with a switch to water-based mill-applied fabric protectants. Curing ovens may need to be added to the production line if they are not currently being used for other fabric treatments. Furthermore, if curing ovens are not already used, then overhead costs could be increased with the use of water-based products due to the increased time required to complete the production process as well as increased energy consumption. If, however, curing ovens are used for other treatments, then the water-based protectants could be cured at the same time.

In most cases, curing ovens are already used in the application of 1,1,1-trichloroethane-based protectants. However, the temperature requirements for 1,1,1-trichloroethane-based products may be lower than those needed for water-based products. In these cases, the curing ovens would require retrofits to allow the temperatures to be increased. Alternatively, new high-temperature curing ovens could be purchased. The curing time, however, would not significantly change.

Associated Materials Costs:

Because of taxes on ODSs in the United States and the extremely low cost of water, water-based formulations are significantly less expensive than 1,1,1-trichloroethane formulations. The same is believed to be true of most of the world, whether or not taxes on ODSs are present. In addition, water-based products may be less expensive to use in the mill process than the 1,1,1-trichloroethane products, because they can be cured in conjunction with other materials placed on the fabric.

Suppliers of Alternative Materials and/or Equipment:

Ciba-Geigy Corp.
Du Pont de Nemours
Evode-Tanner
F.H. Engel S.A.
HBG Export Corporation
IVAX Industries Inc.
Phersee Chemie
NICCA

Suppliers (Continued)

Sequa Chemicals Incorporated
3M Protective Chemicals Division
Yorkshire PAChem

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on water-based nonaerosol mill-applied fabric protectants.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.7 Film Cleaning

User: 16 and 35 mm movie and photographic film cleaners, including original negatives, archive film, and nitrate film

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Perchloroethylene Immersion System***

Description of the Alternative:

One method of eliminating the use of 1,1,1-trichloroethane as a solvent in film cleaning systems is to replace it with perchloroethylene (PERC). PERC is a nonozone-depleting chlorinated solvent that has been used extensively in solvent cleaning applications. While PERC functions satisfactorily as a replacement for 1,1,1-trichloroethane in film cleaning, the film industry must consider three major implications when evaluating this alternative. First, the use of PERC requires modified or new equipment in order to limit PERC emissions. Second, film cleaning machines using PERC may require an increased amount of drying time, because PERC has a lower relative evaporation rate (2.59) in comparison to 1,1,1-trichloroethane (6.00).[10] Third, grades of PERC with high stabilizer contents (greater than 1 percent) can cause the plasticizer in the film to leach, make the film brittle, and cause the dye to fade more rapidly. These effects can be particularly problematic when cleaning archive film or original negatives. Therefore, users of PERC must pay close attention to obtaining the correct grade of PERC.

One advantage to using PERC is that, because of its lower volatility, a smaller quantity is required per metre of film cleaned. Depending on the type of cleaning machine, PERC can clean from 5,637 to 8,053 metres of film per litre (70,000 to 100,000 feet of film per gallon) compared to 1,1,1-trichloroethane which cleans from 4,832 to 6,845 metres of film per litre (60,000 to 85,000 feet of film per gallon). PERC cleaning systems clean 15 to 61 metres of film (50 to 200 feet) per minute and require 2.13 metres (7 feet) of lead in film.

Use and Availability:

Currently, film cleaning machines that use 1,1,1-trichloroethane are manufactured by two companies worldwide. However, only one company, Lipsner Smith, manufactures machines that can be switched back and forth between 1,1,1-trichloroethane and PERC. These machines are on the market and are being used by several film facilities. This company is the only one whose older model machines are known to have been converted so that they are compatible with PERC.

---

[10] *The evaporation rate is relative to that of n-butyl acetate which is used as the reference point and assigned an evaporation rate of 1.0.*

Environmental, Health, and Safety Considerations:

Several potential worker health and safety impacts are associated with the use of PERC as a solvent in film cleaning systems. PERC emissions are regulated in some areas because of its classification both as a volatile organic compound (VOC) and as a suspected carcinogen.[11] However, like 1,1,1-trichloroethane, PERC is nonflammable.

The primary worker health issue associated with the use of PERC is carcinogenicity. The International Agency for Research on Cancer lists PERC as "possibly carcinogenic," the United States Environmental Protection Agency (USEPA) lists it as a "possible/probable" carcinogen, the National Toxicology Program lists it as "reasonably anticipated to be carcinogenic," and the American Conference of Governmental Industrial Hygienists classifies it as an "animal carcinogen." Safety agencies in many countries such as the U.S. Occupational Safety Health Administration, have set workplace standards for PERC.

Emissions of VOCs are one of the environmental concerns associated with the use of PERC in film cleaning systems. Due to its exempt (non-VOC) status, 1,1,1-trichloroethane in film cleaning formulations did not add to VOC emissions. However, because PERC is considered a VOC, emissions may be strictly regulated in some geographic regions. For example, VOC emissions are strictly regulated by the USEPA, although the USEPA is currently considering reclassifying PERC as a non-VOC. Potential users of PERC should consult local regulations to determine the regulatory status of PERC and the acceptability of using products containing VOCs.

Laws regulating the disposal of PERC vary on a federal, state, and local basis. In general, however, PERC must be handled as a hazardous waste and sent to a licensed reclaimer or to permitted incinerators.

Materials and Equipment Changes Required:

Older model cleaning machines that have recycling systems can be converted for use with PERC. In addition, newer model systems are available that are designed for use with both PERC or 1,1,1-trichloroethane. These systems have a switch that converts them back and forth between the two chemicals. In order for PERC to be used, at least three changes must be made to older models. These changes, which have been made in the newer models, include an increased heating ability so that the PERC is distilled (i.e., older models have a maximum capacity of 77°C while newer models can heat the chemical up to 121°C), better seals and gaskets, and an accumulator in the recycling system.

In some cases, older models that do not have recycling systems can also be converted for use with PERC. However, this can be very expensive because of the cost of the recycling system which may need to be added to the machines in areas that strictly regulate VOC emissions.

Associated Materials Costs:

Because of the lower cost of PERC and the increase in the amount of film that can be cleaned, the cost of using PERC in film cleaning systems is less than the cost associated with using 1,1,1-trichloroethane. As indicated previously, as much as 1,208 more metres of film can be cleaned per litre (15,000 feet per gallon) with PERC

[11] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

than with 1,1,1-trichloroethane. In addition, the cost of PERC may be only 1/3 to 1/4 the cost of 1,1,1-trichloroethane. This price differential is due primarily to the taxes now levied on 1,1,1-trichloroethane. Without the taxes, PERC would be approximately 25 percent less expensive than 1,1,1-trichloroethane.

Another cost factor that should be considered is the cost of converting film cleaning machines and/or purchasing newer model machines. The cost of conversion can range from US$6,000 to over US$10,000, while a new machine designed for PERC use can cost over US$65,000.

Suppliers of Alternative Materials and/or Equipment:

Lipsner Smith Company

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact the supplier listed above for more information on PERC-compatible film cleaning systems.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Film Cleaning

User: 16 and 35 mm movie and photographic film cleaners not including camera originals

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Non-Immersion Cleaning System***

Description of the Alternative:

One method of eliminating the use of 1,1,1-trichloroethane as a solvent in film cleaning systems is to replace it with a non-immersion cleaning system. Non-immersion cleaning systems use either water-based cleaners with a surfactant or nonozone-depleting fluorocarbon-based cleaners (e.g., C_6F_{12}) and function satisfactorily as a replacement for 1,1,1-trichloroethane for cleaning most film types. Currently, these systems are not recommended for cleaning camera original negatives. However, as these systems are refined, the film types for which they are compatible may change.

Non-immersion systems use particle transfer rollers and wetted buffers to remove surface contaminants. In these systems, a series of moulded polymer rollers remove static-attracted particles from the film. The film is then cleaned using dacron buffers wetted with the cleaning solution. Finally, the film is dried using a nonimpingement drying system (i.e., forced hot air).

In comparison to 1,1,1-trichloroethane systems, these systems may have increased drying times. On the average, film is processed at 30.5 metres (100 feet) per minute with water-based cleaners and up to 61 metres (200 feet) per minute with fluorocarbon cleaners. Non-immersion systems use approximately 1 litre of cleaner per 10,308 metres (1 ounce per 1,000 feet) of film cleaned.

Water-based non-immersion systems can potentially cause film damage such as colour loss, brittleness, or removal of part of the plastic coating. Because the potential for film damage could be increased with water-based systems, film processors that handle camera original negatives or archival film might require two cleaning systems, one for camera original negatives and one for other film types.

Use and Availability:

Currently, non-immersion systems, which are new to the market, are manufactured by only one company worldwide.

Environmental, Health, and Safety Considerations:

Depending on the fluorocarbons used in the non-immersion system, there may be some significant environmental hazards and should only be used where no other alternatives exist. These fluorochemicals, commonly referred to as perfluorocarbons, have extremely high global warming potentials (GWPs). Because of their GWPs, some countries have indicated that they intend to limit the production and use of perfluorocarbons. HFC solvents are currently being investigated for this use, and are environmentally superior to the PFCs in this regard since they have significantly lower GWPs.

No worker health and safety or environmental impacts are associated with the use of water-based non-immersion systems. In addition, according to the system manufacturer, the surfactant used, polyoxyethylene (12) tridecyl ether, does not pose any worker health and safety or environmental hazards.

Materials and Equipment Changes Required:

Non-immersion systems require new equipment. Old model cleaning equipment cannot be converted. The non-immersion systems are self-contained in a 1.7 metres X 0.8 metres X 0.6 metres (68" high X 32" wide X 25" deep), 136 kilogram cabinet and include a control panel, supply and takeup reels, particle transfer rollers, wet treated buffers, and a drying chamber.

Associated Materials Costs:

Non-immersion systems cost the same as or less than 1,1,1-trichloroethane-based systems on a per foot of film cleaned basis. However, new equipment which costs approximately US$20,000 must be purchased. In addition, the longer drying time, increased chances of film damage, and the cost of running an additional machine for more sensitive film are likely to increase the overall costs associated with the use of water-based systems.

Suppliers of Alternative Materials and/or Equipment:

Lipsner Smith Company

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact the supplier listed above for more information on water-based non-immersion film cleaning systems.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Film Cleaning

User: 16 and 35 mm movie and photographic film cleaners

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Water-Based Spray Cleaning Systems***

Description of the Alternative:

One method of eliminating the use of 1,1,1-trichloroethane as a solvent in film cleaning systems is to replace it with a water-based spray cleaning system. In these systems, the film is continually sprayed with water during the cleaning process. Water-based spray systems function satisfactorily as a replacement for 1,1,1-trichloroethane, and in some cases may outperform 1,1,1-trichloroethane, because the water causes the film emulsion to swell, thereby releasing embedded water. However, as with non-immersion water-based systems, water-based spray systems can potentially damage film if they are not used properly. Therefore, users should consult with the system manufacturer to determine machine compatibility and machine operating methods with different film types to insure that film damage does not occur.

Of the several different types of water-based spray systems, most use a surfactant such as polyoxyethylene (12) tridecyl ether in the water formulation. The surfactant, however, is only a small portion of the formulation (approximately 0.5 to 0.2 percent). Some less expensive systems do not use a surfactant and may, consequently, not clean the film as well as systems using surfactants.

The film drying methods vary depending on the machine type used. Some machines use a nonimpingement drying method (i.e., water is removed with forced hot air), while others use a radio frequency (RF) drying system (i.e., water is radiated off the film). Nonimpingement drying is the standard method of drying used in the film industry, and is often considered the safest drying method. However, with this drying method a maximum of only 30.5 metres (100 feet) of film can be processed per minute. RF drying is a newer method that requires more adjustment control based on the type of film being used. If the water does not form an even coat on the film or if bubbles develop, the film could be damaged because of uneven drying. However, recent refinements in RF drying systems have made this method safer than previously thought possible. RF systems have the advantage of being faster than nonimpingement systems and can process film at a rate of up to 61 metres (200 feet) per minute.

These cleaning systems also vary in the amount of leader film and the amount of water used. Nonimpingement surfactant systems require approximately 7.3 metres (24 feet) of lead in film and 26.5 litres (7 gallons) of water per minute. Nonimpingement water-only systems require 2.13 metres (7 feet) of lead in film and use distilled water that is filtered and reused. RF systems require 7.9 to 8.5 metres (26 to 28 feet) of lead in film and approximately 5.3 litres (1.4 gallons) of water per minute.

Use and Availability:

Currently, water-based spray film cleaning machines, which have recently been introduced to the market, are manufactured by only three companies worldwide.

Environmental, Health, and Safety Considerations:

There are no significant worker health and safety or environmental impacts associated with the use of water-based spray film cleaning systems. According to the system manufacturers, the surfactant used in these systems does not pose any significant worker health and safety or environmental hazards, and the water and surfactant can be drained to the sewer without treatment.

Materials and Equipment Changes Required:

Because old model cleaning equipment cannot be converted, water-based spray systems require new equipment. Although all are self contained, these systems vary considerably in size. The water-only system is 1.97 metres X 1.22 metres X 0.71 metres (77.5" high X 48" wide X 28" deep). The water-based spray system that uses nonimpingement drying is 1.7 metres X 1.65 metres X 0.46 metres (67" high X 65" wide X 18" deep), while the RF water-based system is 1.88 metres X 2.03 metres X 0.84 metres (74" high X 80" wide X 33" deep).

Associated Materials Costs:

On a per metre or per foot of film cleaned basis, water-based spray systems cost the same or less than 1,1,1-trichloroethane-based systems. However, new equipment which costs from US$65,000 to US$85,000 must be purchased. In addition, the longer drying time, increased chance of film damage, and the cost of running an additional machine for more sensitive film could increase the overall costs associated with the use of water-based spray systems.

Suppliers of Alternative Materials and/or Equipment:

Lipsner Smith Company
Radio Frequency Company, Inc.
Technology Film Systems

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact the suppliers listed above for more information on water-based spray film cleaning systems.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.8 Windshield Sprays and Coatings

User: Aircraft manufactures and maintenance facilities

ODS(s) to be Replaced: CFC-113

Alternative: ***Hydrophobic Coating***

Description of the Alternative:

A hydrophobic coating called Surface Seal™ can be used as a replacement for traditional CFC-113 containing coatings. The hydrophobic coating contains four chemicals: cerium oxide, two fluorinated solvents, and fluoroalkylchlorosilane. The coating is applied to production windshields of aircraft prior to installation and reapplied during scheduled maintenance. The hydrophobic coating, a relatively new method of improving visibility in aircraft, is as effective as traditional windshield treatment methods. However, its service life has not yet been determined. An 18-month service life evaluation program is being conducted by Boeing, and the current estimate of service life ranges from 6 months to over two years. The frequency of reapplication will most likely vary with the aircraft's hours of operation and the atmospheric conditions in which the aircraft flies.

Several of the advantages of the newly developed hydrophobic coating system include: better visibility in more precipitation conditions because it does not have to be activated by the pilot, reduced weight on the aircraft because no delivery system is required, no pressurized CFC-113 canister on the flight deck, and reduced workload for the flight crew during approaches in the rain.

Use and Availability:

The new windshield coating system is currently available from only a few manufacturers. The product recently received FAA approval for all glass windshields, is certified on Cessna Citation VII aircraft and all Boeing aircraft, and is being experimentally used by some major airlines. Until the coating's durability has been established, however, the CFC-113 containing system cannot be removed from the aircraft.

Environmental, Health, and Safety Considerations:

No major worker health and safety impacts or environmental considerations are associated with the use of hydrophobic windshield coatings. Flammability is not a concern, and exposure levels encountered during everyday work do not pose any threat to worker health. The chemicals involved do not present a global-warming or ozone-depletion threat.

Materials and Equipment Changes Required:

New materials and equipment required include a kit with mechanical equipment for application (reused for multiple applications) and a kit containing the coating chemicals (purchased for each application). An additional consideration is the time the aircraft would be out of service for application of the coating if application is required between normally scheduled maintenance visits. The 8-10 hours required for application may be offset by the time saved as a result of avoiding the maintenance required for the delivery and wiper system currently used with CFC-113 systems.

Associated Materials Costs:

No study has been performed to compare costs, and the many factors involved (e.g., lifetime of the coating, downtime due to maintenance, and effects of the reduced aircraft weight on fuel consumption) make an estimate of relative costs very difficult.

Known costs associated with hydrophobic coatings include approximately US$3,000 for a kit with the mechanical equipment for application and approximately US$550 for a kit containing the primers and coatings for one window.

Suppliers of Alternative Materials and/or Equipment:

PPG Industries Inc.

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact the suppliers listed above for more information on hydrophobic windshield coatings.

For information on the performance and service life of the coatings contact:

Mr. Anil Shah
Boeing Company, Renton Division
Mail Stop 6-MKE
P.O. Box 3707
Seattle, WA 98124-2207
USA
Tel: (1) 206 234 5908
Fax: (1) 206 237 7229

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.9 Fumigation

User: Grain and seed treatments

ODS(s) to be Replaced: Carbon tetrachloride/carbon tetrachloride fumigant mixtures

Alternative: ***Phosphine Gas***

Description of the Alternative:

Phosphine gas is a fumigant that is produced when magnesium or aluminum phosphide is exposed to moisture. Magnesium and aluminum phosphide are formulated into pellets, tablets, bags, dust, or plates which can be placed by the user into the treatment area or container. Depending on the temperature and humidity, treatment takes from 2 to 10 days. Under high moisture conditions, the use of phosphine may be limited because it reacts with copper, silver, and gold present in some treatment facilities.

Phosphine can be used to control numerous pests and is currently used as a quarantine treatment for some commodities. In addition, in the United States, it is the recommended fumigant for on-farm treatment. It functions as effectively as carbon tetrachloride in these applications. A concern with the use of phosphine is potential pest resistance caused by improper application. In addition, phosphine treatments require more time to complete than those using carbon tetrachloride or carbon tetrachloride mixtures.

Recent research indicates that combining hot carbon dioxide with low rates of phosphine gas can provide good pest control while lessening problems associated with metal corrosion. The use of carbon dioxide will significantly increase the penetration of the phosphine, as well as increase insect susceptibility to the material.

Use and Availability:

Phosphine is currently manufactured by several companies. There are, however, only a few pesticide formulators.

Environmental, Health, and Safety Considerations:

Depending on the level of applicator training, there may be consumer and worker health and safety or environmental impacts associated with the use of phosphine.

Magnesium and aluminum phosphide, when exposed to moisture in the air, release hydrogen phosphide, a poisonous gas. Inhalation exposure limits for hydrogen phosphide may vary depending on the country in which it is used. In the United States, the Occupational Safety and Health Administration has set Permissible Exposure Limits (PELs) at 0.3 ppm for hydrogen phosphide.

In addition to being poisonous, hydrogen phosphide is explosive if concentrations exceed 1.8 percent in the air.

Materials and Equipment Changes Required:

No materials or equipment changes are required for the use of phosphine gas. In some cases, less monitoring equipment is required with phosphine than with carbon tetrachloride. However, using the best available gas detection equipment is always recommended. While no equipment changes are required, phosphine treatment may take longer than treatment with carbon tetrachloride. Therefore, additional grain storage area may be needed.

Associated Materials Costs:

In the United States, phosphine is much less expensive than carbon tetrachloride. Phosphine treatment, at an average application rate of 33 grams per 28.3 m^3, costs from US$2 to US$3 per 28.3 m^3 treated.

Suppliers of Alternative Materials and/or Equipment:

Degesch America, Inc.

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on phosphine gas fumigants.

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Fumigation

User: Grain and seed treatments

ODS(s) to be Replaced: Carbon tetrachloride/Carbon tetrachloride mixtures

Alternative: ***Controlled/Modified Atmosphere***

Description of the Alternative:

Controlled/modified atmosphere treatments (CA/MA) suffocate pests by exposing them to decreased amounts of oxygen and/or increased amounts of carbon dioxide or nitrogen for periods ranging from 4 hours to 30 days. The CA/MA is achieved by introducing carbon dioxide into the storage area, flooding the storage area with nitrogen, or burning oxygen to lower the oxygen level in the storage area. One drawback to CA/MA is the length of treatment time required. Unless the treatment time can be decreased, these techniques may not be viable alternatives for quarantine treatments because long treatment periods may delay shipping. CA/MA, however, is primarily effective at destroying insect pests and can produce similar results as carbon tetrachloride and carbon tetrachloride fumigant mixtures.

Use and Availability:

CA/MA techniques are widely used in areas such as Australia and parts of the Pacific. The sealing materials and gas generation equipment are readily available. CA/MA-generating equipment is currently manufactured by several companies around the world.

Environmental, Health, and Safety Considerations:

There may be worker safety or environmental impacts associated with the use of CA/MA. Workers must be aware of the danger of low levels of oxygen. In addition, CO_2 has a global warming potential of 1.0.

Burning to decrease oxygen content in storage areas is not a common method of creating a CA/MA. However, if this method is used, precautions should be taken to minimize worker exposure to flames.

Materials and Equipment Changes Required:

To achieve high efficiency levels, treatment facilities must be completely sealed. This may pose a problem for some storage facilities. In addition, because of the long treatment times, additional grain storage area may be needed.

Equipment to generate CA/MA and the equipment (e.g., hoses, pipes, fans) necessary to circulate the carbon dioxide or nitrogen in the storage area can be expensive. However, modified atmospheres can be created with proper sealing of stored grains without the use of any gas-generating equipment by hermetically sealing the storage area.

Associated Materials Costs:

CA/MA is initially more expensive than carbon tetrachloride. In the long-run, however, it is a very inexpensive treatment method. Sealing of storage or treatment facilities costs approximately US$5 per 2.83 m^3. If done properly, the sealing can last several years. Hermetic generation of modified atmospheres costs very little. Generating a CA/MA using purging and CO_2/N-generating equipment can cost as little as US$3 and as much as US$133 per 28.3 m^3, depending on the generation method used.

Suppliers of Alternative Materials and/or Equipment:

Aerogen Company Limited
Genron Systems
PERMEA, Inc.

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on controlled/modified atmosphere generating equipment.

The following resources provide information on the development of modified atmospheres without using generation equipment and general information on controlled/modified atmospheres:

Banks, H.J., and P.C. Annis. 1980. "Conversion of existing grain storage structures for modified atmosphere use." J. Shejbal, editor. Controlled Atmosphere Storage of Grains. Elsevier Scientific Publishing Company: New York.

Calderon, M. and R. Barkai-Golan, editors. 1989. Food Preservation by Modified Atmospheres. CRC Press: Boston.

Ripp, B.E., editor. 1984. Practical Aspects of Controlled Atmosphere and Fumigation in Grain Storages, Proceedings of an International Symposium, 11-22 April, 1983. Perth, Western Australia. Elsevier Science Publishing Co.: New York.

For further information and listings of other resources please contact:

Dr. Valerie Wright
Secretary/Treasurer
International Working Conferences on Stored-Product Protection
P.O. Box 1974
Manhattan, KS 66502
USA

ASEAN Plant Quarantine Centre and Training Institute
Post Bag 209, UPM Post
43400 Serdang, Selangor
Malaysia
Tel: (60) 3 948 6010
Fax: (60) 3 948 6023

Stored Grain Research Laboratory
Division of Entomology
Commonwealth Scientific and Industrial Research Organization
GPO Box 1700
Canberra, ACT 2601
Australia
Tel: (61) 62 46 4207
Fax: (61) 62 46 4202

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

Use: Fumigation

User: Grain and seed treatment

ODS(s) to be Replaced: Carbon tetrachloride/Carbon tetrachloride fumigant mixtures

Alternative: ***Thermotherapy***

Description of the Alternative:

Thermotherapy is the use of high (up to 100°C) temperatures to kill pests. In order for the treatment to be effective, the grain being treated must be exposed to these temperatures for extensive periods of time. Thermotherapy, if maintained for the proper period of time, can be as effective as carbon tetrachloride and carbon tetrachloride fumigant mixtures. However, heat treatments can be more difficult to regulate because they are specific to pest species and development stage.

The heat required for thermotherapy treatments can be generated using steam heaters, although in areas with high temperatures, heat from the sun can be used. Steam heaters are expensive to install and run, but quickly generate the temperatures required to kill pests. If solar heating is used, the grain is covered with tarpaulins which trap the heat. This method is inexpensive but requires long periods of time.

Use and Availability:

Thermotherapy techniques are widely known, but are not commonly used. Information on these techniques is best obtained through local agricultural and commodity storage organizations. Because thermotherapy equipment is usually designed for a particular facility, standard generators are not readily available.

Environmental, Health, and Safety Considerations:

No major environmental, health, or safety hazards are associated with thermotherapy. However, workers should be trained and some precautions should be taken so that no one enters areas being heated before the temperature is returns to safe levels.

Materials and Equipment Changes Required:

To achieve high levels of efficiency with steam heat, treatment facilities must be completely sealed. This may pose a problem for some storage facilities. With tarpaulin and solar heating, the commodity must also be properly sealed to prevent reinfestation. In either case, because of long treatment times, additional grain storage area may be needed.

In most cases, with the exception of sealing materials, no equipment is necessary in areas such as Africa, where the temperatures can easily be raised to levels lethal to pests. However, if less time is available for treatment and the temperature needs to be raised quickly, equipment may need to be used.

Associated Materials Costs:

Thermotherapy is less expensive than carbon tetrachloride because in many cases no equipment is required. However, costs could be incurred if more storage areas need to be built to compensate for the long treatment times required. In addition, if steam heating equipment is used, the cost of the equipment and the gas to run the equipment also add to the expense.

Suppliers of Alternative Materials and/or Equipment:

No thermotherapy equipment suppliers have been identified, but the steam heaters used are similar to those used in homes and are widely available.

Sources of Information:

The following resources can provide information on the application, use, construction, and efficiency of thermotherapy equipment:

Stout, O.O. 1983. International Plant Quarantine Treatment Manual. Revised by H. L. Roth. J.F. Karpati, C.Y. Schotman, and K.A. Zammarano, editors. Plant Production and Protection Paper No. 50. Food and Agricultural Organization of the United Nations: Rome.

Dr. Valerie Wright
Secretary/Treasurer
International Working Conferences on Stored-Product Protection
P.O. Box 1974
Manhattan, KS 66502
USA

ASEAN Plant Quarantine Centre and Training Institute
Post Bag 209, UPM Post
43400 Serdang, Selangor
Malaysia
Tel: (60) 3 948 6010
Fax: (60) 3 948 6023

Stored Grain Research Laboratory
Division of Entomology
Commonwealth Scientific and Industrial Research Organization
GPO Box 1700
Canberra, ACT 2601
Australia
Tel: (61) 62 46 4207
Fax: (61) 62 46 4202

Date of Datasheet Completion:

May 1, 1994

Alternative Technology Datasheet

4.10 Correction Fluids

User: Ink and other pen types, copies, and type

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Petroleum Distillate Formulations***

Description of the Alternative:

In petroleum distillate-based correction fluids, 1,1,1-trichloroethane is replaced as the main solvent with petroleum distillates, a class of organic solvents derived from petroleum products. As replacements for 1,1,1-trichloroethane in correction fluids, petroleum distillates function satisfactorily. However, due to their lower vapour pressure, formulations containing petroleum distillates may require an increased amount of drying time. Petroleum distillates are flammable, and this may require that retailers and distributors storing large amounts of products alter their storage methods because of the fire hazard associated with the petroleum distillate-based fluids.

Petroleum distillate-based correction fluids have two advantages over the 1,1,1-trichloroethane formulations. First, they are more versatile than 1,1,1-trichloroethane-based correction fluids. Unlike 1,1,1-trichloroethane-based correction fluids, they can be used not only for inks and typewriters but also for copies. Second, petroleum distillate formulations do not require the use of thinners. Instead, the container must be shaken well before using to obtain the proper flow qualities.

Use and Availability:

Petroleum distillate-based correction fluids are currently manufactured and distributed by several companies. They are widely used in offices and households around the world.

Environmental, Health, and Safety Considerations:

There may be consumer and worker health and safety or environmental impacts associated with using petroleum distillates as a solvent in correction fluid formulations. These impacts and the potential risks they pose depend on the level of consumer and retailer awareness concerning the differences between products previously used and the newly formulated products.

The primary safety concern associated with the new formulations is flammability. Previous formulations containing 1,1,1-trichloroethane were nonflammable. Petroleum distillate-based formulations, however, have flash points ranging from as low as -24°C to over -20.6°C. However, due to the small quantity of product contained in the average bottle available to office workers and consumers, the risk of flammability is not significant.

Another health and safety consideration is the strong odour of some petroleum distillate-based products. While these odours are not dangerous, they may result in minor discomfort for workers or consumers using these products. To reduce the concentration of the product in the air and thereby reduce the odour, products with strong odours should be used only in well-ventilated areas.

Emissions of volatile organic compounds (VOCs) are a possible environmental concern associated with the use of petroleum distillates in correction fluids.[12] Because of its exempt status, however, 1,1,1-trichloroethane in formulations did not add to VOC emissions. Petroleum distillates are considered VOCs and therefore, add to VOC emissions when used in the new product formulations. However, because petroleum distillates make up only a small portion of the formulation, the actual VOC emissions are small.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

According to shelf surveys conducted in the Washington D.C. area, petroleum distillate-based and 1,1,1-trichloroethane-based formulations are similarly priced in the United States. However, the taxes imposed in the United States on ozone-depleting substances, 1,1,1-trichloroethane formulations may be less expensive than petroleum distillate-based formulations.

Suppliers of Alternative Materials and/or Equipment:

Bic Corporation
Eberhard-Faber, Inc.
Gillette Company
Repeat-O-Type Manufacturing Corp.
Wite-Out Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on petroleum distillate-based correction fluids.

Date of Datasheet Completion:

May 1, 1994

[12] *VOC classifications discussed in this datasheet are based on United States policy and may not apply in other regions of the world.*

Alternative Technology Datasheet

Use: Correction Fluids

User: Type, copies, some pen types

ODS(s) to be Replaced: 1,1,1-trichloroethane

Alternative: ***Water-Based Formulations***

Description of the Alternative:

In water-based correction fluids, the 1,1,1-trichloroethane solvent is replaced with water. Water-based correction fluids, which can be used for most of the same applications as those containing 1,1,1-trichloroethane, are effective for copies (for which 1,1,1-trichloroethane cannot be used), typewriters, and some pen types (e.g., felt pens). They cannot, however, be easily used on ink pens, because they cause most inks to bleed. If they are used to cover ink pens, many coats will be required.

Water-based correction fluids have an advantage over 1,1,1-trichloroethane-based correction fluids in that they can be used in schools and prisons, where the use of toxic and flammable substances is often strictly regulated. In addition, unlike 1,1,1-trichloroethane-based products, they do not require the use of a specially purchased thinner. Instead, water can be added to the product if it becomes too thick. Water-based correction fluids have the disadvantage of requiring longer to dry (e.g., up to 50 seconds) in comparison to 1,1,1-trichloroethane-based products. This can cause some delays when more than one coat is required to properly cover ink.

Use and Availability:

Water-based correction fluids, widely used in offices and households around the world, are currently manufactured and distributed by several companies.

Environmental, Health, and Safety Considerations:

There are no worker safety or environmental impacts associated with the use of water-based correction fluids.

Materials and Equipment Changes Required:

No changes are required for the user.

Associated Materials Costs:

According to shelf surveys conducted in the Washington D.C. area, water-based and 1,1,1-trichloroethane-based formulations are marketed at similar prices. However, because of the low cost of water, water-based formulations may be less expensive than 1,1,1-trichloroethane-based formulations in other areas.

Suppliers of Alternative Materials and/or Equipment:

Bic Corporation
Eberhard-Faber, Inc.
Wite-Out Products

See Annex E for complete addresses, telephone numbers, and fax numbers.

Sources of Information:

Contact any of the suppliers listed above for more information on water-based correction fluids.

Date of Datasheet Completion:

May 1, 1994

5. Sources of Information on Major Solvents, Coatings, and Adhesives uses of Ozone Depleting Substances

5. Sources of Information on Major Solvents, Coatings, and Adhesives Uses of Ozone Depleting Substances

Information on major solvents, coatings, and adhesives uses of ozone-depleting substances (ODSs) is not included in this catalogue because sufficient material is already available about these uses and their alternatives. Examples of major uses are vapour degreasing, dry cleaning, adhesives, and precision cleaning applications. This section provides information on the sources of information that exists about these uses and their major alternatives.

UNEP Technical Options Report

In response to a mandate of the Montreal Protocol, the United Nations Environment Programme (UNEP) has assembled a Technical Options Committee to address alternatives to ODSs for the solvents, coatings, and adhesives use sectors. This committee prepared a report in late 1991 that provides very detailed information on the use of and substitutes for ODSs in a variety of use sectors. The sectors addressed include:

- Electronics cleaning
- Metal cleaning
- Precision cleaning
- Dry cleaning
- Adhesives
- Coatings and inks
- Aerosols

Both currently available and emerging alternatives are presented in the report.

Developing countries can obtain copies of the UNEP Solvents, Coatings, and Adhesives Technical Options Report free-of-charge from UNEP IE/PAC at the following address:

United Nations Environment Programme Industry and Environment Programme Activity Centre (UNEP IE/PAC)
Attn: R. M. Shende
39-43 Quai Andre Citroën
75739 Paris Cedex 15
France
Tel:(33) 1 44 37 14 50
Fax:(33) 1 44 37 14 74

Persons in developed countries can obtain the report from the UNEP Ozone Secretariat at the following address:

Ozone Secretariat
Attn: K. M. Sarma
PO Box 30552
Nairobi
Kenya
Tel:(254) 2 521 928/9
Fax:(254) 2 521 930

OzonAction Information Clearinghouse

UNEP IE/PAC's OzonAction Information Clearinghouse can provide a wide range of additional information about the solvents, coatings and adhesives use sector. The OzonAction Programme will respond to any technical or policy questions (see Annex A for a full description of available services).

USEPA/ICOLP Technical Manuals

The International Cooperative for Ozone Layer Protection (ICOLP) is an organization whose members include 5 manufacturing companies, government agencies, scientific organizations, and interest groups. Together, these organizations work to share information on the alternatives to ODSs in a variety of applications. As a part of this effort, ICOLP and the United States Environmental Protection Agency (USEPA) have published six technical manuals aimed at the solvents sector. They are the following:

- Alternatives for CFC-113 and Methyl Chloroform in Metal Cleaning
- Aqueous and Semi-Aqueous Alternatives for CFC-113 and Methyl Chloroform Cleaning of Printed Circuit Board Assemblies
- Conservation and Recycling Practices for CFC-113 and Methyl Chloroform
- Eliminating CFC-113 and Methyl Chloroform in Precision Cleaning Operations
- No-Clean Soldering to Eliminate CFC-113 and Methyl Chloroform Cleaning of Printed Circuit Board Assemblies
- Eliminating CFC-113 and Methyl Chloroform in Aircraft Maintenance Procedures

The first four of these manuals were originally published in June 1991 and are now being revised and updated. The last two manuals were published in November 1993.

The USEPA/ICOLP manuals are educational documents that endeavour to present engineers and decisionmakers with basic information on the major alternatives to ODSs in a particular application. The purpose of the manuals is to:

- Update facilities and governments on the progress of various countries in phasing out CFC-113 and 1,1,1-trichloroethane
- Publicize the fact that alternative cleaning procedures exist for most applications
- Provide a strategy for streamlining the selection and implementation of alternative chemicals or processes

- Identify and describe currently available and emerging alternatives for replacing CFC-113 and 1,1,1-trichloroethane
- Provide an overview of the environmental, health, and safety factors affecting the selection of an alternative.

Each manual is written by a committee of experts from the industry being addressed.

Copies of the USEPA/ICOLP manuals can be obtained free-of-charge by calling the USEPA's Stratospheric Protection Division Hotline at (1) 202-775-6677 or 1-800-896-1996.

6. Annex

6. Annex A - UNEP IE/PAC

The UNEP IE/PAC OzonAction Programme under the Multilateral Ozone Fund

The Montreal Protocol

Mounting scientific research has implicated chlorofluorocarbons (CFCs), halons, carbon tetrachloride, 1,1,1-trichloroethane, methyl bromide, and hydrochlorofluorocarbons (HCFCs) in the depletion of the stratospheric ozone layer, that segment of the earth's atmosphere which protects animal and plant life from the damaging effects of ultraviolet radiation. In September 1987, nations concerned about this crisis signed the Montreal Protocol, a landmark agreement that identified the major ozone depleting substances (ODSs) and established a timetable for their eventual phase-out. Under the Montreal Protocol, ODS production and consumption of the controlled substances are to be reduced and eliminated through the development of chemical substitutes and alternative manufacturing processes.

The Multilateral Fund and the UNEP OzonAction Programme

Under the London and Copenhagen amendments to the Protocol, the Multilateral Fund (MF) was established to provide financial and technical assistance to developing countries that are Parties to the Montreal Protocol. The United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), the World Bank and the United Nations Industrial Development Organization (UNIDO) were chosen to be the Fund's implementing agencies, with UNEP being assigned the responsibility of conducting research, data gathering, and providing a clearinghouse function to:

(i)Assist Parties operating under paragraph 1 of Article 5, through country specific studies and other technical co-operation, to identify their needs for co-operation;

(ii)Facilitate technical co-operation to meet these identified needs;

(iii)Distribute, as provided for in Article 9, information and relevant materials, and hold workshops, training sessions, and other related activities, for the benefir of Parties that are developing countries; and

(iv)Facilitate and monitor other multilateral, regional and bilateral co-operation available to Parties that are developing countries.

UNEP IE/PAC's OzonAction Programme is the result of that mandate. It consists of several major elements: information exchange, training, networking, country programmes, institutional strengthening, and international halon bank management..

Information Exchange

The information exchange element of the OzonAction Programme aims to transfer information concerning policy and technical options for the phase-out of the controlled ODSs to developing countries.

OzonAction Information Clearinghouse (OAIC):
The OAIC is an integrated information exchange service designed to meet the needs of developing countries through various communication media. The OAIC provides technical, policy and scientific information on a range of ODS phase-out issues including:

- descriptions of alternative technologies and product listings for each industrial use sector;
- an international directory of experts and consultants;
- technical literature abstracts, and information for ordering documents;
- descriptions of national and corporate strategies, policies, legislation, and programmes to phase out ODS;
- listings of workshops, conferences, and meetings concerning ozone depletion issues;
- bulletins containing news on phase-out initiatives.

There is no charge for using the OAIC query response service -- simply phone, fax or write us with your question. Anyone with a personal computer can use the diskette version, and with the addition of a modem and communication software, the on-line system.

OzonAction Newsletter:
This quarterly newsletter reports on the initiatives undertaken by countries and organizations that are implementing the Montreal Protocol. The OzonAction newsletter contains the latest news from governments and industry regarding the phase-out of the controlled ODSs, as well as science and technology updates.

Other ODS-Reduction Documents:
OzonAction will publish specific technical and policy documents and
brochures in response to specific information needs within industry and government.

Training

Regional Workshops:
A series of regional workshops is designed to provide government and industry decision-makers with basic information on ODS control policies and strategies. Additionally, these workshops provide participants with the latest information about replacement technologies and products relating to the controlled substances.

Regional Training Courses:
Based on a "train the trainer" approach, these sectorial courses impart the latest technical information and skills required to phase out ODSs (for example, service and maintenance practices, and recovery/recycling for the refrigeration sector).

National Activities:
The OzonAction Programme will sponsor information campaigns at the national level to help raise the consciousness of the general public about the threat posed by the controlled ODSs. OzonAction will also be cooperating with UNDP to address specific technological issues within specific countries.

Documentation/Training Manuals:
The OzonAction Programme will additionally publish technical papers, workshop proceedings, and training manuals/guidelines/handbooks.

Networking

The OzonAction Programme facilitates regional networking activities, which enable government officers in charge of their countries' National Ozone Units to interact and share information on strategies and policies to phase out ODS. Such information sharing and regional co-operation is hoped to expedite the phase-out. Presently, two ODS Officers Networks (ODSONETs) in South East Asia & Pacific and Latin America are in operation, and a third in Africa is being launched.

Country Programmes

The OzonAction Programme is conducting a series of country programmes for developing nations that have low rates of consumption for the controlled substances. The purpose of these programmes is to establish a baseline survey on the use of the controlled substances in these countries and to draw up policy strategies for their replacement and control. The data developed under this effort will establish a basis for other phase-out projects.

Institutional Strengthening

The OzonAction Programme assists the development of projects to establish National Ozone Units responsible for the implementation of the ODS phase-out in developing countries.

International Halon Bank Management

In accordance with Decision IV/26 of the Copenhagen Amendment to the Montreal Protocol, UNEP IE/PAC has established an International Halon Bank Management Information Clearinghouse which maintains a contact list for national halon banks, collects information about availability of recycled halons to the national halon banks, answers queries concerning alternative technologies or practices that substitute for halons, and develops halon banking-related documents.

For More Information About These Services
Please contact UNEP IE/PAC at:

Mr. Rajendra Shende, Coordinator
UNEP IE/PAC OzonAction Programme
39-43, quai André Citroën
75739 Paris Cedex 15
France
Tel: (33.1) 44.37.14.59
Fax: (33.1) 44.37.14.74

UNEP's Industry and Environment Programme Activity Centre (IE/PAC), formerly the Industry and Environment Office, was established in Paris in 1975 to bring industry, government, and nongovernmental organizations together to work towards environmentally sound forms of industrial development. To this end, the IE/PAC concentrates on formulating and promoting appropriate policies and strategies. More specifically, it seeks to:

- Define and encourage the incorporation of environmental criteria in industrial development;
- formulate and facilitate the implementation of principles and procedures to protect the environment;
- promote the use of safe, low and non-waste technologies (LNWT); and
- stimulate the exchange of information and experience on environmentally sound forms of industrial development throughout the world.

IE/PAC's work programme follows four principal areas: the publication of technical guides; technical cooperation; training; and information transfer. It has also developed two priority programmes: "Awareness and Preparedness for Emergencies at the Local Level" (APELL) to prevent and respond to technological accidents, and Cleaner Production.

Annex B - Glossary of Significant Terms

Alcohols -- A series of hydrocarbon derivatives with at least one hydrogen atom replaced by an -OH group. The simplest alcohols (methanol, ethanol, n-propanol, and isopropanol) are good solvents for some organic soils, notably rosin, but are flammable and can form explosive mixtures with air: their use requires caution and well-designed equipment.

Aqueous cleaning -- Cleaning parts with water to which may be added suitable detergents, saponifiers or other additives.

Article 5 Countries -- Parties to the Montreal Protocol that are considered developing countries. Article 5 countries are eligible to receive technical and financial assistance from the Multilateral Fund to phase out consumption of ODSs.

CFC -- An abbreviation for chlorofluorocarbon.

CFC-113 -- A common designation for the most popular CFC solvent, 1,1,2-trichloro-1,2,2-trifluoroethane, with an ODP of approximately 0.8.

Chlorofluorocarbon -- Organic chemicals composed of chlorine, fluorine and carbon atoms, usually characterized by high stability contributing to a high ODP. These chemicals are commonly used in refrigeration, foam blowing, aerosols, sterilants, solvent cleaning, and a variety of other applications. CFCs have the potential to destroy ozone in the stratosphere.

Corrosion inhibitor -- A constituent of many water-based cleaner formulations which helps to reduce the risk of corrosion of parts.

Detergent -- A product designed to render, for example, oils and greases soluble in water, usually made from synthetic surfactants.

DME -- Dimethyl Ether; a flammable aerosol propellant used in some European, Japanese, and U.S. aerosol formulations.

Greenhouse effect -- A thermodynamic effect whereby energy absorbed at the earth's surface, which is normally able to radiate back out to space in the form of long-wave infrared radiation, is retained by gases in the atmosphere, causing a rise in temperature. The gases in question are partially natural, but man-made pollution is thought to increasingly contribute to the effect. The same CFCs that cause ozone depletion are known to be "greenhouse gases", with a single CFC molecule having the same estimated effect as 10,000 carbon dioxide molecules.

GWP -- Global Warming Potential; potential for certain gaseous substances to contribute to the warming of the

Earth's surface. See Greenhouse for further information.

HC -- Hydrocarbon; commonly used substitutes for CFCs in aerosol propellants. Hydrocarbons are also VOCs and their use may be restricted or prohibited in some areas.

HCFC -- An abbreviation for hydrochlorofluorocarbon.

HFC -- An abbreviation for hydrofluorocarbon.

Hydrocarbon/surfactant blend -- A mixture of low-volatile hydrocarbon solvents with surfactants, allowing the use of a two-phase cleaning process. The first phase is solvent cleaning in the blend and the second phase is water cleaning to remove the residues of the blend and any other water-soluble soils. The surfactant ensures the water-solubility of the otherwise insoluble hydrocarbon. Terpenes and other hydrocarbons are often used in this application.

Hydrochlorofluorocarbon -- An organic chemical composed of hydrogen, chlorine, fluorine and carbon atoms. These chemicals are less stable than pure CFCs, thereby having generally lower ODPs.

Metal cleaning -- General cleaning or degreasing of metallic components or assemblies, without specific quality requirements or with low ones.

MCF -- An abbreviation for methyl chloroform; see 1,1,1-trichloroethane.

Methyl chloroform -- See 1,1,1-trichloroethane.

ODP -- An abbreviation for ozone depletion potential.

ODS -- Ozone-Depleting Substance; any substance with an ODP greater than 0.

Organic solvents -- Ketones, alcohols, esters, etc. Used often in aircraft cleaning.

OSHA -- United States Occupational Health and Safety Administration

Ozone -- A gas formed when oxygen is ionized by, for example, the action of ultraviolet light or a strong electric field. It has the property of blocking the passage of dangerous wavelengths of ultraviolet light. Whereas it is a desirable gas in the stratosphere, it is toxic to living organisms at ground level (see volatile organic compound).

Ozone depletion -- Accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced, for the most part, by human activities. The most depleting species for the ozone layer are the chlorine and bromine free radicals generated from relatively stable chlorinated, fluorinated, and brominated products by ultraviolet radiation.

Ozone depletion potential -- A relative index indicating the extent to which a chemical product may cause ozone depletion. The reference level of 1 is the potential of CFC-11 and CFC-12 to cause ozone depletion. If a product has an ozone depletion potential of 0.5, a given weight of the product in the atmosphere would, in time, deplete half the ozone that the same weight of CFC-11 would deplete. The ozone depletion potentials are calculated from mathematical models which take into account factors such as the stability of the product, the rate of diffusion, the quantity of depleting atoms per molecule, and the effect of ultraviolet light and other radiation on the molecules. The substances implicated generally contain chlorine or bromine.

Ozone layer -- A layer in the stratosphere, at an altitude of approximately 10-50 km, where a relatively strong concentration of ozone shields the earth from excessive ultraviolet radiation.

PEL -- Permissible Exposure Limit; maximum exposure to a given chemical recommended by the US Occupational Safety and Health Administration (OSHA) to protect worker health and safety.

PERC -- Perchloroetylene.

Perfluorocarbons (PFCs) -- A group of synthetically produced compounds in which the hydrogen atoms of hydrocarbon are replaced with fluorine atoms. The compounds are characterized by extreme stability, non-flammability, low toxicity, zero ozone depleting potential, but high global warming potential.

Semi-aqueous cleaning -- Cleaning with a nonwater-based cleaner, followed by a water rinse.

Solvent -- Although not a strictly correct definition, in this context a product (aqueous or organic) designed to clean a component or assembly by dissolving the contaminants present on its surface.

Surfactant -- A product designed to reduce the surface tension of water. Also referred to as tensio-active agents/tensides. Detergents are made up principally from surfactants.

TCA -- An abbreviation for 1,1,1-trichloroethane.

Terpene -- Any of many homocyclic hydrocarbons with the empirical formula $C_{10}H_{16}$, characteristic odour. Turpentine is mainly a mixture of terpenes. See hydrocarbon/surfactant blends.

1,1,1-Trichloroethane -- Also known as methyl chloroform; commonly used as a solvent in a variety of metal, electronic, and precision cleaning applications. Has an ODP of approximately 0.12.

TRIF -- Total Release Indoor Foggers.

UNEP -- United Nations Environment Programme

UNEP IE/PAC -- United Nations Environment Programme Industry and Environment Programme Activity Centre

USEPA -- United States Environmental Protection Agency

VOC(s) -- An abbreviation for volatile organic compound(s).

Volatile organic compound (VOC) -- These are constituents that will evaporate at their temperature of use and which, by a photochemical reaction, will cause atmospheric oxygen to be converted into potential smog-promoting tropospheric ozone under favourable climatic conditions.

Annex C - Contacts for Additional Information

American Conference of Governmental Industrial Hygienists (ACGIH)
Attn: William D. Kelley, Executive Secretary
1330 Kemper Meadow Drive
Suite 600
Cincinnati, OH 45240
USA
Tel: (1) 513 742 2020
Fax: (1) 513 742 3355

Center for Emissions Control (CEC)
Attn: Stephen P. Risotto, Executive Director
1025 Connecticut Avenue, N.W.
Suite 712
Washington, D.C. 20036
USA
Tel: (1) 202 785 4374
Fax: (1) 202 223 5979

Chemical Specialties Manufacturers Association (CSMA)
Attn: Ralph Engel, President
1913 I Street, N.W.
Washington, D.C. 20006
USA
Tel: (1) 202 872 8110
Fax: (1) 202 872 8114

Global Center for Process Change
Attn: William G. Kenyon, Director
P.O.Box 553
Montchanin, DE 19710-0553
USA
Tel: (1) 302 652 5597
Fax: (1) 302 652 5701

International Agency for Research on Cancer (IARC)
Attn: Lorenzo Tomatis, Director
150, cours Albert-Thomas
F-69372 Lyon Cedex 08
France
Tel: (33) 1 72 73 84 85
Fax: (33) 1 72 73 85 75

International Cooperative for Ozone Layer Protection (ICOLP)
2000 L Street, N.W.
Suite 710
Washington, D.C. 20036
USA
Tel: (1) 202 737 1419
Fax: (1) 202 296 7442

National Fire Protection Association (NFPA)
Attn: Robert W. Grant, President
One Batterymarch Park
P.O.Box 9101
Quincy, MA 02269-9101
USA
Tel: (1) 617 770 3000
Fax: (1) 617 770 0700

United Nations Development Programme (UNDP)
Attn: Frank Pinto
1 United Nations Plaza
New York
NY 10017 USA
Tel: (1) 212 906 5042
Fax: (1) 212 906 6947

United Nations Environment Programme Industry and Environment Programme Activity Centre (UNEP IE/PAC)
Attn: Rajendra M. Shende
39-43 Quai Andre Citroën
75739 Paris Cedex 15
France
Tel: (33) 1 44 37 14 50
Fax: (33) 1 44 37 14 74

United Nations Environment Programme Technical Options Committee for Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride
Attn: Andrea Hinwood, Chair
G.P.O. Box 4395QQ
Melbourne, Vic 3001
Australia
Tel: (61) 3 628 5290
Fax: (61) 3 628 5945

United Nations Environment Programme Technical Options Committee for Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride
Attn: Helen Tope
Environmental Protection Authority
5th Floor, 235 Queen St.
Melbourne Vic 3000
Australia
Tel: (61) 3 628 5292
Fax: (61) 3 628 5945

United Nations Environment Programme Technical Options Committee for Aerosols, Sterilants, Miscellaneous Uses, and Carbon Tetrachloride
Attn: Jose Pons Pons, Vice-Chair
Spray Quimica CA
Urb Ind SOCO
Calle Sur Edo Aragua
La Victoria 079
Venezuela
Tel: (58) 44 210 465/44 220 192
Fax: (58) 44 220 197

United Nations Industrial Development Organization (UNIDO)
Attn: Mrs. A. Tcheknavorian
P.O.Box 300
A-1400 Vienna
Austria
Tel: (43) 1 211 310
Fax: (43) 1 2307 449

United States Environmental Protection Agency, Stratospheric Protection Division
6205J
401 M St., S.W.
Washington, D.C. 20460
USA
Tel: (1) 202 775 6677
Fax: (1) 202 775 6681

United States Occupational Safety and Health Administration (OSHA)
200 Constitution Ave., N.W.
Washington, D.C. 20210
USA
Tel: (1) 202 219 8148
Fax: (1) 202 219 5986

World Bank
Attn: Mr. Ken Newcombe
1818 H. Street N.W.
Washington DC
20433 USA
Tel: (1) 202 477 1234
Fax: (1) 202 676 0483

Annex D - Request for Information

Request for Information

The documents are **"living"** documents that will be updated on a regular basis to reflect technological advancements, new products, and changing control measures.

Information is welcome both on alternatives to uses covered in the catalogue as well as on alternatives not discussed. The USEPA and UNEP request that companies or individuals with such information use the form in Annex D to supply this information to:

United Nations Environment Programme
Industry and Environment Programme Activity Centre
39-43 Quai André Çitroën
75739 Paris Cedex 15
France
Fax: (33) 1 44 37 14 74

or

Stratospheric Protection Division, 6205J
U.S. Environmental Protection Agency
401 M Street, NW
Washington, D.C. 20460
United States
Fax: (1) 202 233 9577

SPECIALIZED SOLVENT ODS USES DATA FORM

Name: ______________________________

Title: ______________________________

Company: ______________________________

Address: ______________________________

____

Telephone: ____________________ **Fax:** ____________________

Use Description

Name of Use: ______________________________

Brief Description of Use:

ODS Used (e.g., CFC-113): ______________________________

Industry Sectors Using ODS-based Product (e.g., aircraft maintenance, automobile manufacturing):

Non-ODS Alternatives Commercially Available (if necessary, please use a separate sheet for each alternative):

Name of Alternative: ______________________________

Supplier(s)	Contact	Phone/Fax Numbers

Company(s) Using Non-ODS Alternative:

Company	Contact	Phone/Fax Numbers

Annex E - List of Suppliers: Addresses and Phone and Fax Numbers

Supplier	Contact Information	Alternative(s)
Aerogen Company Limited	Newman Lane Alton, Hampshire GU34 2QW United Kingdom Tel: (44) 420 83744 Fax: (44) 420 80032	Controlled/modified atmosphere fumigation equipment
Bic Corporation	Export Division Attn: Guillaume Demontbel 500 Bic Drive Millford, CT 06460 USA Tel: (1) 203 783 2000 Fax: (1) 203 783 2131	Petroleum distillate - and water - based correction fluids
Brymill Corporation	P.O. Box 2392 Vernon, CT 06066 USA Tel: (1) 203 875 2460 Fax: (1) 203 872 2371	Liquid nitrogen printed circuit board "freeze sprays"
Chemtronics, Inc.	8125 Cobb Center Drive Kennesaw, GA 30144 USA Tel: (1) 404 424 4888 Fax: (1) 404 424 4267	HFC-134a printed circuit board "freeze sprays" HFC-134a and HFC-152a dusters Terpene-, alcohol-, and hydrocarbon-based aerosol cleaners/flux removers
Ciba-Geigy Corp.	Doug Parkes P.O. Box 18300 Greensboro, NC 27419 USA Tel: (1) 910 632 2488 Fax: (1) 910 632 7098	Mill-applied fabric protectants

Supplier	Contact Information	Alternative(s)
Degesch	Degesch America, Inc. P.O. Box 116 275 Triangle Dr. Weyers Cave, VA 24486 USA Tel: (1) 703 234 9281 Fax: (1) 703 234 8225	Phosphine fumigants
	Degesch Japan Co. Ltd. New Ginza Building Ginza 7-3-13, Chuo-ku Tokyo Japan Tel: (81) 3 3572 2787 Fax: (81) 3 3574 1631	
	Degesch De Chile Limitada Camino Antiguo A Valparaiso 1321 Padre Hurtado, Penaflor Santiago Chile Tel: (56) 2 8111575 Fax: (56) 2 8111553	
	Degesch South Africa P.O. Box 223 10 Power Street Isando 1600 Republic of South Africa Tel: (27) 11 97 42338 Fax: (27) 11 97 41987	
	Detia Degesch GmbH Dr.-Werner-Freyberg Str. 11 69514 Laudenbach Germany Tel: (49) 6201 7080 Fax: (49) 6201 708205	

Supplier	Contact Information	Alternative(s)
Dexter Corporation	One Dexter Drive Seabrook, NH 03874-4018 USA Tel: (1) 603 474 5541 Fax: (1) 603 474 5545	Water-based mould release agents
Du Pont de Nemours	Du Pont Product Information Barley Mill Plaza X-51488 Wilmington, DE 19880-0029 USA Tel: (1) 302 633 1501 Fax: (1) 302 992 3903	Nonaerosol water-based fabric protectants and mill-applied fabric protectants
	Du Pont de Nemours (France) S.A. 137, Rue de L'Universite F 75334, Paris, Cedex 07 France Tel: (33) 1 4550 6443 Fax: (33) 1 4551 4454	
	Du Pont de Nemours Intl., S.A. Fluorochemicals Division P.O. Box 50 2 Chemin du Pavillon CH-1218 Le Grane - Saconnex Geneva Switzerland Tel: (41) 22 717 5111 Fax: (41) 22 717 5664	
	Du Pont Singapore Pte Ltd. 1 Maritime Square #07-01 World Trade Center Singapore 0409 Tel: (65) 273 2244 Fax: (65) 272 7494	
Eberhard-Faber, Inc.	Corporate Headquarters 4 Century Drive Parsippany, NJ 07054 USA Tel: (1) 201 539 4111 Fax: (1) 201 539 4537	Petroleum distillate- and water-based correction fluids

Supplier	Contact Information	Alternative(s)
	Customer Services P.O. Box 2630 1311 Higgs Road Lewisburg, TN 37091-2630 USA Tel: (1) 615 359 1583 Fax: (1) 615 359 7680	
	AW Faber Germany 8504 Stein Bei Nurenburg Germany Tel: (49) 9 1166791 Fax: (49) 9 116679856	
Evode-Tanner	Furman Hall Court P.O. Box 1967 Greenville, SC 29602 USA Tel: (1) 803 232 3893 Fax: (1) 803 232 3094	Mill-applied fabric protectants
F.H. Engel S.A.	Casilla 61D Santiago Chile Tel: (56) 2 236 1227 Fax: (56) 2 235 7834	Nonaerosol water-based fabric protectants and mill-applied fabric protectants
Fiber Shield Industries Inc.	85 V. South Hoffman Lane Islandia, NY 11722 USA Tel: (1) 516 348 2585 Fax: (1) 516 348 1110	Petroleum distillate-based and nonaerosol water-based retailer applied fabric protectants
Genron Systems	515 West Greens Road, Suite 100 Houston, TX 77067 USA Tel: (1) 713 873 5100 Fax: (1) 713 876 4255	Controlled/modified atmosphere fumigation equipment

Supplier	Contact Information	Alternative(s)
George Mann & Co.	P.O. Box 9066 Providence, RI 02940 USA Tel: (1) 401 781 5600 Fax: (1) 401 941 0830	Non-solvent mould release agents
Gillette Company	The Paper Mate/Stationary Products Division Box 61 Boston, MA 02199 USA Tel: (1) 617 421 7000 Fax: (1) 617 421 8014	Petroleum distillate-based correction fluids
GSI Exim America	385 Fifth Ave. New York, NY 10016 USA Tel: (1) 212 684 5760 Fax: (1) 212 696 4809	HCFC- and water-based mould release agents
Gunze Sangyo Group	3-17, Kanda Nishiki-cho Chioyda-Ku Tokyo 101 Japan Tel: (81) 3 3294 4183 Fax: (81) 3 3233 3590	HCFC- and water-based mould release agents
HBG Export Corporation	454 South Anderson Road, BTC 506 Rock Hill, SC 29730 USA Tel: (1) 803 329 2128 Fax: (1) 803 329 2129	Mill-applied fabric protectants
IVAX Industries Inc.	1880 Langston Street Rock Hill, SC 29730 USA Tel: (1) 803 366 9411 Fax: (1) 803 366 7256	Mill-applied fabric protectants

Supplier	Contact Information	Alternative(s)
	International Division Attn: Will Nadal P.O. Box 31 Boundbrook, NJ 08805 USA Tel: (1) 908 469 7377 Fax: (1) 908 469 8952	
Lipsner Smith Company	4700 Chase Avenue Lincolnwood, IL 60646-1689 USA Tel: (1) 708 677 3000 Fax: (1) 708 677 1311	Perchloroethylene immersion, non-immersion, and water-based spray film cleaning systems
	Unit 6, Swan Wharf, Business Centre Waterloo Road Uxbridge UB8 2RA United Kingdom Tel: (44) 895 252191 Fax: (44) 895 274692	
LPS Laboratories, Inc.	4647 Hugh Howell Road Tucker, GA 30085-5052 USA Tel: (1) 404 934 7800 Fax: (1) 404 493 9206	Terpene- and hydrocarbon-based aerosol cleaners/flux removers
McGee Industries	9 Crozerville Rd. Aston, PA 19014 USA Tel: (1) 215 459 1890 Fax: (1) 215 459 9538	HCFC- and water-based mould release agents
Micro Care Corp.	34 Ronzo Road Bristol, CT 06010 USA Tel: (1) 203 585 7912 Fax: (1) 203 585 7378	Non-solvent mould release agents HFC-134a printed circuit board "freeze sprays" HFC-134a and HFC-152a dusters Terpene-, alcohol-, and hydrocarbon-based aerosol cleaners/flux removers

Supplier	Contact Information	Alternative(s)
Miller-Stephenson Chemical Company, Inc.	George Washington Highway Danbury, CT 06810 USA Tel: (1) 203 743 4447 Fax: (1) 203 791 8702	HCFC-based mould release agents HFC-134a printed circuit board "freeze sprays" HFC-134a and HFC-152a dusters
Newgate Simms, Ltd.	P.O. Box 32 Chester CH4 0EJ United Kingdom Tel: (44) 244 660 771 Fax: (44) 244 661 220	HCFC- and water-based mould release agents
NICCA	P.O. Box 1600 Fountain Inn, SC 29644 USA Tel: (1) 803 862 1426 Fax: (1) 803 862 1427	Mill-applied fabric protectants
Percy Harms Corp.	430 S. Wheeling Rd. Wheeling, IL 60090 USA Tel: (1) 708 541 7220 Fax: (1) 708 541 7986	Non-solvent and HCFC-based mould release agents
PERMEA, Inc.	11444 Lackland Road St. Louis, MO 63146-3544 USA Tel: (1) 314 995 3300 Fax: (1) 314 995 3500 Air Products S.A., Permea Europe 1789, Chaussee de Wavre B-1160 Brussels Belgium Tel: (32) 2 674 9581 Fax: (32) 2 674 9584	Controlled/modified atmosphere fumigation equipment

Supplier	Contact Information	Alternative(s)
	PERMEA Asia/Pacific c/o Air Products Pacific, Inc. Ark Mori Building 16F 1-12-32, Akasaka, Minato-ku Tokyo 107 Japan Tel: (81) 3 5563 1670 Fax: (81) 3 5563 1689	
Phersee Chemie	Hans Peter Rafael Rehlinger Strasse 1 D8901 Langweid Germany Tel: (49) 823 041 285 Fax: (49) 823 041 384	Mill-applied fabric protectants
PPG Industries Inc.	P.O. Box 040004 Huntsville, AL 35804 USA Tel: (1) 205 851 7001 Fax: (1) 205 851 8822	Aircraft windshield products
	Shinnikka PPG Co. Ltd. CNR International R&D/Manufacturing Facility 15-1 Shinminato Kisarazu-Shi Chiba-Ken 292 Japan	
Price-Driscoll Corp.	17 Industrial Drive Waterford, CT 06385 USA Tel: (1) 203 442 3575 Fax: (1) 203 447 3557	HCFC-based mould release agents
Radio Frequency Company, Inc.	150 Dover Road Millis, MA 02054 USA Tel: (1) 617 762 4900 Fax: (1) 617 762 4952	Water-based spray film cleaning systems

Supplier	Contact Information	Alternative(s)
Releasomers, Inc.	P.O. Box 82 Bradford Woods, PA 15015 USA Tel: (1) 412 452 4474 Fax: (1) 412 452 1965	Water based mould release agents
Repeat-O-Type Manufacturing Corp.	Attn: Robert Keen International Department 665 State Highway 23 Wayne, NJ 07470 USA Tel: (1) 201 696 3330 Fax: (1) 201 694 7287	Petroleum distillate-based correction fluids
Rheinchemie	Division of Bayer Dusseldorfer Strasse 23-27 D-6800 Manheim 81 Germany Tel: (49) 621 8907 0 Fax: (49) 621 8907 594	Water-based mould release agents
S.A. MICA Isolamentos S.A.	Hans Frenster A1, Rio Negro 1105 5 Ander C.J. 52 06400 Baruri Sao Paulo Brazil Tel: (55) 11 725 3508 Fax: (55) 11 914 5722	Petroleum distillate-based fabric protectants
Sentry Chemical Co., Inc.	Dept. 3 P.O. Box 748 1481 Rock Mountain Boulevard Stone Mountain, GA 30086 USA Tel: (1) 404 934 4242 Fax: (1) 404 934 0932	Petroleum distillate-based fabric protectants
Sequa Chemicals Incorporated	1 Sequa Drive Chester, SC 29706 USA Tel: (1) 803 385 5181 Fax: (1) 803 377 3542	Mill-applied fabric protectants

Supplier	Contact Information	Alternative(s)
Specialty Chemicals	Rositah Abdul Ghani 45 Kallang Pudding Road #06-01 & 06-03 Alpha Building Singapore 1334 Tel: (65) 743 8633 Fax: (65) 747 3729	Petroleum distillate-based fabric protectants
	Christopher Chapman 15 St. Philips Ave. Maidstone, Kent ME1 57J United Kingdom Tel: (44) 62 266 1991 Fax: (44) 62 275 8343	
Sprayon Products Industrial Supply	6830 Cochran Rd. Solon, OH 44139 USA Tel: (1) 216 498 2400 Fax: (1) 216 498 2402	HCFC-based mould release agents
Stoner Inc.	1070 Robert Fulton Hwy. P.O. Box 65 Quarryville, PA 17566 USA Tel: (1) 717 786 7355 Fax: (1) 717 786 9088	HCFC-based mould release agents
Technology Film Systems	9205 Alabama Avenue Unit D Chatsworth, CA 91311 USA Tel: (1) 818 709 0515 Fax: (1) 818 709 0317	Water-based spray film cleaning systems
3M	3M Consumer Specialties Division 3M Center St. Paul, MN 55144-1000 USA Tel: (1) 612 733 1553 Fax: (1) 612 733 4012	Petroleum distillate-, water-, and nonaerosol water-based fabric protectants and mill-applied fabric protectants

Supplier	Contact Information	Alternative(s)
	3M Protective Chemicals Division 3M Center St. Paul, MN 55144-1000 USA Tel: (1) 612 733 1110 Fax: (1) 612 733 9973	
	3M Europe S.A. 106 Boulevard De La Woluwe B-1200 Brussels Belgium Tel: (32) 2 761 2211 Fax: (32) 2 762 7978	
	3M Argentina S.A.C.I.F.I.A. Los Arboles 842 1686 Hurlingham Provinicia de Buenos Aires Argentina Tel: (54) 1 665 0661 Fax: (54) 1 665 4071	
	3M Asia Pacific PTE, Ltd. 9 Tagore Lane Singapore 2678 Tel: (65) 454 8611 Fax: (65) 458 5432	
	3M Zimbabwe (PVT) Ltd. P.O. Box AY 64, Amby Harare Zimbabwe Tel: (263) 4 46164 Fax: (263) 4 46165	
	Sumitmo 3M Limited 33-1, Tamagawadai 2-chome Setagaya-ku, Tokyo P.O. Box 43 Tamagawa Tokyo, 158 Japan Tel: (81) 3 3709 8111 Fax: (81) 3 3709 8111	

Supplier	Contact Information	Alternative(s)
Wite-Out Products	145 South Chase Blvd. Fountain Inn, SC 29644 USA Tel: (1) 803 967 0444 Fax: (1) 803 967 0449	Petroleum distillate- and water-based correction fluids
Yorkshire PAChem	P.O. Box 1926 Greenville, SC 29602 USA Tel: (1) 803 233 3941 Fax: (1) 803 232 3542	Mill-applied fabric protectants
Zip-Chem Products	1860 Dobbin Drive San Jose, CA 95133 USA Tel: (1) 408 729 0291 Fax: (1) 408 272 8062	Non-solvent mould release agents HFC-134a printed circuit board "freeze sprays" HFC-134a and HFC-152a dusters Terpene- and hydrocarbon-based aerosol cleaners/flux removers

Index