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CONTRACT NO. 94/143

FINAL REPORT

ON

PROJECT FORMULATION FOR THE CONVERSION OF ELECTRONIC CLEANING PROCESSES FROM CFC-113/ALCOHOL BLENDED SOLVENTS AND 1,1,1 TRICHLOROETHANE TO NON-CFC CLEANING IN INDIA.

CENTRE FOR MATERIALS FOR ELECTRONICS TECHNOLOGY (C-MET)
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FINAL REPORT

1. INTRODUCTION

1.1 The India country programme on phase out of ozone depleting substances under the Montreal Protocol was formulated in 1993 consequent to India's accession to the Montreal Protocol in 1992. The national programme for ODS phase out is prepared to ensure the phase out of ODS according to national industrial development strategy. The Indian electronics industries produce and use a large variety of cleaning solvents and other chemicals [illegible] the manufacturing process, some of which fall under the ozone depleting substances causing environment pollution. India produces and uses about 7 of the 20 substances controlled under the Montreal Protocol. Solvents is one of the major user sector in electronics industry accounting for about 47% in ODS terms and 3[illegible].6% in ODP terms.

1.2 Centre for Materials for Electronics Technology (C-MET) is a scientific society under Department of Electronics, Govt. of India, and is engaged in R&D in electronics materials and related products. C-MET is recognised as national consultant for formulation of projects for ODS phase out in solvent sector in India by the coordinating agency, namely, Ministry of Environment and Forest (MOEF). The United Nations Industrial Development Organisation (UNIDO) and C-MET have entered into a contract in December, 1994 for formulation of 4 projects for the conversion of electronic cleaning processes from CFC-113/ alcohol blended solvents and 1,1,1 trichloroethane to non-CFC cleaning in India.

1.3 The scope of work under this contract covers sampling process, data collection, analysis and project formulation. These involve the following activities in detail :

- Identification of three medium to large-scale electronics industries and a cluster of small scale enterprises using ODS based cleaning techniques and solvents in their processes.

- Designing a questionnaire [illegible] from selected enterprises and analysing the data for technological feasibility, cost effectiveness, capability of enterprise etc..

- Formulating 4 project documents in cooperation with UNIDO and modifying as per the requirements of MOEF in the format specified by multilateral funding agency.

1.4 The primary objective in the first phase of activity comprising of selection of suitable enterprises interested in elimination of ODS was achieved. Three medium to large-scale industries were identified for collection of details as per questionnaire evolved through discussions with the user industries. The above activity was detailed in the First Interim Report submitted to UNIDO as part of the contract.

1.5 The Second Interim Report was provided at the end of compilation and analysis of the data collected on selected enterprises. The three medium to large-scale industries, namely, M/s Indian Telephone Industries Limited, Bangalore, M/s Electronic Research Limited and M/s Indian Telephone Industries Palghat were approached with the designed questionnaire and the data on usage of ODS was collected along with all relevant information as per the questionnaire developed. The second Interim Report was submitted to UNIDO on March 10th, 1995 enclosing the filled questionnaire and draft proposals of the above mentioned large scale industries.

After the submission of the above mentioned Second Interim Report Mr. Shatravko visited India on 14/6/95 to finalise the above mentioned proposal and had detailed discussion with ITI, Bangalore, ITI [illegible] Pune. Based on the above inputs final proposals were prepared.

Final report contains the final proposals in respect of ITI, Bangalore, ERL, Bangalore and ITI, Palakkad.

2. DATA COMPILATION

[illegible] activity is to prepare final proposal in respect of the selected industries, namely M/s Electronic Research Limited, Bangalore, M/s Indian Telephone Industries Limited, Bangalore, and M/s Indian Telephone Industries Palghat have been included as Annexure 1, 2 and 3 respectively to this report.

2.3 Based on our earlier experience on interaction and preparation of similar project proposals for M/s Indian Telephone Industries, Mankapur which has since been approved for implementation, the exercise was undertaken in a similar manner to prepare the draft proposals for the interacting organisations as above. Accordingly, the draft proposals in favour of Indian Telephone Industries Limited, Bangalore and M/s Electronic Research Limited, Bangalore and ITI, Pallakkad, were prepared in consultation with the concerned organisations.

Thereafter Mr. Shatravko, UNIDO consultant visited above mentioned organisations, and had detailed discussion with respective industries and based on the inputs provided by the UNIDO consultant and keeping in view threshold limits set by Montreal Protocal, final proposals were prepared.

3. DATA ANALYSIS

3.1 Based on the data collected during the questionnaire and analysis of the same, final project proposals entitled "Conversion of Electronic Cleaning Processes from ODS solvents to [illegible] Blasting and Semi-aqueous Cleaning and No-Clean technologies" are formulated. The analysis of the data received from M/s ITI, Bangalore shows that this project has an impact of phasing out annual consumption of 17.42 metric tones of 1,1,1 Trichloroethane and 0.060 M.T of Halons 1301 and 0.760 M.T. of 1211 that is a total of 18.24 M.T. ODS or 4.06 ODP weighted M.T. The analysis of data in respect M/s ERL, Bangalore shows that a similar project has capability of phasing out annual consumption of 15.0 M.T. of Trichloro-Triflouroethane and 43.50 M.T. of 1,1,1 Trichloroethane which amounts to a total of 58.50 M.T. ODS or 17.57 ODP weighted M.T. Similarly the analysis of data in respect of M/s I.T.I Palakkad shows that similar project has capability of phasing out of annual consumption of 12 MT of CFC-113 and 30 MT of 1,1,1 trichloroethane which amounts to a total of 42 MT ODS or 13.44 ODP weighted MT.

The above projects each with a project economic life of ten years and estimated project duration of 18 months envisage total project outlay of U.S.$ 456,542, U.S.$ 599.366 and US $389,592 respectively for M/s ERL,Bangalore,M/s ITI, Bangalore and ITI, Palakkad. The summarised details in respect of the above project reports is enclosed in the details provided on the first page of Annexure 1, 2 and 3.

4. CONCLUSION

4.1 The data collection as per the designed questionnaire from three medium to large scale enterprises selected has been completed. The details thus received are formatted suitably and based on ODS and ODP consumption weightage, final proposals have been prepared.

MM Ex-1

Project Proposal for the Multilateral Fund for the Implementation of the Montreal Protocol Financing

COUNTRY	**India**	
PROJECT TITLE	Conversion of electronic cleaning processes from ODS solvents to no-clean and hydrocarbon cleaning technologies at ERL, Bangalore	
SECTORS COVERED	Solvents	
ODS USE IN SECTOR	4,876 MT (ODP- weighted) of ODS solvents in 1991	
PROJECT IMPACT	Phased-out annual consumption of 15.0 MT of CFC-113 and 43.5 MT of 1,1,1 trichloroethane (total 17.52 ODP-weighted MT)	
PROJECT DURATION	18 months	
PROJECT ECONOMIC LIFE	10 years	
TOTAL PROJECT COST	Investment (capital) costs, US$	709,500
	Incremental operating costs/savings, US$	252,958
	Total Project Costs, US$	**456,542**
OWNERSHIP STRUCTURE	100 per cent Indian	
PROPOSED MF FINANCING	**US$ 456,542**	
COST EFFECTIVENESS	US$ 26.0 per ODP kg	
UNIT ABATEMENT COST	US$ 2.0 per kg of phased- out ODSs	
CURRENCY CONVERSION	US$ 1.00 = Indian Rs. 30.00	
COUNTER ENTERPRISE	Electronics Research Ltd, Bangalore	
IMPLEMENTING AGENCY	UNIDO	
COORDINATING MINISTRY	Ministry of Environment and Forest	

Project summary

This project will phase-out the use of 15.0 MT of CFC - 113 and 43.5 MT of 1,1,1-trichloroethane (MCF) in cleaning operations at the Electronic Research Ltd. (ERL), Bangalore in the flux removal from electronic assemblies after the soldering operations, precision cleaning of the components of flyback tranformers, electronic tuner assemblies and cleaning of pipings of the three potting units. The phasing-out of ozone depleting substances (ODSs) will be accomplished by replacing the currently used solvent-based cleaning methods with a low solid flux/no-clean soldering technology for manufacture of electronic tuner assemblies, precision cleaning of ceramic substrates, terminal boards and coils of flyback transformers and cleaning of piping of the potting plants with new non-ODS solvents. The project will employ commercially available technologies in one of India's largest ODS consuming sectors. The India Country Programme for the Elimination of ODS has also identified the sector as a high priority area.

1. Project objective

The objective of this project is to phase-out the use of CFC- 113 (TMS formula) and methyl chloroform (MCF) in electronics cleaning operations at the Elctronic Research Ltd. (ERL). The processes in which ODSs are utilized, for example MCF in the electronic tuner unit will be replaced with a no-clean soldering process.

As one of the first projects formulated in the solvent-based electronics cleaning sector in India, this project has additional targets.Considering the structure of the Indian electronics industry and the required steps to phase out ODSs in electronics cleaning, it is expected that this project will additionally identify and strengthen a focal point which will (also see Exhibit1), Pg 3.

- help to increase awareness in the selected electronics industries regarding need for phasing out ODSs and, for this purpose, collection and compilation of technical and technological information:

- generate information and provide technical support regarding the problems associated with phasing-out of ODSs by the electronics industry, which includes process development, materials compatibility testing, reliability testing, cost-effectiveness analysis, technology selection and drawing-up of equipment specifications; and

- accumulate adequate problem solving know-how during the implementation phase of this project so that projects of a similar nature can be implemented in other locations

In cooperation with the Ministry of Environment and Forest, the Center for Materials for Electronics Technology (C-MET) of the Department of Electronics (DOE) has been identified as the focal point[1]. The Center for Materials for Electronics Technology (C-MET) is operating as a registered scientific society under the Department of Electronics with the main objective to establish technology strength in Electronics materials for the present and future industrial requirements.

The electronic industry in India is unique. that is, a significant amount of production is distributed in small and medium scale industry and it is distributed over throughout the country.

[1] The Center for Materials for Electronics Technology (C-MET) set up by DOE has experts in the various materials used in the electronics industry covering chemicals, polymers and other related products such as solvents, cleaning agents etc. and in materials development and commercialization of the R&D results.

2. Sector background

India became a signatory to Montreal Protocol in 1992 and as a part of subsequent exercise, a Country Programme document was prepared by the Government with the assistance of UNDP. This document has assessed the Ozone Depleting Substance (ODS) consumption in the country and on the basis of this, a National Programme for the Phase-out of ODSs has been prepared to ensure the Phase-out of ODSs according to the national industrial development strategy, without undoe burden to consumers and industry.

Solvents is one of the major consumption sectors. Before finalizing the Country Programme, a sectoral report was also developed out in consultation with the industry-users and manufacturers of ODS substances. This report developed the basis for Country Programme preparation.

The amount of consumption has been investigated in a number of studies[2]. According to most recent information presented at the Solvents Workshop convened in June 1993 and revised in the first draft of the India Country Programme in August 1993, in 1991, the solvent sector consumed 100 MT of CFC-12, 300 MT of CFC-113, 4,000 MT of carbon tetrachloride and 550 MT of 1,1,1-trichloroethane (MCF), i.e., a total of 4,876 MT of ODP (ozone depletion potential)-weighted consumption, that is 36.9 per cent of total ODP-weighted consumption in India.

The solvent consumption in India in 1991 is given in Exhibit 2 (table) and Exhibit 3 (chart). ODS consumption in the solvents industry is split between electronics, metal cleaning and other processes such as textiles, pharmaceuticals, pesticides, chlorinated rubber, etc.

Cleaning processes used in the electronics industry consumed in 1991, 150 MT of CFC-113, 75 MT of CTC and 55 MT of MCF (all ODP-weighted) and included flux removal (printed-circuit cards and hybrid circuits), semiconductor manufacturing, microelectronic component cleaning, metal and plastic part cleaning, and photoresist development and stripping. The use of ODSs in electronics cleaning in India has been increasing as a result of the development of electronics industry.

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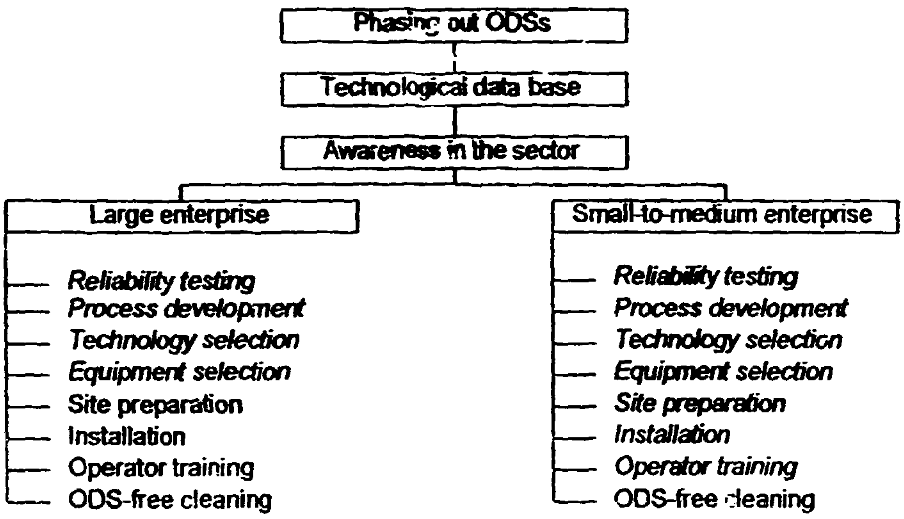
(2) a) Report of the Task Force on National Strategy of Phasing out Ozone Depleting Substances, Ministry of Industry, March 1992 (updated March 1993).
b) Compiled consumption data, Multilateral Fund Secretariat, March 1993.
c) Solvents Workshop, Country Programme Preparatory Meetings Series, 21-25 June 1993, New Delhi.
d) India Country Programme, September 1993.

Exhibit 1

Phasing out of ODSs in Indian Electronics Industry

The role of a focal point of know-how



Note: *Generally, activities written in italic require external technical assistance and will be carried out by the focal point of the sector.*

Exhibit 2. ODS consumption in India
(ODP-weighted figures)

Types of ODS	1991 Consumption					
	All sectors			Solvents		
	Actual, MT	ODP-weighted		Actual, MT	ODP-weighted	
		MT	%		MT	%
CFC-11	1,900	1,900.000	14.385	0	0.000	0.000
CFC-12	2,850	2,850.000	21.577	100	100.000	2.051
CFC-113	320	342.400	2.592	300	321.000	6.583
Sub-Total	**5,070.000**	**5,092.400**	**38.554**	**400.000**	**421.000**	**8.634**

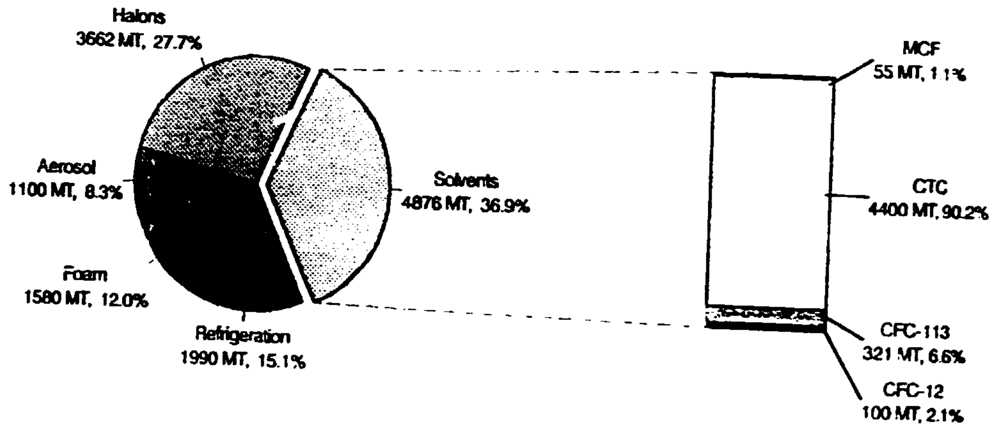
Types of ODS	1991 Consumption					
	All sectors			Solvents		
	Actual, MT	ODP-weighted		Actual, MT	ODP-weighted	
		MT	%		MT	%
Halon-1211	550	1,650.000	12.492	0	0.000	0.000
Halon-1301	200	2,000.000	15.142	0	0.000	0.000
Sub-Total	**750.000**	**3,650.000**	**27.634**	**0.000**	**0.000**	**0.000**
CTC	4000	4,400.000	33.312	4000	4,400.000	90.238
MCF	550	66.000	0.500	550	55.000	1.128
TOTAL	**10,370.000**	**13,208.400**	**100.000**	**4,950.000**	**4,876.000**	**100.000**
Sectoral distribution						
Aerosols	1,100	1,100	8.328			
Foams	1,580	1,580	11.962			
Refrigeration	1,990	1,990	15.067			
Solvents	4,950	4,876	36.917			
Halons	750	3,662	27.726			
TOTAL	10,370.000	13,208.000	100.000			

Source: a) Tentative figures as discussed at the "Solvents Workshop, Country Programme Meetings Series [illegible] 25 June 1993, New Delhi"
[illegible] Country Programme, First Draft, 9 August 1993.

Exhibit 3

ODS consumption in India

1991 figures in ODP-weighted MT



Refrigeration figure includes aerosols.

3. Enterprise background

Electronic Research Ltd. (ERL) is a 100% Indian limited company incorporated in 1968. The corporation is a part of the BPL Group. The turnover for this unit for the year 1993-94 was Rs.660 million and projected turnover for 1994-95 is Rs.800 million. The total manpower employed is 650. The company has technical collaboration with Sanyo Electric Co. of Japan for the manufacture of deflection and RF components for TVs and VCRs. The company exports about 3% of the total production. Electronic Research Ltd. is mainly concentrating on the product mix described below :

Product	Installed Capacity (Nos)	No. Of Shits	Production (Nos) 1994-95
Electronic Tuner	700.000*	1	525,718
Flyback Transformer	700,000*	1	656,042
Deflection Yoke	700,000*	1	659,513
Monitors	25,000	1	16,206
Satellite Receiver	12,000	1	343

* Installed capacity of products 1,2, and 3 will be increased to 1,000,000 by June 1995

The areas where ozone depleting substances are used include manufacture of tuners and flyback transformers. In the case of electronic tuner manufacture, after first soldering of tuner PCBs on the automatic soldering machine, the leads are cut and the PCB is thoroughly cleaned with 1,1,1 trichloroethane to remove soldering flux and other impurities. Subsequently, after the second soldering phase of assembled tuners on automatic soldering machine, the assembly is thoroughly cleaned with 1,1,1 trichloroethane to remove traces of soldering flux and other impurities.

Ozone depleting substances are used in the following four operations in the manufacture of flyback transformers :

a) After HV and LV coils are assembled, the assembly is thoroughly cleaned with CFC-113 in the ultrasonic cleaner to remove traces of soldering flux and other impurities.

b) The terminal board assembly of FBT is also cleaned thoroughly with 1,1,1 trichloroethane.

c) After each day's utilisation of the three potting plants the pipings which transport the epoxy for dispensing are cleaned with 1,1,1-trichloroethane using a flushing device. Also the vacuum chamber is cleaned manually to remove the traces of epoxy spilled-out during vacuum foaming.

d) 1,1,1-trichloroethane-based ultrasonic cleaning is also used for cleaning substrates in the manufacture of focus resistor packs, which is a sub-assembly of the flyback transformer.

The major manufacturing divisions of ERL are as follows:

Electronic Tuner Manufacture

-Tuner Assembly Division

Flyback Transformer Manufacture

- FBT Assembly Divison
- Focus Resistor Pack Assembly Division
- Potting Division

The various cleaning machines used for ODS handling along with their production capacities are shown on the following page, Exhibit 4.

Exhibit 4. ODS Solvent Using Equipment at Electronic Research Ltd

Activity	Production Capacity	Purpose	Cleaning Process	Cost
1. Electronic Tuner Assembly	700,000 Nos/year-1994-95 1,000,000 Nos/year-1995-96 (projected)	Cleaning of solder fluxes from PCBs in two stages and also cleaning of jigs used to handle PCBs	Dip Cleaning (simple tanks)	Rs. 10,000
2. Flyback transformer assembly	700,000 Nos/year-1994-95 1,000,000 Nos/year-1995-96 (projected)			
a) HV & LV Coils		Cleaning of solder fluxes from the coil assembly after assembling and soldering of the coil	CFC-113 cleaning in ultrasonic machine	JY 3.0 Mio
b) Terminal board assembly		Cleaning of fluxes after soldering of diodes and capacitors	1,1,1-trichloroethane dip cleaning tanks	Rs. 15,000
c) Ceramic Substrate [illegible]		Substrate cleaning	1,1,1-trichloroethane in ultrasonic cleaning	Rs. [illegible]
d) Potting Plants 3 Nos. 2 for FBT 1 for FR		Cleaning of the pipings after potting operation	Flushing system	JY 200 Mio

CFC-113 and MCF are the two ozone depleting substances used at ERL. The cost incurred in the ozone depleting substances is indicated in Exhibit 5.

Exhibit 5. ODS Solvent Costs of Electronic Research, Ltd.

Division/Purpose	ODS amount kgs/day	Unit Price US $/ kg	Annual cost US $	ODS amount MT/year	ODP weighted amount MT/year
A. Electronic Tuners (Flux removal)					
1. Cleaning of Frame	5.00				
2. Cleaning of Jigs	10.00				
3. Cleaning of Tuner Assembly	30.00				
Total solvent used - 1,1,1-trichloroethane	45.00	3.5	47,250	13.50	1.62
B. Flyback Transformers(Flux removal)					
	40.00				
1. Cleaning of soil assembly					
	40.00	4.52	54,240	12.00	9.81
Total solvent used- CFC-113					
	60.00				
2. Cleaning of ceramic substrate	10.00				
3. Cleaning of terminal board	30.00				
4. Flushing of potting plants					
Total solvent used- 1,1,1-trichloroethane	100.00	3.5	105,000	30.00	3.6

4. Project description

4.1 Sector-wise approach

The electronics industry uses a variety of chemical substances in the manufacturing processes and packaging operations. Some of these include chemicals which pollute the environment, of which a number of them are classified as ozone depleting substances.

Considering this, a broad-based programme to enhance the awareness about use of such substances in the electronics industry and the development of alternatives for replacing/phasing out of such substances etc., is being pursued under the activities of the Centre for Materials for Electronics Technology (C-MET) of the Department of Electronics.This would be a part of the overall programme within the Government of India that is being implemented by the Ministry of Environment and Forest.

The replacement of ODSs in electronics industry applications with aqueous processes and no clean technologies will require extensive engineering know-how to carry out the tasks such as:

- Reliability testing
- Material compatibility testing and process development
- Technology selection
- Equipment selection/modification of existing equipment
- Purchase of aqueous cleaning machines and systems
- Site preparation
- Installation of machinery
- Operator training

Therefore, the overall programme conceived for implementation here includes awareness of the industry towards phasing out of these chemicals and taking up activites with the help of industry and R&D institutions to develop substitutes for the actual usage, as well as taking up demonstration projects with the help of experts in the field and translating the knowledge and experience gained to the other enterprises of the electronics industry and to the other sectors.

It is, therefore, decided that C-MET of DOE will take part in the project from its start in order to accumulate information and experience to assist ERL-Bangalore, as well to other enterprises of the Indian electronics industry.

4.2 Description of the ERL, Bangalore project

As discussed in the section above, the replacement of ODSs in electronics industry applications with aqueous/semi-aqueous processes and no-clean technologies require extensive engineering know-how to perform a number of tasks

Reliability testing, material compatibility testing and process development will be performed by C-MET, in close cooperation with ERL, Bangalore, prior to the purchase of the cleaning machines in order to choose the best equipment. The process development work is to be documented with graphs, charts, and data showing that the ERL-Bangalore project has determined that the cleaning or no-clean processes are a good decision. The process development work, particularly, will be completed prior to ordering the cleaning machines for the cleaning operations of flyback transformer components and a soldering machine for tuner manufacture.

4.3 Technology and equipment selection

ERL, Bangalore will phase-out the use of CFC-113 in coil assembly cleaning and MCF in electronic cleaning of tuner and flyback transformer components by selecting and utilizing the appropriate non-ODS processes.ERL currently uses seven cleaning stations (simple tanks without heating and ultrasonics are only used for cleaning of coils and ceramic substrates of the flyback transformers). At the end of the project implementation, all the ODS solvents (CFC-113, methyl chloroform) will be eliminated

In the solvents sector, especially in the case of electronics cleaning, there are many options to the use of ozone depleting solvents. Usually the choice of the alternative cleaning process is dependent upon the type of market served by the solvent user. Most commercial applications have more flexibility in the use of new technology, because of the inherent need of maintaining their competitiveness in the world market. However, many organizations build products known for their high degree of reliability for use in military aircraft, satellites or other difficult professional (industrial and commercial) operations. These organizations spare no cost to ensure that products made by their organizations are dependable and reliable. Considering the high reliability requirements of the ERL-Bangalore products, the conversion to non-ODS cleaning will be be planned and evaluated extremely carefully.

US EPA staff have found that the other chlorinated solvents (trichloroethylene, perchloroethylene, and methylene chloride), aqueous and semi-aqueous cleaning, and cleaning with petroleum solvents, ketones, and alcohols are to be viewed as acceptable.

Switching to one of these other halogenated solvents may require companies to apply for a modification to their existing operating permit. These three solvents are generally subject to relatively low occupational exposure limits and are regulated under the Indian air toxicity law.

Aqueous cleaning solutions typically are tailored to the requirements of the specific cleaning application. They require the application of water-soluble fluxes in the production of PCBs. Since the three selected Egyptian companies are dealing with the production of military equipment, which requires a good cleaning strength, the aqueous solution seems not to be optimal.

The semi-aqueous cleaning systems are using terpenes, dibasic esters, glycol esters, or other hydrocarbons, generally in combination with surfactants. These cleaners can be considered for cleaning of PCBs. These solvents exhibit varying degrees of flammability, and generally require that certain precautions be taken, especially if used in spray cleaning applications. All these solvents have low pressures,but are still considered photochemically reactive. The subsequent water treatment following the rinsing operation will require a water treatment plant which would increase the project cost.

Petroleum solvents, alcohols, and ketones are presently used in some sectors of manufacturing and repair industries for cold cleaning applications. Petroleum solvents (mineral spirits, kerosene, Stoddard solvent) show good solvency for most contaminants. Alcohols (e.g. ethanol, isopropanol, and glycol ethers), have been used in certain applications requiring effective solvent power for defluxing operations in the electronics industry. These solvents, however, have several limitations. Their flammability restricts their use in enclosed systems and in vapor degreasing operations.

However, new mixed hydrocarbon cleaning agents (A3-group) based on these cleaners have appeared on the market, e.g. PX 16S with a flash point of 79° C (propylene glycol) from Dow Chemical, XZ 96000 with a flash point of 63°C (butoxyl propanol) from the same company, etc. as well as new techniques with vapor cleaning under vacuum in a closed chamber to avoid solvents flammability have opened new perspectives for these solvents.

Because the PCBs are immersed in a solvent, the solvent must be maintained as free of contamination as possible. Therefore, the distillation process should be used to clean the solvents during the cleaning operations. One of the disadvantages of hydrocarbons is that they exhibit slower drying times than halogenated solvents. To solve this problem, the PCBs are normally vacuum dried. This would eliminate the need for any water rinse and simplify any waste treatment operations.

The new principles presently developed are based on waterless cleaning with A3 cleaners in a closed single chamber utilizing the advantages of the old techniques, like vapor degreasing and ultrasonics. A vapor consisting of A3 cleaning agent is normally produced at approximately 80°C in a vacuum still and then is pumped into the treatment chamber. The vapor condenses on the components to be cleaned and removes all adhering contaminants, such as flux residues, oil, grease, emulsion and dust. Precleaning can be undertaken by means of high-pressure spraying or immersion. The rotation of the basket with components may be required as well as ultrasonic agitation. After the completion of vapor rinsing the parts are then to be vacuum dried. The A3 cleaning agent can be continuously regenerated by means of distillation and recirculation in the same equipment. The contaminants dissolved by the cleaning agent are collected in the vacuum still and can be easily disposed of without any waste treatment. The following cleaning agents can be easily adopted for use: PX16S from Dow Chemicals, Axarel from Petroferm, Proz[illegible] from BP, Purasolv from Purac, Zestron from Dr. Wack, Careclean from Castrol and others.

No-clean technologies with or without nitrogen atmosphere, using low solid fluxes are gaining importance and the quality is well [illegible]ceived for wide range of applications. This is one of the very cost effective technologies available and widely used by industry. For high quality requirements use of low solid fluxes followed by semi-aqueous cleaning would be an effective alternative.

Technology and equipment selection

ERL-Bangalore will phase out the use of CFC-113 (trichlorotrifluoroethane) and methyl chloroform (1,1,1-trichloroethane) in the flux removal from the tuner assemblies, cleaning of the potting systems and precision clearing of the flyback transformer components in the flyback transformer manufacturing division by modifying their processes, as shown below in Exhibit 6.

Exhibit 6. Selection of Aternate Technology

Process	Existing	Proposed	Method
Electronic Tuner Unit			
1. Cleaning of Frame	Dip cleaning using 1,1,1-trichloroethane	Environmentally compatible cleaning system with A3 - group fluids	Fully automatic cleaning machine with ultrasonics vapor rinsing, vacuum drying and solvent distillation
2. Cleaning of Jigs	Dip cleaning using 1,1,1-trichloroethane	No-cleaning	Changing the process by switching over to no-clean technology
3. Cleaning of Tuner Assembly	Dip cleaning using 1,1,1-trichloroethane	No-cleaning	Application of no-clean flux, conversion to no-clean soldering processes
Fly back Transformer Unit			
1. Cleaning of coil [illegible]	Using ultrasonic machine and CFC-113	Environmentally compatible cleaning system with A3-group fluids	Fully automatic cleaning machine with ultrasonic, vapor rinsing, vacuum drying and solvent distillation

2. Cleaning of ceramic substrate	Ultrasonic cleaning using 1,1,1-trichloroethane	A3-group solvent cleaning	Cleaning machine with ultrasonic, vapor rinsing, vacuum drying and solvent distillation
3. Cleaning of terminal board	Dip cleaning, using 1,1,1-trichloroethane	A3-group solvent cleaning	Cleaning machine with ultrasonic, vapor rinsing, vacuum drying and solvent distillation
4. Cleaning of potting systems	Cleaning using flushing devices and 1,1,1-trichloroethane	Cleaning using dibasic esters	Modification of potting system to adopt water based solvent and treating this solvent prior to disposal

Operators and maintenance personnel will be trained in the proper operation and maintenance of the new equipment.Personnel will also be trained to appraise important process changes in the cleaning effectiveness of the new processes.

ERL has special units for potting components with epoxy resins (2 for FBT & 1 for FR).These units require cleaning after each operation.For the flyback transformer and focus resistor, it is proposed to change to an eco-friendly solvent (hydrocarbons) to mantain current cleaning standards. It is proposed to modify the existing potting systems for both FBT and FR to permit the use of a hydrocarbon cleaning solvent.

For the tuners, it is proposed to avoid the past cleaning practices by using no-clean flux. It is also proposed to replace the existing soldering machine with a new machine which can use the low-solid flux. The cleaning of the tuner assemblies will not be required.

In addition to the potting plants, ERL has the four cleaning stations. One is for ceramic substrate using ultrasonic cleaning and employing 1,1,1-trichloroethane. The second station is used for cleaning of the terminal boards by dip cleaning. The third one is used for cleaning coil assemblies in ultrasonic cleaning, and the fourth one is used for cleaning the frames of the electronic tuners.

When rosin fluxes are used at ERL-Bangalore, cleaning with hydrocarbons/surfactants or with saponifiers or mixed hydrocarbons is an effective choice. The alternative technology will be high-pressure spraying with subsequent vapor rinsing under vacuum and vacuum drying.Considering the cleaning requirements of the company, a selection has been made in favor of this alternative technology. The production capacities at this company does not require any in-line cleaning machines. Batch operation immersion type ultrasonic degreasers will be a good solution. The technology selected does not require water and in addition the quantity of the cleaning solvent used (closed chamber with distillation of cleaner) is very low. The proposed new cleaning machine uses an environmentally compatible cleaning concept, whereby MII fluid is utilized for all the three cleaning processes

Site preparation and installation of machinery

The project includes funding to prepare the sites for the equipment installation. This funding is for electrical supply and plumbing to ensure safe installation of the equipment. The modifications are necessary to the cleaning areas and to the soldering area for introduction of new systems. Technical staff of the equipment manufacturers or their agents in India will help the installation work.

Operator Training

Operators and maintenance personnel will be trained in the proper operation and maintenance of the new equipment. Personnel will also be trained to appaise and modify important process changes in the cleaning effectiveness of the semi-aqueous cleaning systems. The training programme will be designed by C-MET in cooperation with the equipment manufacturer and ERL, Bangalore.

5. Project Costs

The project costs refers to all costs, including incremental recurring costs. The costs of utilities and solvents may differ between project to projects in the country. Exhibit 7 indicates the total project cost of US $ 456,542. Because there are no non-ODS investment costs associated with this project, the total project cost equals the ODS reduction portion of the overall project. The total project incremental cost of US $ 456,542 was calculated as the economic capital cost (US $ 709,500) minus the net incremental operating savings for 4 years discounted at 10% (US $ 252,958).

Capital Investment Cost

As given in Annex I, the total investment cost is US $ 456,542. The major components of this cost include the purchase and installation of four hydrocarbon cleaning machines (US $ 360,000) for the replacement of the existing systems and a no-clean soldering machine (US $100,000).

Incremental Operating Costs/savings

If the project was not undertaken, the annual operating cost, exclusive of tax, would be US $ 255,020. If the project is implemented the annual operating cost will be US $ 174,520 resulting in an annual incremental operating savings of US $ 80,050. Given an equipment lifetime of 10 years and a discount rate of 10 per cent, the net present value of the first four years of incremental operating savings is US $ 252,958. A more detailed breakdown of operating savings is provided at Annex II.

Revenues

This project will not provide ERL-Bangalore with any incremental revenues

Local Ownership Ratio

Since the total project incremental cost should be multiplied by the fraction of local ownership to determine the proposed grant amount, total proposed multilateral fund financing is equal to total project incremental cost, i. , US $ 456,5!2.

Contingencies

A 10 percent contingency has been provided on the overall cost of the project.

Exhibit 7. Breakdown of total project costs

Description of cost	10 year period, US $	First four years, US $
Investment (capital) costs	709,500	709,500
NPV of incremental operating (savings)	491,827	252,958
NPC of incremental operating revenues	0	0
Total costs	217,672	456,542

Unit Abatement Cost (UAC)

As shown in Annex 3, the UAC for this project is US $ 2.0 per ODP weighted kilogram of ODS phased-out per year. This number is derived from an annualized incremental cost of capital of US $ 115,436, first year incremental annual operating savings of US $8 0,050 and phasing-out of 58.5 [illegible] (17 2 ODP-weighted) of ODS per year.

Proposed MF Grant

The proposed MF grant for the project is US $ 456,542 was calculated as follows: First the total investment cost of US $709,500 was deducted from the net present value of the incremental operating cost over the first four years of the project, which is US $ 252,958. This sum was then multiplied by the 100 per cent Indian ownership ratio of ERL-Bangalore to yield the same grant amount of US $ 456,542.

Exhibit 8. MF Grant Calculation

Total investment cost ,US $	709,500
Incremental operating savings over the first four years, US $	252,958
Project preparation costs, US $	0
Proposed MF grant, US $	456,542

Financing Plan

MF funding is a grant and is limited to the capital and incremental costs as calculated above. Any costs not covered by the MF funding as calculated above must be financed by other sources.

6. Project Implementation

Management

The project will be carried out at ERL-Bangalore in cooperation with C-MET National Consultant. UNIDO will also provide technical assistance to the project during the implementation.

Procurement

Project procurement will comply with the UNIDO procurement procedures.

Disbursements

Fund disbursements will comply with UNIDO financial procedures. The schedule for disbursements will be decided upon at the beginning of project implementation.

Audits

Concerning auditing, UNIDO project evaluation and review procedures and project financial management data will be used.

Required regulatory actions

No regulatory actions, other than routine permitting, are required to implement this project. Under the existing agreement with the UNIDO/World Bank, equipment and machinery imported as part of this project will be exempted from import duties levied by the Government of India.

Direct Project Impacts

The project will eliminate annually 58.50 MT of ODS (17.52 MT ODP weighted) at the ERL factory.

Indirect Project Impacts

As far as the indirect effect such as the transfer of technology to other enterprises in following projects is concerned, this project will have a large impact. The project design has been made to maximise this impact. Particularly, the involvement of C-MET of DOE will ensure the successful repetition of phasing-out projects in the Indian electronics industry. Otherwise, assuming a successful transition to the new cleaning processes at ERL-Bangalore, the quality and performance of ERL-Bangalore products will remain unchanged.

Exhibit 9. Schedule of activities (Project Roadmap)

Activity	Description	Responsible	Timing
1. Make a detailed work plan		C-MET, ERL, UNIDO	1 Q
2. Prepare technical specifications for equipment procurement	Discuss cleaning technology and equipment specifications with manufactures	C-MET, ERL, UNIDO	1 Q
3. Carry out reliability and materials compatibility tests	Evaluate the effectiveness of the different non-ODS cleaning techniques	C-MET, ERL	1 Q
4. Commercial negotiations	Hold commercial negotiations based on the technologies selected	UNIDO	2 Q
5. Prepare of the site and facilities	Engineering design of facilities (water, electricity, and gas),piping and civil engineering, construction	ERL	3 Q
6. Preparation/procurement of local equipment and machinery	Procure or make in-house the locally supplied equipment and machinery	ERL	3 Q
7. Installation and commissioning of equipment, acceptance tests		C-MET, ERL	4 Q
8. Start utilising new cleaning processes		ERL	4 Q
9. Evaluate the project		UNIDO, C-MET, ERI	5 Q

Annex 1. Breakdown of investment (capital) costs

	Description of cost item	Unit	Unit cost US $	Qty	Total cost US$
1	Project monitoring missions	m/w	5,000	1	5,000
1.1	Material compatibility, process development, equipment selection and reliability testing (local), expences relating to sending samples to manufactures, analysis of the results	m/w	400	20	10,000
2	Equipment				
2.1	No-clean soldering machine using no-clean flux	each	100,000	1	100,000
2.2	Modification of three potting systems to use a new solvent (dibasic esters) for flushing pipings of potting machines	each	100,000	1	100,000
2.3	Cleaning machine with vapor rinsing , vacuum drying and solvent distillation for cleaning ceramic substrate, terminal board,coil assembly and frame	each	90,000	4	360,000
2.4	Purchase of PCB preparation jigs and accessories including carriers to eliminate present jigs	each	30,000	1	30,000
2.5	Installation costs (electrical, piping,etc.)	each	20,000	1	20,000
3	Miscellaneous				
3.1	Transportation: shipping and insurance	set	20,000	1	20,000
3.2	Contingencies 10%				64,500
TOTAL INVESTMENT COSTS					709,500

Annex 2. Breakdown of incremental operating costs/savings

	Description of cost item	Unit	Unit cost, US$	Qty	Pre-project total cost, US$	Post-project total cost, US$
A.	Solvent/media costs per year					
A1	CFC-113/Methanol	kg	4.520	15,000	67,800	0
A2	MCF	kg	3.500	43,500	152,250	0
A3	RMA flux	L	4.000	2,000	8,000	
A4	Low solid flux from Interflux, USA	L	20.000	2,000		40,000
A5	New solvent PX 16S (total solvent capacity -150 kg loading + 500 kg/yr-vapor loss + 300 kg/yr-distillation loss + replacement- 2.0 MT=3.0 MT per a cleaning system), 4 machines-12. MT/yr	kg	8.000	12,000		96,000
A6	New solvent for flushing/ cleaning of piping of the potting machines	kg	1.300	9,000		12,000
	Sub-total				228,050	148,000
B.	Electricity costs per year					
B1	Current cleaning systems (78 kW/day, 300 days/year, 1 shifts)	kWh	0.050	23,400	1,170	0
B3	Old soldering machine (15 kWh)	kWh	0.050	36,000	1,800	
B4	New soldering machine (30 kW/h), 1 shift	kWh	0.050	72,000	0	3,600
B5	New A3 hydrocarbon cleaning systems (14 kwh, 1 shift, 4 machines)	kWh	0.050	134,400		6,720
	Sub-total				2,970	10,320
C	Labor costs					
C1	Labour costs (processes using ODSs), 5 operators	w/m	400	60	24,000	0
C2	Labour costs (non-ODS processes),4 operators	w/m	400	48		19,200
	Sub-total				24,000	19,200
TOTAL PRE-PROJECT COSTS/YEAR					255,020	
TOTAL POST-PROJECT COSTS/YEAR						174,520
TOTAL INCREMENTAL SAVINGS/YEAR						(30,050)

Annex 3. Calculation of unit abatement cost

A.	ODS phase-out		
A1	Annual consumption CFC-113 based solvent	MT	15.00
A2	ODP of CFC-113		0.82
A3	ODP-weighted CFC-113 phase out (A1*A2)	MT	12.30
A4	Annual consumption of 1,1,1-trichloroethane	MT	43.50
A5	ODP of MCF		0.12
A6	ODP-weighted MCF phase-out (A5*A6)	MT	5.22
A7	Total ODP-weighted phase-out		17.52
B.	Annualized capital cost		
B1	Total investment cost from Annex 1	US$	709,500
B2	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	115,436
C.	Annual incremental operating savings from Annex 2	US$	(80,050)
D.	Unit abatement cost		
D1	Annualized capital cost per kg ODS phased out	US$/kg	6.58
D2	Annual incremental operating savings per kg ODS phased out (C/A7*1000)	US$/kg	-4.57
D3	Unit abatement cost (D1+D2)	US$/kg	2.00

ANNEX-2

PROJECT PROPOSAL FOR THE MULTILATERAL FUND FOR THE IMPLEMENTATION OF THE MONTREAL PROTOCOL FINANCING

COUNTRY	:	India
PROJECT TITLE	:	Conversion of electronic cleaning processes from ODS solvents to Wet-media blasting & semi aqueous cleaning and No clean technologies at Indian Telephone solvents in 1993-94
PROJECT IMPACT	:	Phase out annual consumption of 17.42 MT of 1,1,1,trichloroethane and 0.060 MT of Halons 1301 and 0.760 MT of 1211 (total 18.24 MT ODS or 4.602 ODP weighted MT)
PROJECT DURATION	:	18 Months
PROJECT ECONOMIC LIFE	:	10 Years
TOTAL PROJECT COST	:	Investment(Capital)costs, US $ 481,055 Incremental operating costs/savings,US $ 118,311 Total Project costs, US $ 599,366
OWNERSHIP STRUCTURE	:	100 per cent Indian
PROPOSED MF FINANCING	:	US $ 599,366
UNIT ABATEMENT COST	:	US $ 6.34 per Kg ODS or US $ 25.11 per Kg ODP
COUNTERPART ENTERPRISE	:	Indian Telephone Industries Ltd., Bangalore
IMPLEMENTING AGENCY	:	UNIDO
COORDINATING MINISTRY	:	Ministry of Environment & Forests

PROJECT SUMMARY

This project will phase out the use of methyl chloroform in the flux removal, and precision cleaning operations at the Bangalore Factory of Indian Telephone Industries Ltd. (ITI).

The phasing out of ozone depleting substances (ODSs) will be accomplished by replacing the currently used solvent-based cleaning methods with water-based processes,i.e. batch semi aqueous process for flux removal and no clean technologies using LS Fluxes.

The project will employ commercially available technologies. Previous country studies and the Country Programme prepared during 1992 have identified the sector as a high priority area.

CHAPTER - 1

PROJECT OBJECTIVE:

The objective of this project is to phase out the use of methyl chloroform (MCF) in electronics cleaning operations. The processes in which ODSs are utilized, will be replaced with aqueous cleaning processes and no clean technologies. In addition to this Halon Cylinders containing halons 1301and 1211 would be replaced with ABC powders.

India became a signatory to Montreal Protocol in 1992 and as a part of subsequent exercise, a Country Programme document was prepared by the Government. This document has assessed the Ozone Depleting Substance (ODS) consumption by various factories in the country and on the basis of this, has worked out detailed activities under this Programme. Electronics is one of the major sectors consuming large quantities of Ozone Depleting Substance. Before finalising the Country Programme report, a sectoral report was also worked out in consultation with the industry - users and manufacturers of ODS substances which has formed the basis for Country Programme preparation.

Electronics industry has a special feature that its significant production is distributed in small and medium scale industry and it is spread over throughout the country. The discussion was then started for implementation of the programme and as a test case in the first instance, it has been realised that there would be individual projects for larger consumers and for smaller consumers a cluster type of approach could be taken up. One of the major recommendations provided in the document was to involve a nodal agency to assist the industry by increasing awareness and helping them in preparation of projects for ODS phase-out. This activity is being looked after by Centre for Materials for Electronics Technology (C-MET) of Department of Electronics

Subsequent to the finalisation of India Country Programme, and taking into consideration the structure and distribution of Indian electronics industries and lack of awareness, UNIDO took initiative and formulated a programme under which a few solvent phase out proposals can be worked out with the help of a national consultant and approached Multilateral Fund for financial assistance and finalised a project proposal for the preparation of four projects aiming at ODS phase-out by electronics industries. Considering the expertise and the infrastructure available at the Centre for Materials for Electronics Technology (C-MET)/Department of Electronics (DOE), Ministry of Environment & Forests as also UNIDO approved C-MET as the National Consultant in this project. As a result UNIDO appointed C-MET as a National Consultant to work on this project for solvent sector.

A brief background of the focal point (C-MET) is given below:

The Centre for Materials for Electronics Technology (C-MET) is operating as a registered scientific society under the Department of Electronics, Government of India with the main objective to establish technology strength in Electronics materials for the present and future industrial requirements. C-MET has been operating in a project mode for both short and long duration projects and a very few of longer duration projects. During the last four years of its existence, C-MET has already achieved the following:

(i) Has been operating in innovation/diffusion interface segment of the "invention - innovation and diffusion chain" of industrial R&D.

(ii) Has established the formal and informal linkages with all stake-holders, i.e., R&D user industry and manufacturing industry. It has also signed several technology transfer and collaboration agreements with R&D institutions.

(iii) Has undertaken several projects with financial participation from industry. Already C-MET has successfully completed a few such projects which have given significant economic benefits to them.

(iv) Has established itself as an organisation with effective and efficient management for undertaking projects, completing the tasks and transfer the technology to industry. It has also developed a system engineering and networking capability to deliver acceptable products with optimum resources.

(v) The "Solvent Sector" report for India Country Programme for ODS phase out was prepared under the leadership of Dr.S.G. Patil, Sr.Director, Department of Electronics and Executive Director, C-MET.

(vi) Participated in the formulation of project for ODS phase out with ODS free technology for Indian Telephone Industries Ltd., Bangalore.

This is the second project formulated by C-MET /DOE in the solvent-based electronics cleaning sector in India. Considering the structure of the Indian electronics industry and required steps to phase out ODSs in electronics cleaning, it is expected that this project will additionally identify and strengthen a focal point which will

* Help to increase awareness in the selected electronics industries regarding need for phasing out ODSs and, for this purpose, collect and compile technical and technological information.

* Generate information and provide technical support regarding problems associated with phasing out of ODSs by the electronics industry, which include process development, materials compatibility testing, cost-effectiveness analysis, technology selection and drawing up of equipment specifications.

* Accumulate adequate problem solving know-how during the implementation phase of this project so that the projects of a similar nature can be implemented in other locations.

The activities to be carried out at focal point level are described in the following Exhibit - 1.

EXHIBIT - I

PHASING OUT OF ODSs IN INDIAN ELECTRONICS INDUSTRY

The role of a focal point of know-how

```
                      /-----------------\
                      | Phasing out ODSs |
                      \-----------------/
                               |
                  /-------------------------\
                  | Technological data base |
                  \-------------------------/
                               |
                  /-------------------------\
                  | Awareness in the sector |
                  \-------------------------/
                               |
      /-------------------------------------------------\
      |                                                 |
 /-----------------\               /---------------------------\
 | Large enterprise |              | Small-to-medium enterprise|
 |-----------------/               |---------------------------/
 |- Reliability testing*           |-  Reliability testing*
 |- Process development*           |-  Process development*
 |- Technology selection*          |-  Technology selection*
 |- Equipment selection*           |-  Equipment selection*
 |- Site preparpation              |-  Site preparation
 |- Installation                   |-  Installation
 |- Operator training              |-  Operator training
 |- ODS-free cleaning              |-  ODS-free cleaning
```

Note: Generally, the activities indicated against * require technical assistance and will be carried out by the focal point of the sector.

CHAPTER - 2

SECTOR BACKGROUND

The solvents sector is the largest user of ozone depleting substances (ODSs) in India. The size of consumption has been investigated in a number of studies. According to India Country Programme: August 1993, the total consumption of ODS in the country by 1991 was 10,370 tonnes equivalent to 13,111 tonnes ODP. Out of which, the solvent sector consumed 100 MT of CFC-12, 300 MT of CFC-113, 4,000 MT of carbontetrachloride and 550 MT of 1,1,1-trichloroethane (MCF), i.e. a total of 4,876 MT of ODP (ozone depletion potential)-weighted consumption, that is 36.6 per cent of total ODP-weighted consumption in India. The total ODS consumption as solvent in India in 1991 is given at Table-1.

Table-1

		ODS MT	ODP Equivalent MT
Electronics	CFC-113	150	120
	CTC	80	88
	MCF	30	3
Textile cleaning	CTC	600	660
Pharmaceuticals	CTC	1060	1166
Pesticides	CTC	800	880
Rubber industry	CTC	320	352
Chemicals & Laboratory	CTC	70	77
	MCF	50	5
Sterlization	CFC-113	10	8
	CFC-12	100	100
Metal and precision cleaning	CFC-113	130	104
	MCF	40	4
Miscellaneous uses	CFC-113	10	8
	CTC	1070	1177
	MCF	430	43
Subtotal	CFC-12	100	100
	CFC-113	300	240
	CTC	4000	4400
	MCF	550	55

ODS consumption in the solvents industry is split between electronics, metal cleaning and other processes such as textiles, pharmaceuticals, pesticides, chlorinated rubber, etc. Cleaning processes used in the electronics industry consumed in 1991, 150 MT CFC-113, 75 MT CTC and 30 MT of MFC and included flux removal (printed circuit cards and hybrid circuits), semiconductor manufacturing, microelectronic component cleaning, metal and plastic part cleaning and photoresist development and stripping. The use of ODSs in electronics cleaning in India has been increasing as a result of the development of the electronics industry.

ODS consumption in India: As per the India Country Programme the ODS & ODP figures for the year 1991 and unconstrained scenario by 2010 is given in the following Table-2, Exhibit-2 and Table-3, respectively.

Table-2

1991 Consumption

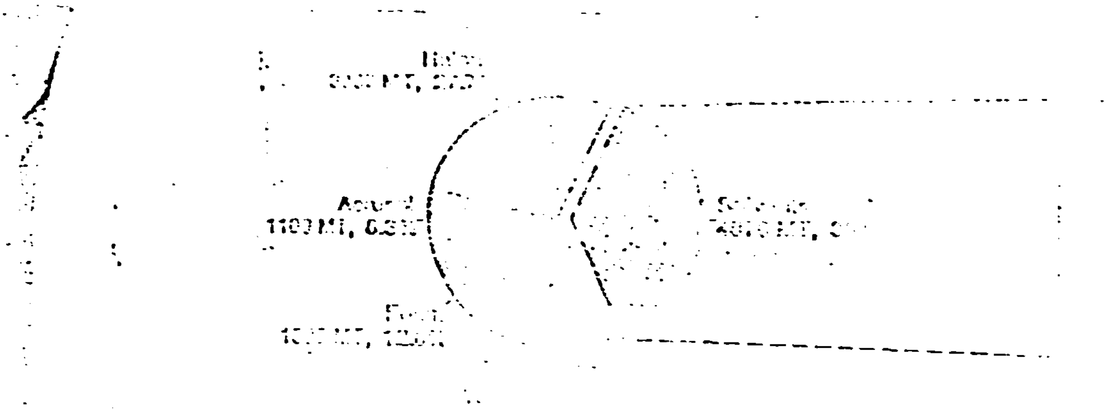
Types of ODS	All Sectors			Solvents		
	Actual MT	ODP-Weighted		Actual MT	ODP-Weighted	
		MT	%		MT	%
CFC-11	1900	1900	14.4	0	0	0.0
CFC-12	2850	2850	21.6	100	100	2.1
CFC-113	320	342	2.6	300	321	6.6
Sub-total	5070	5092	38.6	400	421	8.7
Halon-1211	550	1650	12.5	0	0	0.0
Halon-1301	200	2000	15.1	0	0	0.0
Sub-total	750	3650	27.6	0	0	0.0
CTC	4000	4400	33.3	4000	4400	90.2
MCF	550	66	0.5	550	55	1.1
TOTAL	10370	13208	100.0	4950	4876	100.0

Sectoral Distribution

Aerosols	1100	1100	8.3
Foams	1580	1580	12.0
Refrigeration	1990	1990	15.1
Solvents	4950	4876	36.9
Halons	750	3662	27.7
TOTAL	10370	13208	100.0

Exhibit – 2

ODS CONSUMPTION IN INDIA
1991 FIGURES IN ODP-WEIGHTED MT



(tonnes)

	1991 Actual		[illegible]		[illegible]		[illegible]		[illegible]	
Substance	ODS	ODP	ODS	ODP	ODS	ODP	ODS	ODP	ODS	ODP
CFC-11	1900	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CFC-12	2050	2050	5960	5960	10560	10560	20900	20900	41200	[illegible]
CFC-113	320	[illegible]	[illegible]	600	1500	[illegible]	4240	[illegible]	[illegible]	[illegible]
Halon-1211	550	1650	1050	3150	1350	4050	1750	5250	2100	[illegible]
Halon 1301	200	[illegible]	[illegible]	[illegible]	500	5000	[illegible]	[illegible]	[illegible]	[illegible]
CTC	4000	4400	10600	11600	[illegible]	26180	[illegible]	[illegible]	[illegible]	[illegible]
MCF	550	55	1120	135	2000	240	[illegible]	427	[illegible]	[illegible]
Total	10370	13111	24170	29255	47590	55094	95450	107259	[illegible]	[illegible]

POOR QUALITY ORIGINAL

CHAPTER-3

ENTERPRISE BACKGROUND

Indian Telephone industries Ltd. (ITI) is a 100% Government of India owned company incorporated in 1948. ITI has six units all over India and manufactures the entire range of telecommunication equipment and accessories such as telephones, switching, transmission, satellite and fibre optic equipments, etc. Annual production of ITI exceeds Indian Rs.14 billions (about US $ 494 million).

ITI-Bangalore complex is one of the largest units of ITI employing a work force of around 13,000. The investment in the Bangalore complex as on 1994 was Rs.1037 million including model plant. The major production of ITI-Bangalore ranges in six categories such as:

i) Transmission System Division
ii) Electronic Switching Division
iii) SATCOM Division
iv) Defence Production
v) Telephones
vi) Control Systems

Electronic switching equipments manufactured by ITI-Bangalore are based on indigenous technology developed inhouse. The exchanges manufactured include XD-90, MILT, ILT-512, ILT Mark II and MILT-64 using non-conventional source of energy.

Transmission equipments production started by ITI-Bangalore way back in 1950. The main products include DAMA for DOT, 140 MB digital mux, digital microwave system, ADPCM transcoder, IDR modems and digitial distribution frame.

Under new products category, the manufacturing activity include electronic switching equipments in addition to strowger spares. Subscriber line cards (XFJ) required for E10B exchanges are also manufactured as well as RLUS for E10B exchanges and C-DOT 512 exchanges.

A wide variety of telephones are being manufactured by ITI-Bangalore. The product-mix include Electronic Switching Push Button Telephones (EPBT), Executive Secretary Systems (ESS-89) and electronic pulse/tone switchable telephone EPT-90. In addition, the manufacturing activity also includes head gear sets for various applications. ILT-512/2K also developed inhouse, medium size digital switch of 2000 lines capacity unexpandable in steps of 8 subscriber lines and 4 trunk lines, employing TDM-PCM techniques. 128-RAX is 128 port digital rural automatic exchange of C-DOT technology specially designed to meet the requirements of rural networks. MILT-64 is a small size digital switch of inhouse design to cater to 56 subscribers and 8 trunks.

Transmission equipment covers a range of applications such as fibre optic, digital mux, digital microwave (6-13 GHz), 30 channel digital UHF and MARR.

Under the category of subscriber end equipment, the items of manufacture include switchable telephones, cordless and magneto.

Defence equipment include subscriber apparatus and transmission equipments.

In order to cater to the needs of communication equipments of bulk users such as railways, and electricity boards, the manufacturing activity on data switching activity is also covered by ITI.

The manufacturing division of ITI, Bangalore are shown in Exhibit - 3 below alongwith the broad product-mix.

Exhibit - 3 Manufacturing Divisions of ITI, Bangalore

```
                         /-----------------\
                         |Managing Director|
                         \-----------------/
                                  |
 /----------------------------------------------------------------\
 |          |          |           |           |           |
/-------\ /----------\ /-------\ /----------\ /---------\/----------\
|Trans- | |Electronic| |SATCOM | |Control   | |Defence  ||Telephones|
|mission| |Switching | |Div.   | |Systems   | |Produc-  |\----------/
|System | |Division  | \-------/ |Division  | |tion Div.|
|Div.   | \----------/           \----------/ \---------/
\-------/
```

Transmission System Div.	Electronic Switching Division	SATCOM Div.	Control Systems Division	Defence Production Div.	Telephones
* DAMA * 140 MB Digital MUX * Digital Microwave Systems * ADPCM Trans-coder * IDR modems * Digital distribution frame	* XD-90 * MILT * ILT-512 * ILT Mark II * MILT-64 * Strowger spares * Electronic Switching Equpt. * Line Cards for E10B exchange * RLUS for E10B exch. & C-DOT 512 exch. * communication equpt. for bulk users * SPC Telex * ITEX 75	* SATCOM Eqpt. * LCT * LNA	* MARR Systems * UHF/VHF systems * O/W Carrier Eqpt. * Fibre optic Eqpt.	* Subscriber apparatus & Eqpt.	* EPBT * EPT-90 * ESE-89 * Special items for Mines & Navy

The capacity of individual products in the divisions is indicated below.

I. <u>Electronic Switching</u>: **1800 cards/day**

a) Electronic Switching
b) New Products
c) SPC Telexes
d) Model Plant

II. **Transmission**

a) Transmission
b) PCM
c) Multiplexing Voicefrequency Terminal

III. **Defence Production**

a)Defence equipments	4000 Nos/year

IV. **Telephones**

Telephone instruments	500,000 Nos/year

V. **SATCOM**

a) LCT/SDCPC/CCE/SBRIN	610 terminals/ year
b) LNA	40 Nos/year
c) HPA	1050 Nos/year

VI. **CONTROL SYSTEMS**

The Transmission division of ITI-Bangalore has a product-mix of various transmission equipments and assemblies such as microwave systems, co-axial line equipments, multiplexing equipments, channels (Bays), etc. It has a production capacity of 800 T/Rs microwave radio equipments, 2000 rout km co-axial line equipments, 5000 terminals, multiplexing equipments, 350 Nos. interstice equipments and 250 Bays VFT channels, etc. The Electronic Switching Division is manufacturing different kind of switching assemblies including manufacture of sub-racks, racks and rack assemblies, Bay assemblies, automatic exchange assemblies, etc. In addition, this division is also capable of manufacturing spares (Strowger), line cards for E10B exchanges, RLUS, telexes, etc. The electronic switching activity is managed by separate sub-divisions, i.e., electronic switching division, new products division and SPC telexes. The capacity of electronic switching division and new products division is of the order of 5 lakh lines per year whereas SPC telexes is capable of producing 12,000 equivalent lines per year based on two shifts per day. SATCOM Division of ITI-Bangalore is dedicated for the manufacture of satellite communication equipments such as LCT and LNA. The manufacturing capacity for LCT and LNA is of the order of 60 terminals and 40 Nos per year, respectively. The Control System division of ITI-Bangalore has a product-mix of MARR systems (100 Nos), UHF/VHF systems (2900 terminals), OYW carrier equipment (2000 terminals), fibre optic equipments (5000 terminals). The requirement of defence in terms of subscriber apparatus and transmission equipment is manufactured under Defence Equipment division and has a capacity of 4000 Nos per year for ADM channels. Production of telephone equipment is one of the major activity of ITI-Bangalore wherein an installed capacity of 5 lakh telephone instruments has been created. The telephone instruments manufactured by this Division include EPBT, EPT-90m ESC-89and special items for mines and navy.

The PCB Division of ITI-Bangalore has already switched over from solvent processable process to aqueous processable process and, therefore, is not using any CFCs or ozone depleting substances in the PCB manufacture. The use of ODS solvent at ITI-Bangalore in various operations is presented in the following tables that is Exhibits 4 and 5.

India became a party to the Vienna Convention on June 19, 1991 and the Montreal Protocol on substances that depleted the ozone layer on September 17, 1992. In the protocol, the emphasis was given to the restricted use and manufacture of ODS substances which depletes the ozone layer. Subsequently, it was proposed to phase-out all ozone depleting substances by the Member-countries. It was also highlighted to meet the financial requirement of the developing countries for ODS phase-out by providing financial assistance by multi-lateral funds. Keeping in mind that the financial assistance would now be available as India has signed the Protocol, while Country Programme report preparation was on, parallely, ITI took initiative to phase-out the ozone depleting substances in a phased manner. As a result, during 1992 and in their model plant, the CFC (1,1,1 trichloroethane) cleaning was replaced with aqueous cleaning by installation of Holi's model Holi clean 16 polypropylene aqueous system using aqueous metals. The system costed a total of Rs.30 lakhs. In addition, as a trial to start with in the new products division, ultrasonic flux unit using no clean fluxes was introduced in Scho model 8000 recently in 1994. The cost of the Spray model was of the order of US $ 20,600. The cost of both these units has been taken into account in this proposal as it was presumed that the phase-out cost would be reimbursable in total.

Exhibit - 4 ODS Solvent - Cost of ITL, Bangalore

Division/Purpose	Amount MT/Yr.	Unit Price US $	Annual Cost US $	ODP Weighted amount MT/year
I. Electronic Switching/flux removal				
a) Electronic Switching: 1,1,1-trichloroethane (CH3CCl3, MCF)		$ 8/litre or $ 8/1.3 kg		
b) New Products: 1,1,1-trichloroethane (CH3CCl3,MCF)		$ 8/1.3 kg		
c) SPC Telexes: 1,1,1-trichloroethane (CH3CCl3,MCF)		$ 8/1.3 kg		
d) Model Plant:1,1,1-trichloroethane (CH3CCl3, MCF)		$ 8/1.3 kg		
II. TRANSMISSION/ Flux Removal				
a) Transmission:1,1,1 trichloroethane (CH3CCl3, MCF)		$ 8/1.3 kg		
b) PCM:1,1,1-trichloroethane (CH3CCl3, MCF)	1.80	$ 8/1.3 kg		
c) Multiplexing:1,1,1 trichloroethane (CH3CCl3, MCF)		$ 8/1.3 kg		
III.Defence Production flux removal 1,1,1-trichloroethane (CH3CCl3, MCF)		$ 8/1.3 kg		
IV. Telephones/flux removal 1,1,1-trichloroethane (CH3CCl3,MCF)		$ 8/1.3 kg		
V. SATCOM/flux removal 1,1,1-trichloroethane (CH3CCl3,MCF)		$ 8/1.3 kg		
VI. Fire Fighting Halon 1301 Halon 1211	 60 kgs 760 kgs	 $ 100/cylinder $ 100/cylinder		
Total consumption of MCF	17,420 kg	$ 8/1.30kg	$ 1,07,200	

Exhibit - 5 ODS Solvent Using Equipment at ITI, Bangalore

Activity	Production Capacity	Purpose	Equipment	Year of Purchase	Cost (Rs. Million $)
I. Electronic Switching					
a) Electronic Switching	200,000 lines/ yr or .... cards/day /8 hrs	Cleaning of solder fluxes from populated PCBs.	1,1,1 tri-chloroethane cleaning machine supplied by M/s Kanagawa	1990	-
b) New Products & SPC telexes	300,000 lines/yr or .... cards/day /8 hrs	Cleaning of solder fluxes from populated PCBs	Compatible with KOKI using 1,1,1 trichloroethane as solvent. ultrasonic spray flux unit has now been installed. System compatible with SEHO Model 8000. (Cost of the model is DM 25124/-. Only hand cleaning is now practised for final cleaning.	1990	-
c) Model Plant	....	Cleaning of solder fluxes from populated	Holi clean 16 polypropylene aqueous system	1992	$ 22,235
II. Transmission					
a) Transmission	30,000 sq.m. Solder/ cleaning area or .... cards/day	Cleaning of solder fluxes from populated PCBs	Attached to Kristen Jet Immersion bath followed by hard cleaning with 1,1,1,trichloro-ethane	1990	-
b) PCM	30,000 sq.m. Solder/ cleaning area or .... cards/day	Cleaning of solder fluxes from populated PCBs	Kerry cleaning machine compatible with SEHO model No.8000	1987	-
c) Multiplexing	5,000 sqm	Cleaning of solder fluxes from populated PCBs	Kerry cleaning machine compatible with SEHO Model No.8040C	1987	-

III. <u>Defence Production</u>	4000 No.	Cleaning of solder fluxes from populated PCBs	Econopak cleaning machine used with Electrovert solder unit. Solvent is 1,1,1 trichloro-ethane.			-
IV. <u>Telephone</u>						
Telephone	400,000 Nos (2 lines)	Cleaning of fluxes from populated PCBs	a) Attached to Soldamatic Immersion tanks followed by hand cleaning with 1,1,1 trichloro-ethane.	1986		-
			b) Attached to Hallies. Immersion tanks followed by hard cleaning 1,1,1 trichloro-ethane.	1988		
V. <u>SATCOM</u>						
LCT/SCPC/ CCE and LMA, HPA	6010 Terminals 100 Nos	Cleaning of fluxes from populated PCBs	Attached to Aries Italia. Immersion tanks hand cleaning with 1,1,1 trichloroethane.	1991		-
VI. <u>Control Systems</u>	Solder area 30,000 L/hr	Cleaning of solder fluxes from populated PCBs	Cleaning attached to Electrovert soldering machine.	1982		

CHAPTER-4

PROJECT DESCRIPTION

4.1 Sector-wide approach

The electronics industry uses a variety of chemical substances in the manufacturing processes and packaging operations. Some of these include chemicals which are polluting the environment, out of which a number of them are classified as ozone depleting substances.

Considering this, a broad based programme to enhance the awareness about use of such substances in the electronics industry, development of alternatives for replacing/phasing out of such substances etc., is being pursued under the activities of the Centre for Materials for Electronics Technology (C-MET) of the Department of Electronics, Government of India. This would be a part of the overall programme of the Government of India which is being implemented under the overall coordination of the Ministry of Environment and Forest.

The replacement of ODSs in electronics industry applications with aqueous processes and no clean technologies will require extensive engineering know-how to carry out tasks such as:

- Reliability testing
- Material compatibility testing and process development
- Technology selection
- Equipment selection
- Purchase of aqueous cleaning machines and systems
- Site preparation
- Installation of machinery
- Operator training

Therefore, the overall programme conceived for implementation here includes awareness of the industry towards phasing out of these chemicals and taking up activites with the help of industry and R&D institutions to develop substitutes for the actual usage as well as taking up demonstration projects with the help of experts in the field and translating the knowledge and experience gained to the other enterprises of the electronics industry and to the other sectors.

It is, therefore, decided that C-MET of DOE will take part in the project from its start in order to accumulate information and experience to assist ITI-Bangalore as well as to other enterprises of the Indian electronics industry.

4.2 Description of the ITI-Bangalore project

As discussed in the section above, the replacement of ODSs in electronics industry applications with aqueous processes and no clean technologies requires extensive engineering know-how to perform a number of tasks. Each of these tasks, or project elements, is explained and shown in Exhibit - 6.

Reliability testing material compatibility testing and Process Development

Reliability testing, material compatibility testing and process development will be performed by C-MET, in close cooperation with ITI-Bangalore, prior to the purchase of the aqueous cleaning machines or no cleaning systems in order to choose the best equipment and to decide if water additives are necessary to achieve the desired cleaning results. The process development work is to be documented with graphs, charts, and data showing that the ITI-Bangalore project has determined that the aqueous cleaning process or no clean process is a good decision. The process development work particularly will be completed prior to ordering the aqueous cleaning machines for the Switching Exchange Assembly Division & multiplexing in transmission Division, and no clean systems for transmission equipment assembly (New Products) ,Transmission including pulse code modulatcr , Defence production and Control systems.

C-MET is required to complete and document reliability testing of aqueous cleaning systems for the Transmission, and Switching Exchange Assembly prior to ordering the five systems, mostly immersion tank type with adequate number of compartments for cleaning with alternate solvent and rinsing by deionised water followed by hot air drying. The reliability tests should evaluate the long term effects of increased moisture inside the electronic assemblies, parts and components that may be attributed to the use of the aqueous cleaning process. Parallely C-MET would also complete the documentation with regard to the five no clean systems.

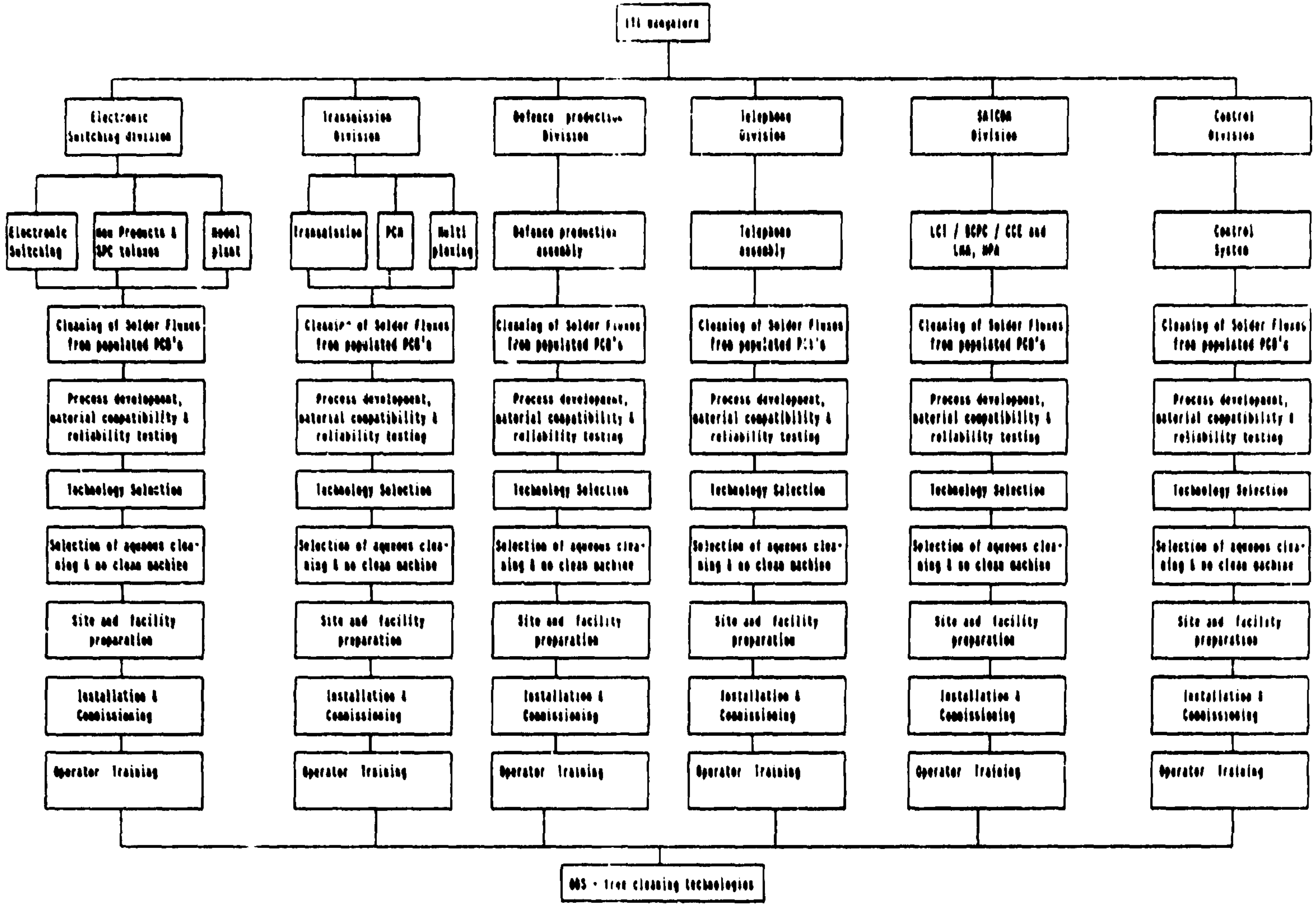
Technology selection, equipment selection and purchase of aqueous cleaning machines and no clean systems.

ITI-Bangalore will phase out the use of methyl chloroform (1,1,1-trichloroethane) in the flux removal and precision cleaning in its six manufacturing divisions by selecting and utilizing the appropriate aqueous and no clean processes. ITI-Bangalore currently uses five multi stage batch operations vapor degreasers, and five batch operation immersion type ultrasonic degreasers/manually operated systems, which are to be replaced.

At the end of the project implementation, all solvents with a ODP will be eliminated. It is planned that, all fully chlorinated solvents will be eliminated before the year 2000.

There are several technologies and equipment available in the market, and it depends to a great extent on the type of process and technology chosen for cleaning. For the large scale, high production applications, there is continuous, conveyor-operated equipment which has a range of controls which can be included, depending on the amount of labour available for monitoring operations, and the quality requirements. This applies to both the aqueous and the semi-aqueous (such as solvent

Chart ... Main Elements of ITI, Bangalore ODS Phase out Project



wash/water rinse) equipment. Aqueous systems generally use water filtration and purification to enable water recycling and to capture waste stream contaminants. Semi-aqueous systems normally use carbon absorption or membrane separation techniques to recycle both the water and the solvent streams if the electronic circuit assemblies have high quality requirements, and/or are difficult to clean due to complex geometries of design, then mechanical assistance through the use of strong, directed sprays may be required. No clean technologies with or without nitrogen atmosphere, using low solid fluxes are gaining importance and the quality is well received for wide range of applications. This is one of the very cost effective technologies available and widely used by industry.

ODS-free cleaning technologies are implemented by different suppliers using fairly different hardware and software components and widely varying system integration philosophies. Particularly when the automatic workpiece transport systems are included, the cleaning system has to be designed and built individually. Capabilities of the suppliers and those of their products and systems should be evaluated in situ before the final decision.

Therefore, a study-tour for the technical staff/managers of ITI-Bangalore and C-MET is proposed to be arranged to visit no clean, aqueous and semi-aqueous equipment and system manufacturers and electronic industry enterprises which have phased out the ODS's using these systems. It is desirable to arrange the timing of the study-tour to coincide with a technical/industrial fair as far as possible which would give an across-the-board comparison/evaluation possibility.

<u>Purchase of aqueous cleaning machines and no clean systems</u>

Batch operation aqueous cleaning systems

A typical Batch operation aqueous cleaning system is shown in the schematic diagram given in the following Exhibit -7. This system includes the following components:

a) Main sub-system includes cleaning, rinsing, drying and deionizer units. Its cost can be in the range of US$ 100,000 to 150,000 depending upon the automation and control requirements. For semi aqueous technology, submerged sprays or inert blanketed sprays are often included in the design, normally as part of the quote.

b) The water filtration and recycling, sub-system (waste water treatment system) can be integrated into the main sub-system and costs about US $ 50,000 extra.

c) Computerized work piece transport system which has to be custom built to match the other system components and the cost has been duly considered.

d) The aqueous cleaners to replace the present ultrasonic and other batch systems will be smaller than the continious systems and will be designed to suit the existing systems. The following table shows the capacities and functions of the batch operation aqueous cleaners. As it is seen from Exhibit - 8, the non ODS systems do not aim at any capacity increase but reprpesent an one-to-one replacement scheme.

```
/----------------------------------------------------------\
| EXHIBIT - 7 BATCH AQUEOUS WORK PIECE TRANSPORT SYSTEM     |
\----------------------------------------------------------/
  /-----------\
  | WORK PIECE |
  |   TO BE    |                          /-------------------\
  |  CLEANED   |                          | WORK PIECE CLEANED |
  \-----------/                           \-------------------/
        |                                            |
        |                                            |
/----------\    /----------\    /----------\    /---------\
| CLEANING  |   | RINSING   |   | RINSING   |   | DRYING   |
| WITH      |-> | WITH      |-> | WITH      |-> | WITH     |
| ORGANIC   |   | WATER     |   | DI WATER  |   | HOT AIR  |
| SOLVENT   |   | AGITATION |   \----------/    \---------/
\----------/    \----------/        |   |
   |    |          |   |            |   |
/-------\       /-----------\     /-----------\
| FILTER |      | MIXED BED  |    | MIXED BED  |
\-------/       | EXCHANGER  |    | EXCHANGER  |
                \-----------/     \-----------/
                      |                 |
      /----------------------------------\
      | WATER  TREATMENT AND REGENERATION |
      \----------------------------------/
```

* Mannual Cleaning Systems

The environmental quality and safety considerations mentioned above are still required, however, equipment design must include these components as needed. There are ranges of quality and construction materials in this equipment category, for this project, it is estimated that each cleaner will cost in the region of US$ 60,000. Water recycling systems will be installed; for these manufacturing units. The total cost of the systems is estimated at US$ 40,000.

Exhibit - 8. Comparison of present and proposed batch operation Aqueous cleaning systems

Location	No	Capacity of the present ultrasonic system using ODS's systems	Capacity of the proposed aqueous/ No clean systems
Transmission System Div.	2+1*	Kery cleaning M/c (4.16 sq.mt./hr)	325 x 450 x 350mm
Satcom Div.	1*	Hand cleaning	
Defence production	1	Econopak cleaning (3.1 sq.mt./hr)	
Telephones (4 Lines)	1*	Hand cleaning	
Electronic Switching Division	4	PCB cleaning M/c (8.62 sq.mt./hr)	325 X 450 X 350mm
Control Systems	1*	Hand cleaning	

Site preparation and installation of machinery

The project includes funding to prepare the sites for the equipment installation. This funding is for electrical supply and plumbing to ensure safe installation of the equipment. The modifications are necessary to the cleaning areas or to the soldering area for introduction of spray modules, so that the process flow of the new equipment is uninterrupted in terms of high volume cleaning. Technical staff of the equipment manufacturer or their agents in India will help the installation work.

Operator Training

Operators and maintenance personnel will be trained in the proper operation and maintenance of the new equipment. Personnel will also be trained to measure important process changes in the cleaning effectiveness of the aqueous clean or the ultrasonic spray fluxers. The training programme will be designed by C-MET in cooperation with the equipment manufacturer and ITI-Bangalore.

CHAPTER-5

JUSTIFICATION FOR SELECTION OF ALTERNATIVE TECHNOLOGY

In the solvent sector, especially in the case of electronics cleaning, there are many options to the use of ozone depleting solvents. Usually the choice of the alternative cleaning process is dependent upon the type of market served by the solvent user. Most commercial applications have more flexibility in the use of new technology, because of the inherent need for commercial entities to maintain their competitiveness in the world market by maintaining high quality standards. However, many organizations build products known for their high degree of reliability for use in military aircraft, satellites or other difficult professional (industrial and commercial) operations. These organizations spare no cost to ensure that products made by their organizations are dependable and reliable. Considering the reliability requirements of ITI-Bangaloes also requires that the materials used in the production of the product are not damaged by water or aqueous based residues. No-clean technologies employing Low residue fluxes have proved a success in number of applications and, therefore, wherever possible attempts are being made to implement this technology in ITI-Bangalore. In this project, the use of no-clean technologies has been chosen aiming at maintaining the quality standards as before using CFCs and also this would require minimum investment.

For high reliability applications the use of semi aqueous based process is chosen because the efficient use of water as a solvent will not damage the environment and because water is a plentiful and inexpensive resource in Bangalore.

CHAPTER-6

PROJECT COSTS

The project costs refers to all costs in this section are economic rather than financial costs. The incremental recurring costs are included in this project. Incremental costs are offset by the reduction in cost for the ODS solvents and cost of waste disposal. The costs of utilities and of solvents may differ between project to projects in the country. Cost of acquiring the necessary environmental permits is included as part of the project.

Total Project costs:

Annexure-I indicates the total project cost of US $ 599,366. Because there are no non-ODS investment costs associated with this project, the total project cost equals the ODS reduction portion of the overall project. The total project incremental cost of US $ 599,366 was calculated as the economic capital cost plus the net incremental operating costs for 4 years discounted at 10%.

Capital Investment Cost

As given in Annex-I, the total investment cost is US $ 481,055. The major components of this cost include the purchase and installation of three batch operation semi aqueous cleaning machines (US $ 1,72,255), eight ultrasonic spray flux units for introducing no-clean technologies in the existing systems (US $ 1,64,800). Ground water treatment plant and waste treatment facilities have also been included under this which are of the order of US $ 38,700.

Since 150 cylinders of fire-fighting applications containing halons 1301 and 1211 are also proposed to be replaced with ABC powders. The cost of replacement (US $ 33,300) has also been included in this project.

Incremental Operating Costs/savings

If the project was not undertaken, the annual operating cost, exclusive of tax, would be US$ 40,450. If the project is implemented the annual operating cost will be US $ 77,774 resulting in an annual incremental operating costs of US$ 37,324. Given an equipment lifetime of 10 years and a discount rate of 10 per cent, the net present value of the first four years of incremental operating costs is US $ 118,311. A more detailed breakdown of operating costs is provided in Annex-II.

Revenues

This project will not provide ITI-Bangalore with any incremental revenues.

Local Ownership Ratio

Local ownership fraction of 100 per cent was considered to determine the amount of eligible MF grant financing. Since the total project incremental cost should be multiplied by the fraction of local ownership to determine the proposed grant amount, total proposed multilateral fund financing is equal to total project incremental cost, i.e. US $ 599,366.

Contingencies

A 10 per cent contingency has been provided on the overall cost of the project.

Exhibit 9. Breakdown of total project costs

Description of cost	Full-life of project		First four Years	
	Local US$	Foreign US$	Local US$	Foreign US$
Investment (capital)costs		481,055		481,055
NPV of incremental operating (savings)		---		---
NPV of incremental operating revenues		[illegible]		[illegible]
Total costs		710,401		599,366

Unit Abatement Cost (UAC)

As shown in Annex-III,the UAC for this project is US $ 6.34 per ODS-weighted kilogram or US $ 25.11 per ODP weighted kilogram of ODS phased out per year. This number is derived from an annualized incremental cost of capital of US $ 78,268, first year incremental annual operating cost of US$ 37.324 and phasing out of 18.24 tonnes (4.6023 ODP-weighted) tonnes of ODS per year.

Proposed MF Grant

The proposed MF grant for the project is US $ 599,366 and was calculated as follows; First the total ivestment cost of US $ 481,055 was added to the net present value of the incremental operating, cost over the first four years of the project, which is US $ 118,311. This sum was then multiplied by the 100 per cent Indian ownership ratio of ITI-Bangalore to yield the same grant amount of US $ 599,366.

Exhibit - 10. MF Grant Calculation

Total investment cost, US$	481,055
Incremental operating savings over the first four year, US $	118,311
Project preparation costs US$	---
Proposed MF grant, US$	599,366

Financing Plan

MF funding is a grant and is limited to the incremental cost as calculated above. Any costs not covered by the MF funding as calculated above must be financed by other sources.

Project Implementation

Management

The Ministry of Environemnt and Forest (MOEF) will oversee the successful implementation of this project. The project will be carried out at the ITI-Bangalore in cooperation with C-MET National Consultant of the Department of Electronics. UNIDO will also provide technical assistance to the project during the implementation. The expenses related with international expert services have been provided in the project cost.

Procurement

Project procurement will comply with the UNIDO procurement procedures.

Disbursements

Fund disbursements will comply with World Bank financial procedures. The schedule for disbursements will be decided upon at the beginning of project implementation.

Audits

For auditing, World Bank project evaluation and review procedues and project financial management data will be used.

Exhibit -11. Schedule of activ... (PROJECT ROADMAP)

Activity	D... ion	Responsible	Timing
1. Sign the project, receive funding	------	1. MOEF, UNIDO, Multilateral Fund	1 Q
2. Make a detailed project work plan	------	2. C-MET, ITI, Bangalore, UNIDO	1 Q
3. Arrange the study-tour	------	3. UNIDO	1 Q
4. Technical discussion	4. Discuss cleaning technology & equipment specifications with manufactures & other end-user as per the technical proposal besed on the study tour	4. C-MET, ITI, Bangalore, UNIDO	1 Q
5. Carry out reliability and materials compatibility tests	5. Evaluate the effectiveness of the different non-ODS cleaning techniques	5. C-MET, ITI, Bangalore, UNIDO	2 Q
6. Select technology	6. Finalize the optimum cleaning technology & prepare the list & specifications & equipment & materials	6. C-MET, ITI, Bangalore	2 Q
7. Commercial negotiations	7. Hold commercial negotiation based on the selected technology & equipment & sign the contract	7. ITI, Bangalore, UNIDO	3 Q
8. Design modifications of the site and facilities	8. Engineering design of utilities (water electricity, and gas)piping & civil engineering	8. ITI, Bangalore	3 Q
9. Prepare facilities	9. Construction	9. ITI, Bangalore	4 Q
10. Preparation/procurement of local equipment and machinery	10. Procure or make in-house the locally supplied equipment & machinery	10. ITI, Bangalore	4 Q
11. Technical training	11. Send staff abroad for technical training/design & run local training programme	11. ITI, Bangalore, UNIDO	5 Q
12. Acceptance test, installation and commissioning of equipment	------	12. C-MET, ITI, Bangalore	5 Q
13. Start utilising new cleaning processes	------	13. ITI, Bangalore	5 Q
14. Evaluate the process	------	14. C-MET, ITI, Bangalore	5 Q
15. Evaluate the project	------	15. C-MET, ITI, Bangalore, UNIDO	6 Q
16. Promotion of phasing out of ODSs in the Indian electronics industry	------	16. MOEF, C-MET, UNIDO	6 Q

Required regulatory actions

No regulatory actions, other than routine permitting, are required to implement this project. Under the existing agreement with the World Bank, equipment and machinery imported as part of this project will be exempt from import duties levied by the Government of India.

Results

Direct Project Impacts

The project will eliminate annually 2.606 MT of ODSs (ODP-weighted) at the ITI-Bangalore Factory.

Indirect Project Impacts

As far as the indirect effect such as the transfer of technology to other enterprises in following projects is concerned, this project will have a big impact. The project design has been made to maximize this impact. Particularly, the involvement of C-MET of DOE will ensure the successful repetition of phasing out projects in the Indian electronics industry.

Otherwise, assuming a successful transition to aqueous cleaning in ITI-Bangalore, the quality and peprformance of ITI-Bangalore products will remain unchanged. Assuming that a grant is provided to cover the incremental costs, there is unlikely to be any impact on product price. Absent a change in quality or price, consumer demand and production levels are expected to be unaffected by the project. The environmental impacts associated with this project are discussed in Annex-4.

Annex 1. Breakdown of investment (capital) costs

	Description of cost item	Unit	Unit cost US$	Qty	Total cost US$
1.	Batch Process aqueous cleaning systems				
1.1	Aqueous cleaning machines process development (LOCAL)	Nos.	60,000	2	1,20,000
1.2	Installation costs (piping electricals, etc.)	Nos.	5,000	2	10,000
1.3	Water Filtration and recycling equipment	Nos.	20,000	1	20,000
2.	Aqueous systems				
2.1	Aqueous cleaning machine	Nos.	22,255	1	22,255
3.	No clean systems				
3.1	Ultrasonic spray flux unit	Nos.	15,600	8	124.800
3.2	Installation costs	Nos.	5,000	8	40,000
4.	Ground water treatment plant	Set	8,700	1	8,700
5.	Waste treatment	Set	30,000	1	30,000
6.	Engineering and training				
6.1	Material compatibility, reliability testing	Week	400	20	8,000
6.2	Study tour	Week	4,000	8	32,000
6.3	Equipment Operator training	Week	4,000	4	16,000
6.4	Consultant charges during project implementation	Fixed	16,000	-	16,000
	TOTAL:				4,47,755
7.	Replacement of fire fighting cylinders (Halons) with ABC powders	Nos	150	222	33,300
	GRAND TOTAL:				4,81,055

Annex 2. Breakdown of incremental operating costs/savings

Description	Unit	Unit cost US$	Qty	Pre-project total cost, US$	Post-project total cost US$
A Solvent Cost per year					
A1 1,1,1 trichloroethane	Litres	2.00	13,400	26,800	0
A2 Alternative solvent/ chemicals	Boards	0.103	144,000	-	14,832
A3 Flux cost					
Rosin flux	litres	3.35	1,500	5,025	0
LS Flux	Litres	18.25	750	-	13,687
A4 Water treatment and 80% recylcing cost	Cu metr	5.00	2,000	-	10,000
Sub-total				31,825	38,519
B Electricity cost per year	kWh				
B1 Current systems (5.5 kW, 16 hrs, 300 days)	kWh	0.0806	26,400	2,128	0
B2 Proposed new systems (72 kW, 16 hrs, 300 days)	kWh	0.0806	3,45,600		27,855
Sub-total				2,128	27,855
C Water treatement costs per year					
C1 Recycling costs		5,000	1		5,000
C2 Labour costs(ODS System) w/m		400	16	6,400	0
C3 Labour costs(non-ODS system)w/m		400	16		6,400
Sub-total:				6,400	11,400
TOTAL PRE-PROJECT COSTS/YEAR:				40,450	77,774

Annex.3 Breakdown of incremental benefits

For this project, there is no incremental benefit.

Annex.4 Calculation of Unit Abatement Cost

A	ODS Phase out		
A1	Average use of MCF based solvent per year	MT	17.42
A2	ODP of MCF		0.10
A3	ODP-weighted MCF phase out(A1*A2)	MT	1.742
A4	Average use of Halons 1301 per year	MT	0.06
A5	ODP of Halons-1301		10.00
A6	ODP-weighted Halons-13-1 (A4*A5)	MT	0.60
A7	Average use of Halons-1211 per year	MT	0.76
A8	ODP of Halon-1211		3.00
A9	ODP-weighted Halons-1211 (A7*A8)	MT	2.26
A10	Total ODP-weighted phase out		4.602
B	Annualized capital cost		
B1	Total investment cost from Annex [illegible]	US $	[illegible]
B2	Equipment life	Years	10
B3	Discount rate	%	10
B4	Annualized capital cost(B1*0.1627)	US $	78,267
C	Annual incremental operating costs from Annex 2	US $	37,324
D	Unit abatement cost		
D1	Annualized unit abatement cost per kg of ODS phase out	US $/ kg	6.34
D2	Annualised unit abatement cost per kg of ODP Phase out	US $/ kg	[illegible]
D3	Benchmark unit abatement cost per kg of ODS phase out	US $/ kg	5.77-7.47

Annex 5. Environmental Assessment

In the proposed aqueous cleaning systems, deionized water will be used to clean electronic parts without the aid of additional cleaning agents. Therefore, this method of cleaning does not pose an environmental hazard. The waste water effluent from both the aqueous system and the wet-media blasting system will be filtered and deionized by a waste water recycling system. The solid waste generated during resin column and filter maintenance will be or disposed of properly off-site.

It is unlikely that the project will have an adverse environmental impact. ITI-Bangalore will have to obtain permits from the necessary authorities prior to installation of the cleaning.

Project Proposal for the Multilateral Fund for the Implementation of the Montreal Protocol Financing

COUNTRY	**India**	
PROJECT TITLE	Conversion of electronic cleaning processes from ODS solvents to no-clean and aqueous photoresist developing and stripping technologies at ITI-Palakkad	
SECTORS COVERED	Solvents	
ODS USE IN SECTOR	4,876 MT (ODP- weighted) of ODS solvents in 1991	
PROJECT IMPACT	Phased-out annual consumption of 12MT of CFC-113 and 30 MT of 1,1,1 trichloroethane (total 13.44 ODP-weighted MT)	
PROJECT DURATION	18 months	
PROJECT ECONOMIC LIFE	10 years	
TOTAL PROJECT COST	Investment (capital) costs, US$	528,000
	Incremental operating costs/savings, US$	138,400
	Total Project Costs, US$	**389,592**
OWNERSHIP STRUCTURE	100 per cent Indian	
PROPOSED MF FINANCING	**US$ 389,592**	
COST EFECTIVENESS	US$ 28.9 per ODP kg	
UNIT ABATEMENT COST	US$ 3.14 per kg of phased-out ODSs	
CURRENCY CONVERSION	US$ 1.00 = Indian Rs. 30.00	
COUNTER ENTERPRISE	Indian Telephone Industries, Palakkad	
IMPLEMENTING AGENCY	UNIDO	
COORDINATING MINISTRY	Ministry of Environment and Forest	

Project summary

This project will phase-out the use of CFC - 113, and 1,1,1 trichloroethane (MCF) in cleaning operations at the Palakkad factory of Indian Telephone Industries Ltd. The phasing-out of ozone depleting substances (ODSs) will be accomplished by replacing the currently used solvent-based cleaning methods with low solid fluxes and no-clean soldering technology. The printed circuit board unit will replace methyl chloroform with aqueous based systems employing water processable photoresists. The phasing-out of ozone depleting substances (ODSs) will be accomplished by replacing the currently used solvent-based cleaning methods with three different types of water-based processes:no-clean soldering; and water-based photoresist development and stripping. The project will employ commercially available technologies in one of India's largest ODS consuming sectors. The India Country Programme for the Elimination of ODS has also identified the sector as a high priority area.

1. Project objective

The objective of this project is to phase out the use of CFC- 113 (TMS formula) and methyl chloroform (MCF) in electronics cleaning operations and photoresist developing and stripping operations. The processes in which ODSs are utilized will be replaced with no-clean soldering and aqueous cleaning processes.

As one of the first projects formulated in the solvent-based electronics cleaning sector in India, this project has additional targets. Considering the structure of the Indian electronics industry and the required steps to phase-out ODSs in electronics cleaning, it is expected that this project will additionally identify and strengthen a focal point which will (also see Exhibit 1):

- help to increase awareness in the selected electronics industries regarding the need for phasing out ODSs and, for this purpose, collect, and compilation of technical and technological information;
- generate information and provide technical support regarding problems associated with phasing-out of ODSs by the electronics industry, which includes process development, materials compatibility testing, reliability testing, cost-effectiveness analysis, technology selection and drawing-up of equipment specifications; and
- accumulate adequate problem solving know-how during the implementation phase of this project so that projects of a similar nature can be implemented in other locations.

In cooperation with the Ministry of Environment and Forest, the Center for Materials for Electronics Technology (C-MET) of the Department of Electronics (DOE) has been identified as the focal point[1]. The Center for Materials for Electronics Technology (C-MET) is operating as a registered scientific society under the Department of Electronics with the main objective to establish technology strength in Electronics materials for the present and future industrial requirements. The electronics industry in India is unique, that is, a significant part of its production is distributed in small- and medium-scale industry and is distributed throughout the country.

[1] The Center for Materials for Electronics Technology (C-MET) set up by DOE has experts in the various materials used in the electronics industry covering chemicals, polymers and other related products such as solvents, cleaning agents etc. and in materials development and commercialization of the R&D results.

2. Sector background

India became a signatory to Montreal Protocol in 1992 and as a part of subsequent exercise, a Country Programme document was prepared by the Government with the assistance of UNDP. This document has assessed the Ozone Depleting Substance (ODS) consumption in the country and on the basis of this, a National Programme for the Phase-out of ODSs has been prepared to ensure the Phase-out of ODSs according to the national industrial development strategy, without undoe burden to consumers and industry.

Solvents is one of the major consumption sectors. Before finalizing the Country Programme, a sectoral report was also developed out in consultation with the industry-users and manufacturers of ODS substances . This report developed the basis for Country Programme preparation.

The amount of consumption has been investigated in a number of studies[2]. According to most recent information presented at the Solvents Workshop convened in June 1993 and revised in the first draft of the India Country Programme in August 1993, in 1991, the solvent sector consumed 100 MT of CFC-12, 300 MT of CFC-113, 4,000 MT of carbon tetrachloride and 550 MT of 1,1,1-trichloroethane (MCF), i.e., a total of 4,876 MT of ODP (ozone depletion potential)-weighted consumption, that is 36.9 per cent of total ODP-weighted consumption in India.

The solvent consumption in India in 1991 is given in Exhibit 2 (table) and Exhibit 3 (chart). ODS consumption in the solvents industry is split between electronics, metal cleaning and other processes such as textiles, pharmaceuticals, pesticides, chlorinated rubber, etc.

Cleaning processes used in the electronics industry consumed in 1991, 150 MT of CFC-113, 75 MT of CTC and 55 MT of MCF (all ODP-weighted) and included flux removal (printed-circuit cards and hybrid circuits), semiconductor manufacturing, microelectronic component cleaning, metal and plastic part cleaning, and photoresist development and stripping. The use of ODSs in electronics cleaning in India has been increasing as a result of the development of electronics industry.

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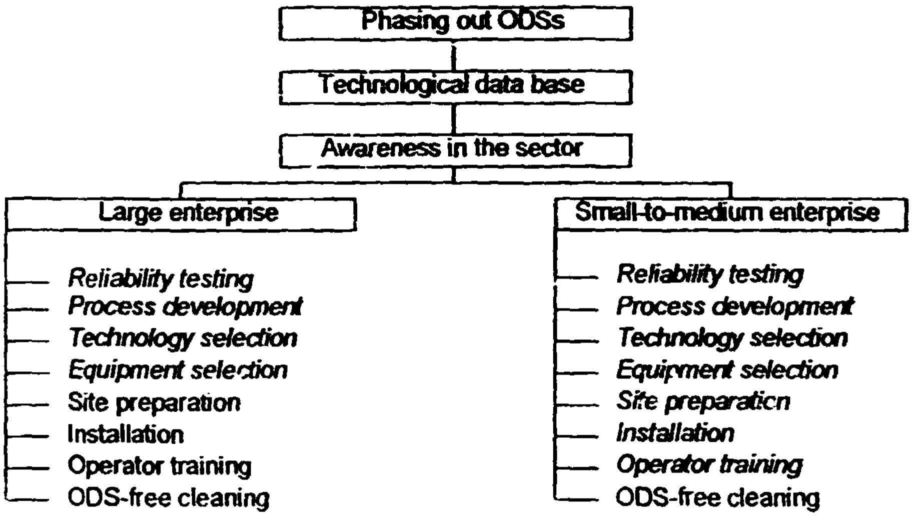
[2] a) Report of the Task Force on National Strategy of Phasing out Ozone Depleting Substances, Ministry of Industry, March 1992 (updated March 1993).
b) Compiled consumption data, Multilateral Fund Secretariat, March 1993.
c) Solvents Workshop, Country Programme Preparatory Meetings Series, 21-25 June 1993, New Delhi.
d) India Country Programme, September 1993.

Exhibit 1

Phasing out of ODSs in Indian Electronics Industry

The role of a focal point of know-how



Note: *Generally, activities written in italic require external technical assistance and will be carried out by the focal point of the sector.*

Exhibit 2. ODS consumption in India
(ODP-weighted)

Types of ODS	1991 Consumption					
	All sectors			Solvents		
	Actual, MT	ODP-weighted		Actual, MT	ODP-weighted	
		MT	%		MT	%
CFC-11	1,900	1,900.000	14.385	0	0.000	0.000
CFC-12	2,850	2,850.000	21.577	100	100.000	2.051
CFC-113	320	342.400	2.592	300	321.000	6.583
Sub-Total	5,070.000	5,092.400	38.554	400.000	421.000	8.634

Types of ODS	1991 Consumption					
	All sectors			Solvents		
	Actual, MT	ODP-weighted		Actual, MT	ODP-weighted	
		MT	%		MT	%
Halon-1211	550	1,650.000	12.492	0	0.000	0.000
Halon-1301	200	2,000.000	15.142	0	0.000	0.000
Sub-Total	**750.000**	**3,650.000**	**27.634**	**0.000**	**0.000**	**0.000**
CTC	4000	4,400.000	33.312	4000	4,400.000	90.238
MCF	550	66.000	0.500	550	55.000	1.128
TOTAL	**10,370.000**	**13,208.400**	**100.000**	**4,950.000**	**4,876.000**	**100.000**
Sectoral distribution						
Aerosols	1,100	1,100	8.328			
Foams	1,580	1,580	11.962			
Refrigeration	1,990	1,990	15.067			
Solvents	4,950	4,876	36.917			
Halons	750	3,662	27.726			
TOTAL	10,370.000	13,208.000	100.000			

Source: a) Tentative figures as discussed at the "Solvents Workshop, Country Programme Meetings Series, 21-25 June 1993, New Delhi."
b) India Country Programme, First Draft, 9 August 1993.

3. Enterprise background

ITI Palakkad was established during 1974-75 to manufacture electronic PABXs, integrated local-cum-transit exchanges, electronic digital exchanges, wich are in-house-design.

The Unit has grown in four phases:

Phase	Year	Investment Rs in lakhs	Installed Capacity (lines)	Product
I	1976	26	10,500	Small Exchanges of In-house Design
II	1980	98	60,000	Microprocessor Controlled PAM Exchanges
III	1985	5900	2,060,000	DTAX of Alcatel Design, ILT & EPABSx

IV	1992	4445	10,000,000(*) OCB 283 of Alcatel Design (Under project Stage)

(*After phasing out DTAX)

In 1985 an agreement was signed, with CIT Alcatel, France to manufacture Digital Trunk Automatic Exchanges with an investment of US $ 18.0 Mio. and also to set up a state of the art Printed Circuit Board Plant with an installed capacity of 14,400 m^2 of finished PCBs. The PCB plant is a modern one with an investment of US $ 3.0 Mio. The plant is on its expansion programme to go in for multi-layer PCBs of 4 & 6 layers. The total turnover of ITI Palakkad unit for the year 1993-94 was Rs. 1,6 Mio. and the total manpower employed is 877. ITI-Palakkad is not manufacturing for exports.

Performance figures

	1992-93	1993-94
Lines produced	185 kl	302 kl
Production value (Rs in crores)	105	165
Sales value (Rs in crores)	99	163
Profit (Rs in crores)	2.24	33.29
Production per employee (Rs in lakhs)	1 64	17.89
Value added per employee (Rs in lakhs)	4.18	7.92
Inventory turnover ratio	1. 84	3.40
Material consumption (%)	64	44
Profit to turnover ratio (%)	2.26	20.38
Return on capital (%)	3.1	29.10

Quality

The quality obtained in the Plant has constantly met the requirements of international standards. In recognition of the high quality standards the Department of Telecommunications awarded the unit, the Self Certification status for DTAX Products. The unit has earned the prestigious ISO 9002

Accreditation in Sept.1993. The Palakkad unit of ITI was the first industry in Kerala to obtain certification from this International Quality Standard Organization.

Production and service facilities

Electronic Assembly Plant:

Extending to 7000 square meters, this fully air conditioned plant is the heart of ess production. State-of-art electronic assembly equipments such as semi- automatic component forming machines, semi-automatic light beam guided assembly machines, wave soldering station, semi-automatic wiring machines, sophisticated pc board test station comprising microprocessor-based tlp, digital card testers, analog card testers are some of the key facilities available here. A recent step taken towards the goal of total automation of the assembly process is the positioning of a fully automatic assembly line with pick and place facility.

PCB plant:

A modern facility with an investment of Rs 9.5 crores and extending to 480 square meters of air-conditioned area (a portion of which contains ultra-clean rooms), this plant has sophisticated equipment like a laser plotter, CNC drilling/routing/plating machines and various other microprocessor controlled process equipment. The plant is equipped with a SMOBC (solder mask on bare copper) facility. The PCB plant was set in 1985 with an installed capacity of 14,400 m^2/annum in collaboration with Alcatel, France. The plant is intending after its expansion programme to produce high tech multi-layered PCBs. A recent development is the expansion of the PCB processing facility to manufacture PCBs up to 6 layers.

R&d center:

A R&D Center with an investment of US $ 1.0 Mio. is equipped with a CAD facility. A Model Exchange and Calibration Lab is set up to provide technical support for production and to aid product evolution.

Computer center

Equipped with a Fourth Generation IBM Mainframe equivalent computer, the computer provides on line information support for production and other departments.

Chemistry

CFC-113, and MCF are the two ozone depleting substances used at ITI, Palakkad. Methylene chloride as a halogenated solvent is also used for photoresist stripping. The following three manufacturing processes use considerable amount of ODSs in cleaning and in photoresist developing and stripping.

Process - I : Usage of CFC-113 (Freon TMS)

CFC-113 is used in the cleaning of PCBs after wave soldering. Freon TMS is the main ODS solvent used in the card assembly area for cleaning of assembled PCBs after wave soldering. The cleaning makes the PCBs free from contaminants and flux. The wave soldering machine is from Electrovert, USA and a cleaning machine used is from OSL, UK. The total consumption of Freon TMS in 1994 was 12.0 MT. The number of cards assembled per day is 300 pcs/shift. The maximum size of cards produced is 660*300 mm.

Process - II : Usage of 1,1,1-trichloroethane (MCF)

This solvent is used for developing exposed dry film resist laminated PCBs. The development of exposed photoresists with solvent employs a high speed method with broad process latitude. The details are as follows:

I) Laminating speed - 0.2 meters/minute
ii) Alignment timing - 20 meters for a standard pcb
iii) Exposure timing - 0.3 meters for a standard pcb
iv) Developing timing - 1.2 meters/minute

The solvent process has many process conveniences, like high speed process, high contrast, less rejection and high yield. 1,1,1-trichloroethane is used for developing inner and outer layers of PCBs and PISM. The total consumption of MCF in 1994 was 30.0 MT

Process - III : Usage of Methylene Chloride

This solvent, which is not controlled by the Montreal Protocol, is used to strip the polymerized dry film after the plating process. Presently, the solvent stripper is same for both double sided PCBs and inner layers of PCBs.

The various cleaning machines used for ODS handling along with their production capacity is given at Table 4

Table 4. Solvent Using Equipment at ITI, Palakkad

Activity	Production Capacity	Purpose	Cleaning Machine	Cost
1. Component assembly	As per Table 3	Cleaning of PCBs	Freon cleaning machine	US $ 0.2 Mio
2. PCBs	14,400 sq.meters	Dry film developing	Developer	US $ 0.2 Mio
3. PCBs	14,000 sq.meters	Dry film stripping	Stripping M/C	US $ 0.2 Mio

Name of equipment	Year	Solvent used	Energy kWh/day	Cost of kWh,US$	Water m3/day	Cost of m3,US$
Cleaning System for Flux Removal from OSL, UK (max. size of PCBs-660*300 mm)	1985	Freon TMS 12 MT/y	70	0.04	Nil	
Inner Layer and PISM C2 Processes Developer from Du Pont, USA (max. Size of lamination 660*400mm)	1985	MCF 30 MT/y	64	0.04	20	0.10
Inner Layer Stripping System	1985	Methylene Chloride 17 MT/y	64	0.04	Nil	

The amount of cost incurred for solvent ODSs is indicated in Table 5 the following page,

Table 5. ODS Solvent Costs of ITI, Palakkad

Division/Purpose/ Type of Solvent	Amount MT/Year	Unit Price US$/Kg	Amount Cost US$	ODS amount MT/Year	ODP-weighted amount Mt/Year
Assembly/ Cleaning of PCBs/ CFC-113	12.00	10.00	120,000	12.00	9.84
PCBs/ Dry film developing/ MCF	30.00	1.5	375,000	30.00	3.6
PCBs/ Dry film strippng/ Methylene Chloride (Not identified as ODS)	17.00	1.0	17,000	-	-

4 Project description

4.1 Sector-wise approach

The electronics industry uses a variety of chemical substances in the manufacturing processes and packaging operations. Some of these include chemicals which polluting the environment, t of which a number of them are classified as ozone depleting substances.

Considering this, a broad-based programme to enhance the awareness about use of such substances in the electronics industry and the development of alternatives for replacing/phasing out of such substances etc., is being pursued under the activities of the Center for Materials for Electronics Technology (C-MET) of the Department of Electronics, Government of India. This would be a part of the overall programme by the Government of India which is being implemented under the overall coordination of the Ministry of Environment and Forest.

The replacement of ODSs in electronics industry applications with aqueous processes and no clean technologies will require extensive engineering know-how to carry out the tasks such as:

- Reliability testing
- Material compatibility testing and process development
- Technology selection
- Equipment selection
- Purchase of aqueous cleaning machines and systems
- Site preparation
- Installation of machinery
- Operator training

Therefore, the overall programme conceived for implementation here includes awareness of the industry towards phasing-out these chemicals and taking up activities with the help of industry and R&D institutions to develop substitutes for the actual usage, as well as taking up demonstration projects with the help of experts in the field and translating the knowledge and experience gained to the other enterprises of the electronics industry and to the other sectors.

It is, therefore, decided that C-MET of DOE will take part in the project from its start in order to accumulate information and experience to assist ITI- Palakkad, as well to other enterprises of the Indian electronics industry.

4.2 Description of the ITI, Palakkad project

As discussed in the section above, the replacement of ODSs in electronics industry applications with aqueous/semi-aqueous processes and no clean technologies requires extensive engineering know-how to perform a number of tasks. Reliability testing, material compatibility testing and process development will be performed by C-MET, in close cooperation with ITI, Palakkad, prior to the purchase of the no-clean technology and aqueous-based developing and stripping machines in order to choose the best equipment and to decide if water additives are necessary to achieve the desired results. The process development work is to be documented with graphs, charts, and data showing that the ITI, Palakkad project has determined that the no-clean technology and aqueous cleaning processes are a good decision. The process development work, particularly, will be completed prior to ordering the no-clean soldering equipment for the various PCBs, dry film developing and dry film stripping operations. The reliability testing should evalute the long term effects of remaining residues inside the electronics assemblies, parts and components.

4.3 Technology and equipment selection

ITI, Palakkad will phase-out the use of CFC-113 methyl chloroform and methylene chloride in the PCB cleaning, dry film developing and stripping in the manufacture of PCBs by selecting and utilizing the appropriate aqueous processes. ITI, Palakkad have in all three systems viz Freon cleaning, C-II processor and stripping machine. All these three systems could be replaced using non-ODS substances.

At the end of the project implementation all the ODS solvents (CFC-113, methyl chloroform) will be eliminated. In the solvents sector, especially in the case of electronics cleaning, there are many options to the use of ozone depleting solvents. Usually the choice of the alternative cleaning process is dependent upon the type of market served by the solvent user. Most commercial applications have more flexibility in the use of new technology, because of the inherent need of maintaining their competitiveness in the world market. However, many organizations build products known for their high degree of reliability for use in military aircraft, satellites or other difficult professional (industrial and commercial) operations. These organizations spare no cost to ensure that products made by their organizations are dependable and reliable. Considering the high reliability requirements of ITI-Palakkad products, the migration to non-ODS cleaning should be planned and evaluated extremely carefully.

US EPA staff have found that the other chlorinated solvents (trichloroethylene, perchloroethylene, and methylene chloride), aqueous and semi-aqueous cleaning, and cleaning with petroleum solvents, ketones, and alcohols are to be viewed as acceptable for new alternative technologies to phase out the utilization of ODSs in cleaning processes.

Aqueous cleaning solutions typically are tailored to the requirements of the specific cleaning application. Aqueous cleaners use water as the primary solvent. Synthetic detergents and surfactants are combined with special additives such as bilders, pH buffers, inhibitors, saponifiers, emulsifiers, etc. The key stages of an aqueous cleaning process are washing, rinsing and drying. Oils, organic films, and greases, inorganic or polar soils can be effectively removed by aqueous chemistry. Ultrasonics are much more effective in water-based solvents than in 1,1,1-Trichloroethane.

Semi-aqueous cleaning uses hydrocarbon/surfactant cleaners which are emulsion cleaners that can be substitutes for CFC-113 in electronic applications. Hydrocarbon/surfactant have been included in many different cleaners formulated for different purposes. Hydrocarbons/surfactants are used in cleaning processes in two ways. They are either emulsified in water solutions and applied in a manner similar to standard aqueous cleaners or they are applied in concentrated form and then rinsed with water. Semi-aqueous cleaning systems can use terpenes, dibasic esters, glycol esters, or other hydrocarbons, generally in combination with surfactants. These cleaners can be considered for cleaning of PCBs.

These solvents exhibit varying degrees of flammability, and generally require that certain precautions be taken, especially if used in spray cleaning applications. All these solvents have low pressures, but are still considered photochemically reactive. The subsequent water treatment after the rinsing operation will require a water treatment plant which would increase the project cost. Semi-aqueous cleaning solutions have good cleaning ability especially for heavy grease, tar, waxes, and hard to remove soils.

Petroleum solvents, alcohols, and ketones are presently used in some sectors of manufacturing and repair industries for cold cleaning applications. Petroleum solvents (mineral spirits, kerosene, Stoddard solvent) show good solvency for most contaminants. Alcohols (e.g. ethanol, isopropanol, and glycol ethers), have been used in certain applications requiring effective solvent power for defluxing operations in engineering industry. These solvents, however have several limitations. Their flammability restricts their use in enclosed systems and in vapor degreasing operations. The common alcohols and ketones have flash points that are quite low and are considered flammable. Also, alcohols as well as ketones are not compatible with many polymeric and elastomeric materials. In addition, these solvents are photochemically reactive.

When rosin fluxes are used, cleaning with hydrocarbons/surfactants or with saponifiers may be necessary. With water soluble flux/paste, plain water cleaning is preferred although aqueous saponified or semi-aqueous cleaning are also applicable. No-clean processes may be applicable for rosin-based flux formulations used with through-hole, surface mount and mixed component single- and double-sided boards. No-clean is the classification given to fluxes whose residues are benign and may be left on a printed circuit board after the soldering operation is completed. Thus, no post-solder cleaning operation is required and the use of CFC-113 or MCF is eliminated. However, the application of his technology requires low-solids no-clean fluxes, which are comparatively expensive (the cost of this flux from Interflux, USA in India is about US $ 20 per liter), and a new type of soldering machines with a spray fluxer and a dual wave soldering system.

There are several technologies and equipment available in the market, and it depends to a great extent on the type of process and technology chosen for cleaning. For the large scale, high production applications, there is continuous, conveyor-operated equipment which has a range of controls which can be included, depending on the amount of labor available for monitoring operations, and the quality requirements. This applies to both the aqueous and the semi-aqueous (such as solvent wash/water rinse) equipment. Aqueous systems generally use water filtration and purification to enable water recycling and to capture waste stream contaminants. Semi-aqueous systems normally use carbon absorption or membrane separation techniques to recycle both the water and the solvent streams if the electronic circuit assemblies have high quality requirements, and/or are difficult to clean due to complex geometries of design, then mechanical assistance through the use of strong, directed sprays may be required.

No clean technologies with or without nitrogen atmosphere, using low solid fluxes are gaining importance and the quality is well received for wide range of applications. This is one of the very cost effective technologies available and widely used by industry. For high quality requirements use, of low solid fluxes followed by semi-aqueous cleaning would be an effective alternative.

1.1 Justification for selection of alternative technology

After careful examination of various ODS free alternative technologies and considering the quality consciousness and reliability aspects of the ITI Palakkad, it is proposed to introduce no clean fluxes by providing a new soldering machine without post-soldering cleaning. This will eliminate the use of 15 MT of CFC-113 at ITI-Palakkad.

An alternate technology proposed for dry film photoresist developing at ITI-Palakkad to eliminate 30 MT of 1,1,1-trichloroethane consists of the operations like aqueous dry film lamination, alignment, exposure and developing.The aqueous process proposed is complex in nature, that is, it has a very narrow process latitude like low contrast, low speed and thereby low yield. In this process the solder masking developing operation cannot be carried out in the same machine. However, this technology completely eliminates the usage of 30 MT of 1,1,1- trichloroethane for dry film developing and PISM developing. The solvents used for this process are as follows:

1) Dry film developing - Potassium carbonate or sodium carbonate solution
2) PISM developing - sodium carbonate solution with additives

The various process parameters are:

1) Laminating speed -0.8 meters/minutes
2) Alignment timing -35 minutes for a standard PCB

3) Exposure speed -0.6 minutes for a standard PCB
4) Developing speed -0.6 meters/minute

Presently ODS solvent-based dry film phot resist process is used to:

a) Transfer circuit pattern on to copper clad laminate; and
b) Transfer solder mask image on to the Processed board

The proposed aqueous DFPR is less efficient than the present solvent system. Hence in switching over to aqueous technology the production output will be reduced by more than 50 units. In order to balance the capacity and also to phase-out the ODS technology the following justification for the new systems is given below:

1. Special aqueous dry film laminator

The speed of the laminating with solvent film is more considerable. On the other hand when the technology is converted to use aqueous the speed is considerably reduced, as mentioned earlier. Due to capacity limitation, ITI Palakkad would be able to implement the ODS phase-out programme if one aqueous dry film lamination is provided. This aqueous dry film laminator need to have a heating source with pneumatic pressure. The finished PCBs will emerge with both sides laminated.

2. Autoglass self alignment device

In the solvent process, the image is aligned on to the blank prior to exposure by manual alignment/verification. The solvent film has got a very wide contrast and hence the above is possible. But on the other hand, for the aqueous film, the contract is very narrow and hence manual alignment is difficult. This necessitates the use of the self alignment autoglass table. Once in the fixture the laminated PCBs are positioned with respect to the location holes and then exposure takes place.

3. High power exposing system

The solvent-based dry film is more susceptible to UV light and hence the exposure time required will be at a minimum. With the aqueous films, the exposure time will be slightly more. This will result in reduction of output. To compensate the production loss due to this, the requirement of one number high power exposing system is projected.

4. Double chamber developer

The solvent process uses 1,1,1 -trichloroethane exclusively for developing double-sided photo-printed PCBs. This machine has to be replaced to take up the aqueous dry film. The aqueous developer will handle 1% sodium carbonate at 50°C. The size of the PCBs handled will be 660 x 400 (bland size). This equipment should be provided to ITI Palakkad for ODS phase out.

5 & 6. Double chamber PISM developer & baking oven

The solvent PISM developing is exclusively done by 1,1,1-trichloroethane. This has to be stopped to phase-out the ODS. The alternate technology aqueous PISM developer will contain coated and baked solder ink in a media of Sodium carbonate 2% at the temperature of 60°C. The solder mask ink is being dissolved in the media and the liquid (aqueous) will be changed everyday. Since the system needs a curing/baking oven, it is also suggested to be procured to this project.

Table 6. Proposed non ODS systems

ODS Process	Alternate Process
Cleaning of assembled PCBs using Freon TMS	No-clean technology Low solid flux with a new soldering system
Developing solvent based dry film laminated PCBs and PISM using 1,1,1-trichloroethane	Aqueous processing method 1.Aqueous dry film laminator 2.Self alignment glass device 3.SPL high power exposing system 4. Double chamber developer (augmentation) 5 Double chamber PISM developer 6.Curing/baking oven
Stripping solvent-based dry film laminated double-side PCBs and inner layers using Methylene Chloride	1.Low speed/low temp. double chamber stripping machine 2.High speed/high temp./high pressure SS bodied stripping machine for inner layers

Purchase of no clean system

Considering the strict quality control maintained at the ITI-Palakkad the introduction of Low Solid Fluxes has been chosen. The no-clean flux wave soldering machine is to be procured against this project funds. This would give the same quality as in the case of ODS cleaning. Its cost will be in the range of US $ 100,000 to US $ 200,000

Purchase of an additional exposure and related processing unit

Presently ODS solvent processed dry film photoresists (DFPR) is used to transfer circuit patterns on copper clad laminates. The proposed aqueous DFPR is less efficient than the present system. As shown in the table below, it requires 25 - 30% more time, that is, there will be a 25 - 30% reduction in productivity. Considering the actual annual production output of 14,400 sq.meters, an additional

DFPR exposure, developing system, special aqueous dry film laminator, dryer and related accessories will be required to raise the output capacity of the non-ODS process to that of the present ODS solvent using process. The estimated cost of developing and stripping machines would be around US $ 250,0000 as per the break-down given below.

Bearing in mind the cost-effectiveness threshold for the elimination of 1,1,1-trichloroethane (i.e. US $ 38.50 per one ODP -weighted kg of 1,1,1-trichloroethane, by the MP Executive Committee) and the necessity of procuring the full set of equipment for this project, while formulating the project, it was decided, to take into account the cost of equipment available on the Indian market which are considerably lower then the cost of similar equipment on the international market.

Name of equipment	Cost
Special aqueous dry film laminator	US $ 30,000
Auto glass self alignment device	US $ 30,000
PC 130 SPL high power exposing system	US $ 30,000
Double chamber developing machine with dryer for double sided PCBs (augmentation)	US $ 50,000
Double chamber exclusive aqueous PISM developer with dryer	US $100,000
Curing / baking oven	US $ 10,000
	Total US $ 250,000

The estimated cost of an aqueous stripping machine is US $ 135,000.Since the solvent used for stripping is methylene chloride, which is not controlled by the Montreal Protocol, the machine is to be procured against the funds allotted by the ITI-Palakkad for this project.

Water treatment

In this project, the use of aqueous based processes (dry film developing and stripping) is chosen because the efficient use of water as a solvent will not damage the environment and because water is a plentiful and inexpensive resource in Palakkad. The use of dry film development and stripping process will require treatment of waste stream. The water filtration and recycling, sub-system (waste water treatment system) can be integrated into the main sub-system and it costs about US $ 20,000 extra.

Site preparation and installation of machinery

The project includes funding to prepare the sites for the equipment installation. This funding is for electrical supply and plumbing to ensure safe installation of the equipment.Technical staff of the equipment manufacturer or their agents in India wi'l help the installation work.

Operator Training

Operators and maintenance personnel will be trained in the proper operation and maintenance of the new equipment. Personnel will also be trained to measure important process changes in the effectiveness of the no-clean technology . The training programme will be designed by C-MET in cooperation with the equipment manufacturer and ITI-Palakkad.

5. Project Costs

The project costs in referance to all costs in this section are economic rather than financial costs. The incremental recurring costs are included in this project. Incremental costs are offset by the reduction in cost for the ODS solvents.The costs of utilities and of solvents may differ between project to projects in the country. Cost of acquiring the necessary environmental permits is included as part of the project.

Total Project Costs

The total project cost is US $ 389,592. Because there are no non-ODS investment costs associated with this project, the total project cost equals the ODS reduction portion of the overall project. The total project incremental cost of US $ 389,592 was calculated as the economic capital cost (US $528,000) minus the net incremental operating savings for 3 years discounted at 10% (US $ 138,400).

Capital Investment Cost

As given in Annex, I, the total investment cost is US $ 389,592. The major components of this cost include the purchase and installation of a low solid flux soldering machine (US $ 150,000) and aqueous cleaning developing machines (US $ 250,600) for the replacement of the existing systems. The stripping machine will be purchased by ITI-Palakkad.

Incremental Operating Costs/savings

If the project was not undertaken, the annual operating cost, exclusive of tax, would be US $ 121,680. If the project is implemented the annual operating cost will be US $ 77,880 resulting in an annual incremental operating savings of US $ 43,800. Given an equipment lifetime of 10 years and a discount rate of 10 per cent, the net present value of the first three years of incremental operating savings is US $ 138,592. A more detailed breakdown of operating savings is provided at

Annex II.

Revenues

This project will not provide ITI-Palakkad with any incremental revenues.

Local Ownership Ratio

Local ownership fraction of 100 percent was considered to determine the amount of eligible MF grant financing. Since the total project incremental cost should be multiplied by the fraction of local ownership to determine the proposed grant amount, total proposed multilateral fund financing is equal to total project incremental cost, i.e., US $ 389,592.

Contingencies

A 10 percent contingency has been provided on the overall cost of the project.

Unit Abatement Cost (UAC)

As shown in Annexure-4, the UAC for this project is US $ 3.14 per ODS-weighted kilogram per year. This number is derived from an annualized incremental cost of capital of US $ 85,905, first year incremental annual operating savings of US $ 43,800 and phasing out of 42 tones (13.44 ODP weighted tones) of ODSs per year.

Proposed MF Grant

The proposed MF grant for the project is US $ 389,592 was calculated as follows: first the total investment cost of US $ 528,000 was deducted from the net present value of the incremental operating cost over the first three years of the project, which is US $ 138,592. This sum was then multiplied by the 100 per cent Indian ownership ratio of ITI-Palakkad to yield the same grant amount of US $389,592.

Financing Plan

MF funding is a grant and is limited to the incremental cost as calculated above. Any costs not covered by the MF funding as calculated above must be financed by other sources.

6. Project Implementation

Management

The Ministry of Environment and Forest (MOEF) will oversee the successful implementation of this project. The project will be carried out at ITI-Palakkad in cooperation with C-MET National Consultant. UNIDO will also provide technical assistance to the project during the implementation.

Procurement

Project procurement will comply with the UNIDO procurement procedures.

Disbursements

Fund disbursements will comply with UNIDO financial procedures. The schedule for disbursements will be decided upon at the beginning of project implementation.

Audits

For auditing, UNIDO project evaluation and review procedures and project financial management data will be used.

Required regulatory actions

No regulatory actions, other than routine permitting, are required to implement this project. Under the existing agreement with the UNIDO/World Bank, equipment and machinery imported as part of this project will be exempted from import duties levied by the Government of India.

Direct Project Impacts

The project will eliminate annually 42.0 MT of ODS (13.44 MT ODP weighted) at the ITI Palakkad factory.

Indirect Project Impacts

As far as the indirect effect such as the transfer of technology to other enterprises in following projects is concerned, this project will have a big impact. The project design has been made to maximize this impact. Particularly, the involvement of C-MET of DOE will ensure the successful repetition of phasing out projects in the Indian electronics industry.

Otherwise, assuming a successful transition to aqueous cleaning in ITI-Palakkad, the quality and performance of ITI-Palakkad products will remain unchanged. Assuming that a grant is provided to cover the incremental costs, there is unlikely to be any impact on product price. Absent a change in quality to price, consumer demand and production levels are expected to be unaffected by the project.

Schedule of activities (Project Road map)

N	Activity	Description	Responsible	Tim.
1	Preparation of a detailed project work plan		ITI,UNIDO	1Q
2	Carry out reliability and materials compatibility tests	Evaluate the effectiveness of the different nono-ODS techniqeus	ITI, C-MET, UNIDO	1Q
3	Select technology	Prepare the list and specifications of equipment and materials	ITI,UNIDO	1Q
4	Procurement of equipment	Carrying out an international bidding and sign the contract	UNIDO	2Q
5	Design modifications on the site and facilities	Engineering design of utilities (water electricity, piping ,civil engineering)	ITI	2Q
6	Preparation of facilities	Construction work	IT!	3Q
7	Preparation/ procurement of local e uipment and machinery	Procure or in-house make the locally supplied equipment and machinery	ITI,C-MET	3Q
8	Acceptance test, installation and commissioning of equipment	Install and commission the equipment and run training programme for operators, carrying out acceptance tests	UNIDO,ITI	4Q
9	Start utilising new non-ODS technology	Evaluation of the processes	UNIDO,C-MET	4Q

Annex 1. Breakdown of investment (capital) costs

	Description of cost item	Unit	Unit cost, US$	Q ty	Total cost US$
1	Project monitoring missions	week	5,000	1	5,000
2	Equipment				
2	No-clean soldering machine	each	150,000	1	150,000
2.2	Special aqueous dry film laminator	each	30,000	1	30,000
2	Auto glass self alignment device	each	30,000	1	30,000
2	PC 130 SPL high power exposing system	each	30,000	1	30,000
3	Double chamber developing machine with dryer for double sided PCBs (augmentation)	each	50,000	1	50,000
2.6	Double chamber exclusive aqueous PISM developer with dryer	each	100,000	1	100,000
2.7	Curing / baking oven	each	10,000	1	10,000
2.8	Water filtration and recycling costs (DI plant)	each	20,000	1	20,000
2.9	Installation costs (electrical, piping,etc.)	each	20,000	1	20,000
3	Miscellaneous				
3	Waste treatment	set	20,000	1	20,000
3	Transportation: shipping and insurance	set	20,000	1	20,000
3.3	Contingencies 10%				48,000
TOTAL INVESTMENT COSTS					528,000

Annex 2. Breakdown of incremental operating costs/savings

	Description of cost item	Unit	Unit cost, US$	Qty	Pre-project total cost, US$	Post-project total cost, US$
A.	Solvent/media costs per year					
A1	CFC-113/Methanol	kg	3.500	12,000	42,000	0
A2	MCF	kg	1.500	30,000	45,000	0
A3	RMA flux	L	4.000	2,000	8,000	
A4	Low solid flux from Interflux, USA	L	20.000	2,000		40,000
A5	Regeneration of carbon (4pcs) and deionising (4pcs) cylinders for DI plant	each	300.000	8		2,400
A6	Water @ 80% recycling	m3	0.100	5,000	0	500
	Sub-total				95,000	42,800
B.	Electricity costs per year					
B1	Current systems (224 kW/day, 300 days/year, 1 shifts)	kWh	0.040	30,000	2,688	0
B2	New soldering machine (30 kW/h), 1 shift	kWh	0.040	64,800	0	2,880
B3	Aqueous cleaning systems (developper and stripper), 250 kW/day, 300 days/yr	kWh	0.040	43,200		3,000
	Sub-total				2,680	5,880
C.	Water treatment costs per year					
C1	Recycling costs		10000	1	0	10,000
C2	Labour costs (processes using ODSs), 5 operators	w/m	400	60	24,000	0
C3	Labour costs (non-ODS processes),4 operators	w/m	400	48		19,200
	Sub-total				24,000	29,200
TOTAL PRE-PROJECT COSTS/YEAR					121,680	
TOTAL POST-PROJECT COSTS/YEAR						77,880
TOTAL INCREMENTAL SAVINGS/YEAR						(43,800)

Annex 3. Calculation of unit abatement cost

A.	ODS phase out		
A1	Average use of CFC-113 based solvent per year	MT	12.00
A2	ODP of CFC-113		0.82
A3	ODP-weighted CFC-113 phase out (A1*A2)	MT	9.84
A4	Average use of 1,1,1-trichloroethane	MT	30.00
A5	ODP of MCF		0.12
A6	ODP-weighted MCF phase out (A5*A6)	MT	3.60
A7	Total ODP-weighted phase out		13.44
B.	Annualized capital cost		
B1	Total investment cost from Annex 1	US$	528,300
B2	Equipment life	Year	10
B3	Discount rate	%	10
B4	Annualized capital cost (B1*0.1627)	US$	85,905
C.	Annual incremental operating savings from Annex 2	US$	(43,800)
D.	Unit abatement cost		
D1	Annualized capital cost per kg ODS phased out	US$/kg	6.40
D2	Annual incremental operating savings per kg ODS phased out (C/A7*1000)	US$/kg	-3.26
D3	Unit abatement cost (D1+D2)	US$/kg	3.14