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TECHNICAL REPORT ON A SURVEY OF INDUSTRY ON THE PRESENT SITUATION REGARDING THE PHASEOUT OF OZONE DEPLETING SUBSTANCES AND ON THE ADHOC UNIDO INDUSTRY MEETING ON PHASING OUT OZONE DEPLETING SUBSTANCES HELD IN VIENNA ON MAY 31 1990

prepared for United Nations Industrial Development Organization UNIDO
June 15. 1990
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PART I

A. INTRODUCTION

UNIDO, the United Nations Industrial Development Organization, is concerned with industrial development in developing countries and, in the Lima Declaration and Plan of Action of the Group of 77 received the mandate to contribute to a target, by which developing countries' industries should reach a share of world industrial output of 25 % by the year 2.000 which meant a more than fourfold increase in slightly less than a quarter of a century, a target which now does not appear out of reach. In carrying out its mandate, UNIDO is in continuous direct contact with ministries of industry and industry itself through a network of projects and offices in practically all developing and industrialized countries.

In its capacity as Industrial Development Organization UNIDO shares the concern of the international community with industry produced pollution and must, for its own activities, take into consideration the resolutions in regard to environmental protection in order to avoid pitfalls in the industrial evolution process, which could be damaging to all concerned, developing and industrialized countries, people and companies.

Considerations regarding technology transfer cannot be restricted to viability alone but have to take into consideration issues such as the influence of industry on the environment, and the conservation of energy.

UNIDO has since many years built up expertise on environmental issues. As a result of its Special Advisory Committee Meeting of May 1989 and the Industrial Development Board Meeting of December 1990 it has been specifically mandated to look into the changes, such issues would have on the industrialization process and into the technology which would be required to meet with environmental objectives enabling the organization to give the necessary guidance to the developing countries. In response to this request, since June 1 1990 UNIDO has appointed a special coordinator. Other professionals in various Divisions are also specifically occupied with environmental issues.

Regarding the role of UNIDO in relation to CFCs, the director general of UNEP, the United, Nations Environment Programme, the UN Organization which has the overall concern with environmental questions, has urged UNIDO to participate in the discussions on the Montreal Protocol and to bring in its views and guidance from an industrial point of view for the benefit of the industry of the developing countries. This is possible only through familiarization with the practical issues involved which again can only be given by industry. Thus UNIDO has participated in the March 1990 meeting with UNEP in Geneva.

This had also motivated the organization of the meeting preceded by a series of 35 interviews with executives and experts from industry, where guidance and orientation was sought on the subject of phasing out ozone depleting substances with a maximum efficiency and compatibility with the present state of know-how as well as with the other urgent requirements of developing countries. This was the first meeting on the subject with industry, and future consultations with industry are foreseen. It was attended by 15 invitees from outside UNIDO eleven of which presented a paper.

The present technical report summarizes the presentations to the meeting and the information obtained through interviews and from documents received from industry.

The activities were initiated and backstopped by Ms. S. Maltezou and benefited from her and Mr. K. Fujita's, Director of the Industrial Policy Promotion Division, professional guidance. The report also took into account the valuable considerations received from Ms. Tcheknavorian-Asenbauer, Director of the Division of Industrial Operations Technology and Messrs. Luken and Williams, Wiedermann, Burmistrov, Rydeng and Zachrisson.

B. DIRECT RECOMMENDATIONS RECEIVED FROM INDUSTRIALISTS

The following is a list of recommendations received more or less directly in relation to what the participants considered UNIDO may do or advocate in relation to the phaseout of ozone depleting substances. Whereas the recommendations made by the participants were based on their perception of UNIDOs role, the conclusions listed below have been developed from these recommendations and from other observations made by the participants and persons interviewed, taking into account some of UNIDOs specific tools of technical cooperation with developing countries. The participants recommended specifically:

Internationally, in view of the problems faced by industry in the development of new chemicals, clear signals should be given to the industry on whether gouvernments wanted to adopt a strategy of gradual phaseout, with the intermediate use of HCFCs, in particular HCFC 22, or whether the more drastic phaseout was preferred, where the end result would be higher cost and sacrifices and a lesser efficiency with regard to reducing the effect on the ozone layer. Uniform regulations should be sought as a means of guaranteeing a coordinated phaseout.

If know-how for the production of substitute products was desired by developing countries, its transfer should be accompanied by an assessment of the conditions in terms of place, time and type of operation to avoid pitfalls due to lack of viability or offensiveness to the environment. Also a huge educational effort would have to be made with the user industry. Regional approaches should be taken (separately for Asia, Latin America etc.).

The developing countries should be encouraged to import existing products (such as HCFC 22) temporarily and wait for the alternatives to be developed to choose the best processes and products as soon as they are available.

Country studies should be executed on use patterns of all polluting substances, sector specific studies, cost assessments for conversion per sector, and realistic time tables for phasing out the product.

Good Working Practice in such areas as refilling of refrigerants, the prevention of leakage and the application of solvents could serve to reduce CFC consumption by up to 50% in some cases and should be promoted by UNIDO.

Innovation in the area of solvent installations using aqueous methods as well as those using terpenes, alcohol or ketones should be internationally accelerated. Mixed technology (brushing and full cleaning) was needed. Water plus terpenes, alcohol and ketones could bring the solution and such processes should be developed fast.

In the solvent field, objective and all-around experts would be required and should be recruited by UNIDO or UNEP, to advise in regard to the uses of alternative solvents (for instance to use non clean fluxes or to choose among the other alternatives). Their advice would pay for itself through the substantial savings to be obtained by choosing the optimum trade-off between the required quality and the cost of production. In some areas like non clean fluxes, the advice would best be given on a plant by plant basis, in other areas, where entire branches could adopt a new cleaning system, seminars would be recommended.

Developing countries, according to some participants, should be given the recommendation to continue using CFC 113 for an interim period for the most sensitive cleaning problems.

Assistance to developing countries in the substitution of CFC solvents should always be given on a case by case basis, where the options for using substitutes versus alternative products or processes, recycling or recovery would be weighed according to the circumstances.

A special expertise on the safe use of solvents should be built up.

Basically, the process of recovery was to be seen already now as a commercial proposition and adding to the effort of phasing out ozone depleting substances. It should therefore be promoted in developing countries.

Conservation in the use of solvents (and other) was one of the techniques to be promoted within the industry of developing countries as a cheap means of reducing the emissions.

In the area of refrigeration, good workmanship for lesser leakage, better education of operators and contractors should be promoted. Specifically for automotive air-conditioning and refrigerated transportation units, where leakage is a considerable problem, up to 50 % further reductions could be achieved through sophisticated technical solutions reducing leakages, and through recovery and recycling.

A recycling infrastructure should be created where possible.

In regard to the disposal of refrigerators, a combination of dismantling and degassing was considered a better proposition for developing countries and should therefore be promoted rather than other schemes, where only the motor, the mercury and the cooling liquid is removed before the unit is shred.

In regard to aerosol and foam disposal, UNIDO may wish to produce a handbook on disposal methods for CFC containing products for the purpose of giving guidance to developing countries interested in the safe disposal of CFC containing waste materials. Such a handbook could comprise various methods but could, at least in the beginning, be restricted to cement kilns and normal waste incineration processes.

There were no specific recommendations with regard to halons.

C. CONCLUSIONS

The following conclusions are inferred from the survey and the recommendations received. They are complementary to the direct recommendations listed above.

As a first step, UNIDO may wish to organize an in house seminar on the strategies to be adopted in regard to its future role in the area of phasing out ozone depleting substances. First, it may wish to determine what should be its position with regard to the proposition made by the producers of substitutes, regarding the usefulness of further developments in this area. This will depend to a great extent on the attitudes of gouvernments in industrialized and developing countries and there are indications, that some countries will not anymore want to use halogenated carbon compounds of any sort.

Then, with regard to each one of the topics discussed below and listed in the summary table, the best possible combination of tools (handbooks, experts, fellowships, equipment, meetings and seminars, country and sector studies, consultations and promotional activities) should be identified. Country studies could be designed in such a way as to result in an immediate assistance to industry and gouvernments and possibly be followed by in-country meetings to coordinate efforts in this area. Independent of the recommendations received and the conclusions listed here, it should establish priorities for the gathering of detailed information on know-how being developed in such areas as solvent alternatives, waste destruction etc., analyzing for each area the best use for technical support services by experts, the publication of handbooks, the promotion of international efforts, the organization of fellowships etc. A matrix could be finalized, where the best methods for assistance would be selected and prioritized for each problem area.

A role for UNIDO in the area of substitute products to the controlled CFCs would be to assist in the preparation of license agreements to manufacture substitute products.

Its main role would however be in the areas of application, conservation, recovery, recycling and destruction:

On solvents, the recommendations listed in the previous chapter could be implemented. In addition to this, a handbook on solvents to handle leakage, explosion protection, recovery and recycling, avoidance of environmental damage should receive priority. The book and expertise should also specifically cover dry cleaning installations.

The activities of UNIDO in the area of building industry could receive inputs from the meeting to promote construction technologies, where fire protection was considered. Other industrial branches of UNIDO, in particular those were halon utilization is considered necessary, should receive orientation to replace the product wherever possible. A handbook on fire protection could contribute to the elimination of halons within the industry of developing countries.

The energy conscious design of buildings would also contribute to the global effort in reducing ozone depleting substances and substances with a global warming effect. Building up such expertise in UNIDO and promoting it through its usual channels would thus be justified. Conscious design in buildings with natural circulation and temperature balancing characteristics could be subject of an expert group meeting, a global contest where the best ideas would be published could be organized. A manual could be prepared.

A similar reasoning applies to the area of Insulation, particularly with regard to refrigeration. A small handbook presenting the various options for the insulation of refrigerators and cooling installations could present the advantages of foams versus other insulating materials and methods such as vacuum chambers or panels, glass or mineral fiber, cork etc. where applicable.

UNIDO should gather the available know-how on foam production with CFC substitutes, where recovery and re-circulation methods could be subject to presentation of a handbook. It would also give orientation on methods of using alternatives such as water vapor and CO2. More important, however, would be the know-how required on the safe destruction of such foams produced with CFC, an area not so likely to be covered by the producers of raw materials or foam blowing installations.

In refrigeration know-how required for the use of substitute products will be part of the package offered by the producers of the new raw materials. However UNIDO may also study the possibility of issuing a hand-book on alternatives to CFCs in refrigeration.

In this most important area, special top level consultations between refrigeration industries from industrialized and developing countries, could be sponsored by UNIDO. All of the other experience in the area of know-how transfer schemes could be useful.

With regard to the phasing out of aerosol cans, gouvernments should be assisted, as part of the overall exercise of the phase-out, to foresee the necessity for adequate destruction and interim storage facilities for such cans.

Another area of know-how transfer would be the technology of using propellants other than CFCs and dispensers. Such know-how transfer could however come through the present producers of alternative products, aerosol cans, dispensers and should be encouraged by UNIDO.

UNIDO may also wish to build up and promote the expertise for maintaining refrigeration installations reducing leakage, improving the refill operation and perhaps adapting existing equipment to the new coolants where this know-how is not provided by the manufacturers.

More detailed conclusions are contained in Chapter E below, which discusses principally the results of the survey prior to the meeting within the context of the specific applications.

POTENTIAL ROLE OF UNIDO IN REGARD TO PHASING OUT OZONE DEPLETING SUBSTANCES IN DEVELOPING COUNTRIES BY APPLICATIONS

	Aerosols	Foams	Solvents	Refrigeration Liquids	Halons
Conservation in production and handling.	0	Building up and spreading expertise for more efficien CFC utilization.	Building up and spreading expertise for more efficient CFC utilization.	Assist in developing and spreading methods for leak- proof design, and filling techniques.	0
Substitution		0	With regard to the production of substitutes for solvents, refrigeration liquids and possibly foams, Assist in the conclusion of such licensing contracts between present producers and companies in DCs where economic, safety and environmental considerations are optimally taken into account.		0
Alternative Products	Encouragement of know-how transfer by can producers.	Assist industry in changing to other blowing agents.	Assist in adaptation to new products.	Assist in the spreading of ammonia technology.	Build up and spread know-how on fire protection techniques.
Alternative Approaches	Encouragement of know-how transfer on dispensers by can producers.	Assist industry in changing to other insulating materia including other foam types.Better designs.	Assist in introducing no clean flux technology where possible.	Closely follow developments in other possible technologies.	Promote methods for better construction in regard to safety (and insulation).
Recovery and Recycling	0	Assist PU foam producers in recovery techniques	Assist in recovery and recycling of CFCs used in solvents.	Assist in spreading the know-how of leak-free refilling methods and total recovery of liquid	0
Destruction	Assistance regarding regulation and facilities of storage and destruction.	Assist in recovery and destruction mainly of polyurethane hard foams	0	Assist in the design of regulations and techniques for safe disposal.	0
Possible one time reduction in tons, DCs only.	For destruction at least 100.000 tons, could be thre times higher.	For destruction at least 200.000 tons over several years.	0	At least 100.000 tons.	0
Possible reduction in annual use until substitutes are accepted.DCs only.	None if eliminated.	At least 10.000 tons.	At least 20.000 tons.	At least 20.000 tons.	Halon elimination and additional benefits to be achieved.

In General: Follow up on suggestion to clarify the position regarding the future of CFC substitutes.

E. DISCUSSION BY MAIN APPLICATION AREAS

The following considerations are based mainly on the content of 35 interviews carried out with industrialists prior to the meeting taking into account also the main findings of the meeting itself. Whereas the report on the meeting PART V gives an account of its development, this part attempts to focus specifically on the scenario within each sector as it presented itself during the interviews. Practically all of its findings were confirmed and some substantially extended by the meeting itself.

1 Aerosols

The use of aerosol in cans is equivalent in some countries to half of the total CFC consumption. The problem of escape into the atmosphere arises with the consumption or industrial application of the product. In a transitional period there is also a significant disposal problem.

1.1 Concepts

1.1.1 Substitution.

With the exception of certain medical sprays where toxicity or inflammability can constitute a problem (in particular medical sprays, where substitution may require another 3 years according to one of the companies interviewed), CFCs in Aerosols can be fully replaced. For medical sprays there is no authorized replacement yet. Now mainly CFC 11 and 12 are being used or 12 and 114 where 12 is the pressure component and the other products the regulators. It is being examined whether 134 A could replace the other products but tests of toxicity will take 5 to 6 years according to a CFC manufacturer after which the authorization process can start. The enthusiasm of present CFC producers for developing substitutes in this area is therefore not very high as it appears, that alternative non CFC solutions may arrive before.

1.1.2 Alternative solutions.

There will be no substitutes necessary for technical or cosmetic sprays because present propellants or solutions like dispensers are satisfactory and since prices for the replacements would be high.

The elimination of CFCs in aerosol cans is therefore feasible already now and has been done simply by decree although some say with substantial investment in other types of cans and equipment. Alternative propellants such as butane or dimethylethylene (dimethylether) propane or dispensers can be used as substitutes.

1.1.3 Disposal.

However, the disposal of aerosols still remaining in cans which are taken off the shelves, can have a counterproductive effect, when there is no satisfactory disposal method available for the full cans. It is suspected by some of the interviewees, that many cans are then simply emptied into the air charging the atmosphere with thousands of tons of material while in other places up to 60.- US$ are spent per kg on recuperating CFCs from refrigerators and foams.

1.2 Present situation

1.2.1 In some industrialized countries.

In Austria, were 4.000 of the annual 8.000 tons of CFCs consumed had been in aerosol cans a decree was passed, according to which all aerosol cans had to be taken from the shelves within two months by March 1 1990. Some people feel, that a longer transition is necessary, when the product has a shelf life of 6 to 12 months since otherwise the cans are emptied in the backyards of the shops to avoid the costly disposal. A telephone call to the only company offering to discard aerosol cans revealed, that only empty cans were accepted. For the disposal of full cans an offer had been obtained in the order of US$ 6 (AS 70) per can or US$ 72.- per kg.6

In Switzerland, which has an interesting retailing infrastructure openly committed to social development, the elimination of aerosol cans was brought about by the refusal of the big chains (Migros and COOP) to carry these products as part of their assortment. The industry complied and within a short time the annual consumption of CFCs in aerosol, which had sunk from 6.000 tons to 3.000 tons between 1977 and 1987 experienced another sharp drop to 600 tons, mostly for medical sprays (part of which probably for exports since the amount used in Switzerland could be considered to be a fraction of this). By 1992 it is expected to have dropped to 300 tons. The industry association had recommended the elimination of CFCs to its members at the end of 1988 but the main leverage had been with the trade.

1.2.2 Assistance to Developing countries.

The use of non-toxic substitutes in medical sprays will be possible only after the development of such products which is not likely to be terminated during the next five years. The amounts of CFCs used in these sprays is very small.

These costs will come down inevitably. Also, in this connection and particularly where refrigerators are disposed of with a similar cost ratio per kg, there are additional benefits. However they may serve to illustrate the necessity to balance cost versus effort, even globally. It is recalled here, that the total amount of CFCs still contained in refrigerating equipment worldwide has been estimated to be in the order of 2 million tons, the amount of CFCs still trapped in cans may be in the order of 500.000 tons, the amount trapped in foams other than those used in refrigeration equipment could be in the order of another 500.000 to a million tons. At a cost of US$ 50 per kg, the amount required for discarding the CFCs already trapped in various applications would be in the order of US $ 150 to 175 billion globally. This just for the CFC already processed. Estimates for phasing out the processing itself are substantially cheaper. According to an estimate of the UNEP working group held in Geneva between Feb. 26 and March 5 1990, the total cost of the phasing out processing in the 24 developing countries now party to the Protocol plus China, India and Brazil is estimated to be in the order of US$ 150 to 200 million. This would represent be a far better cost benefit ratio than the one just mentioned.

The use of non-toxic substitutes in medical sprays will be possible only after the development of such products which is not likely to be terminated during the next five years. The amounts of CFCs used in these sprays is very small.

Know-how transfer here during the next five years will therefore probably be restricted to the technology of using propellants other than CFCs and to dispensers. Know-how transfer could come through the present producers of alternative products, aerosol cans and dispensers and should not constitute a problem.

Another type of know-how transfer will relate to the disposal of unused aerosol cans in line with the disposal methods applicable to CFC containing substances. Here, specialized waste disposal firms may offer the respective technologies. The use of cement kilns for the destruction of the CFCs contained in such cans and even of normal waste incineration methods was seen as promising. While the complete destruction of CFCs in waste disposal plants has been proven by a leading research institute, the potential generation of toxic by-product has not yet been safely disproven.

A suggestion by one of the participants not only applicable to aerosol cans, where several hundreds of thousands of tons of CFC are still stored at present, was that UNIDO may wish to consider the elaboration of a disposal handbook as a means of know-how development and transfer in this area by which almost immediate results at a low cost per kg may be achieved. (there was even the suggestion, that the calorific value of the CFCs may pay for their destruction in cement kilns).

2 Refrigeration liquids

2.1 Concepts applied.

The replacement of the cooling liquid, which is scheduled by the EEC for the 1st of January of 1995 represents several difficulties: CFCs are considered irreplaceable still (for instance by Ammonia), where human safety is a requirement or where panic may lead to disaster (such as in supermarkets, where ammonia leakage could produce a negative effect). Ammonia can be used where safety conditions exist. Alternate solutions using indirect systems require 20 to 30% more energy.

In regard to the refrigeration liquids, three concepts are applicable: substitution, recycling and disposal. In theory, if recycling and disposal could be assured 100%, there would be no need for substitution. However, the leakage of CFCs out of the cooling circuit and the unsatisfactory disposal methods available, make substitution appear as the only alternative at present, as was pointed out by a number of interviewees and one of the experts present in the meeting, who stated, that alternative processes were not viable for safety or energy reasons.

2.1.1. Substitution.

Substitution appears to be the main road considered for cooling liquids. The most promising product appears to be HCFC 134 A or HCFC 134 AK. Reportedly, two large manufacturers are already building plants for this product available in the moment only in sample quantities from pilot operations for tests with oil and compressor producers (for small machines).It was reported, that one of these manufacturers would offer the product in 1991 along with a new mixture of oils required for the product. Other manufacturers consider, the product will be in the market only in 1992/1993 since the toxicity tests (and probably the production scale operations) will only then be terminated. Different from HCFC 22, which for its long term acceptance has been considered as an interim solution for the heavier machines, 134 A would also accommodate household refrigerators. It had performed well in tests but long its term toxicity not yet proven. Also, to replace CFC 12 with 134 A meant a 15% energy loss in refrigeration. HFC 152 A has also been contemplated but has the disadvantage of being inflammable. HFCs and pentafluor were also mentioned as possible substitutes.

For the CFC presently used in larger refrigeration units, which account for 80 to 90 % of all cooling liquid and for a high share also of the insulating foam, HCFC 22, which is known since 30 years and has an ODP of 5% is suggested by basic industry as an alternative on an interim basis. The point was, that the adoption of this product together with other safeguards would in practice reduce the further pollution of the ozone layer. Its use would however be restricted to only the industrial and commercial equipment since HCFC 22 needs only 2/3 of the quantity which means that the small pumps for refrigerators would have to be made still smaller, a problem not worth solving on an interim basis. Also, because of its lower boiling point, the product requires sturdier compressors again only viable for the heavier equipment.

To summarize, substitution of presently used cooling liquids by 134 A in the industrialized countries appears likely although not yet 100% certain. It's probably higher cost and the adaptation requirements will present a problem to the developing countries making special efforts for know-how transfer in this area desirable. If the use of tens of thousands of tons of CFC 11 in refrigeration liquids could be avoided through HCFC 22, the effort to spread the corresponding know-how would easily pay off. For a start, UNIDO might consider an industrial consultation between representatives from basic producers in developing countries, basic industries developing substitutes and government officials to assess this specific point and in the case of a decision in favour of the interim use of HCFC 22, publish a manual on necessary adaptations of heavy refrigeration equipment, safe refill procedures if required, safeguards against leakage and training in these techniques.

2.1.2 Recycling

Some consider CFCs very difficult to replace as a cooling liquid and feel recycling should be, if not a long term, an interim solution. Such views were expressed by one of the representatives of the Chemical Industries interviewed who considered the idea of recycling as favored by the US as a good interim solution arguing that this would also permit the developing countries to keep pace.

Recycling of CFC coolants requires reprocessing the product which is usually contaminated with oils. It will probably never be a commercial proposition for household refrigerators but possibly for the larger installations containing in excess of three kg of a product which may soon have risen to US$ 7 per kg, since the quantities will become smaller, and increasingly high taxes will be applied possibly even to HFC 22.

2.1.3 Alternative approaches

Better protection against leakage, better training for maintenance, new insulation methods with different materials and vacuum panels are such alternative approaches, which could be used to reduce the loss of CFCs into the atmosphere.

2.1.4 Disposal

As with the foams one problem is disposing of the equipment still containing enormous quantities of CFCs in foams and liquid. In Germany, the number of household refrigerators discarded annually is said to be in the order of approximately 2.5 million, in Austria 200.000.-. Projecting from these figures one can estimate the annual disposal of refrigerators in the world to be in the order of 50 million units containing between 20 and 35.000 tons of CFCs. Adding to this a rough estimate for other cooling equipment containing a still higher amount of CFCs in foams and liquids and assuming roughly an average life-cycle of ten years for both, the CFC trapped in refrigeration would be in the order of 700.000 tons. The figures given by one of the participants place the amount at almost 2 million tons.

There are no regulations on the subject until now in either Austria or Germany. The present philosophy regarding this disposal problem is to charge the communities with the responsibility. Simple equipment is available for plumbers to extract the liquid from the refrigerators. Some question the reliability of this equipment being able to fully extract the cooling liquid and the willingness of the plumbers to carry this heavy equipment to where the refrigerators are being disposed. Also, rough handling of the refrigerator during transportation has often resulted in leakages. Thus, a leading foam manufacturer studying junked refrigerators in Western Germany informed they had found only 10% of the original CFCs in the cooling units of these appliances, due to careless handling, dismounting of parts etc..

A mobile total disposal plant consisting of three vehicles one of which a heavy truck is now available in Austria at a cost of US$ 4 million. If operated on a 1 1/2 shift basis and staying for at least 5 days in each place it can process 80.000 refrigerators per year. The cost per refrigerator thus discarded is US $ 38 to 48 (or per kg of CFC US$ 55 to 70 if one assumes an average content of 700 grams and substantially higher if the amount is in the area of 400 grams).

Another system is stationary and caters to regions with 2.5 million inhabitants in Germany. The cost per refrigerator is somewhat lower (US$ 22 per unit or US$ 32 per kg of CFC). The disposal of both products during the years to come and the still substantial costs of the processes offered should be a subject of primary concern.

2.2 Assistance to developing countries

The substitution of CFCs in cooling and air-conditioning equipment is seen as one of the major if not the most important problem for developing countries.

While waiting for 100% safe substitutes, efforts to use HCFC 22 in larger installations accompanied by the introduction of more leak proof cooling circuits and safer refilling methods could be a solution.

UNIDO could follow these developments and assist in spreading - at least the publicly accessible - know-how through its usual channels of communication, i. e. handbook, experts, fellowships and provision of equipment, to advise on or train people as experts in leakproof designs and the adoption of safe refilling techniques (also useful in regard to disposal).

UNIDO may also wish to consider, in consultation with developing countries, whether the interim use of HCFC 22 would not be preferable to the continued application of CFC 11 with a twenty times higher ODP and if so, assist in the necessary adaptations of equipment through fellowships and the publication of a manual on the changes required.

Assistance would finally be most useful in developing and promoting cheaper disposal methods for the substantial quantities of CFCs still stored in cooling circuits and foams. Studying the use of cement kilns and waste incineration plants for this purpose (along with the disposal of aerosol cans) could yield highly beneficial results within the overall effort.

3 Foams

3.1 Concepts

Foams are to be seen as part of the market for insulation, which - expressed in cbm of volume - according to a well informed source, in Europe subdivides as follows:

Mineral fiber,	53%
EPS Expanded polystyrene and	32 to 33%
Extruded polystyrene foam	3.5 to 4%
Polyurethane foam	6%

the rest of 4 to 5% was cork, glass etc. Vacuum panels are presently being developed. These latter are considered by some as the potentially best insulators.

The problem of CFC admission to the atmosphere arises at different points during the product's life-cycle. It starts already in the production process. One of the presentations made in the meeting was on recovering the CFCs in the foam production process itself using activated charcoal filters which are said to recuperate - under ideal conditions - up to 99 % of the material used in the process. Others contend that such filters only recuperate a fraction of the product.

A second stage of potential contamination is the customizing process to suit the size requirements of the foam using companies. Up to 30% of the material is cut and disposed of losing its 10% content of CFCs in part immediately and the rest over the years being exposed to the influences of the climate. One company processing foams reports having between 500 and 1 000 tons annually of scrapped material which corresponds to 50 to 100 tons of CFCs. Other losses are incurred in small scale on the spot application using cans for instance for the insulation of windows in buildings. Leakages also occur during the useful life of the product and again during the disposal period due to climatic influences or inadequate disposal processes.

There are different opinions as to the rate of diffusion of the CFC through the plastic. Some consider, that foam will continuously lose the containing gas while others are firm in saying, that hard foams conserve their CFC-load intact.

The possibilities of CFC substitution are different for polystyrene and polyurethane foams the latter of which must be divided into soft and semi-hard as well as hard foams. Only in this latter category, CFCs are considered irreplaceable.

3.1.1 Substitution possibilities of different foam types.

3.1.1.1 Polystyrene Foams

In polystyrene foams, the problem of contamination of the atmosphere arises almost exclusively in the production process, since the product has open pores. As the producers are large firms, used to control even potentially hazardous production processes, it is to be assumed that the problem of pollution can soon be eliminated as the industry has pledged to do.

Polystyrene foam is either expanded or extruded. The expanded polystyrene foam is now processed with pentane and this is the most likely process also for the future. For the extruded polystyrene foam, also called XPS, CFC 11 and 12 are hitherto used for their cooling characteristics. However, these too will soon be replaced most probably by 142 B, which presents a problem of inflammability requiring production in rooms without oxygen and recuperation before the product escapes into the atmosphere. HCFC 22 appears to be considered as an interim solution. Ethylenechloride can also be used as it appears.

3.1.1.2 Polyurethane

The situation is different for polyurethane foams.

3.1.1.2.1 Soft and semi-hard foams

Propellant gases escape from the soft and semi hard foams already during the production process. Replacement of the CFCs in soft foams is considered easy since HCFC 22 and even CO_2 can be used, although the latter not everywhere.

3.1.1.2.2 Hard foams

A problem remains with the hard polyurethane foams. Here, the propellant gases have an additional insulating function making it more difficult to replace the CFC. Its elimination would mean a reduction of the insulating effect by 20 to 30 % which means in turn that walls have to be so much thicker, taking away space from the usable storage area (or increasing the outer dimensions).

The substitution picture is confuse. It is hoped, that substitute products will be available by 1992/93. CFC 11 will be replaced probably by HCFC 123 which is available in sample quantities only. It can substitute CFC 11 without a problem, has however some small ODP too. While according to some sources HCFC 123 will be sold still this year others say that only in 1992 the toxicological research will be terminated and that the time schedule is said to be similar to the one for 134 A mentioned above. The EEC will forbid the use of the controlled CFCs in foams starting 1993. According to some sources, there are already considerations regarding the phaseout of HFC 123. According to one interviewee new refrigeration equipment already use very small amounts of CFCs in its foams. Another reports that the CFC proportion has been reduced to 50% without a significant reduction of the insulating effect. Research is also still going on with tests with pentane which is however a fire hazard. Results are subject to evaluation still.

To summarize, it is assumed now, that substitute products with the same basic characteristics but without the ODP of CFC 11 etc. will account for 30% of the earlier CFC consumption for foams. There will be no need anymore for using such products in the expanded polystyrene and the soft and semisoft polyurethane foams which will be produced with pentane, water vapor, isocyanates or CO_2 (although not everywhere).

3.1.2 Alternative approaches.

In the same time, the volume of mineral fiber and the use of new construction techniques in buildings as well as the introduction of vacuum panels for refrigerating equipment will take an as yet unknown share of the insulating market.

3.1.3 Recycling

Recycling was mentioned as an interim option for the hard foams.

3.1.4 Disposal

Regarding the disposal of the foams, shredding, pressing and burning are the options which have been developed respectively tested for the destruction of CFCs in foams.

Shredding requires destruction of the spheres containing the CFC and recuperating the escaping gas. Apparently two methods are being tried: electrostatic filters operating with supersaturated vapor chambers and activated charcoal. Doubts have been expressed as to the completeness of the recovery, in particular with respect to the activated charcoal. It is also reported, that the foam is often shredded without an effort to recuperate the CFC it still may contain. Compressing the foam with a press operating with 2.000 atmospheres results - according to the company operating this process - in an almost full recuperation of the CFCs the end product being the liquid gas and a solid foam brick. The cost of foam disposal cannot be measured by the cost of total household refrigerator disposal, it appears to be however well above the figure of US$ 5 per kg mentioned above.

The burning process appears to offer potentially better perspectives with regard to destruction and cost of disposal, is however still in a test stage. While some consider it impossible to destroy CFCs at normal temperatures, recent tests under such normal conditions which were conducted by the Karlsruhe Atomic Research Center until March 1990 have proven, that CFCs do not survive combustion temperatures as they are used for normal wastes by communities. However, although toxic side products had not been observed, tests are going on to exclude or prove the generation of such products.

The destruction of CFCs in cement kilns is being studied and a presentation was made to the meeting.

As the polystyrene and the soft and semisoft polyurethane foams do not store ("bank") the propellants, there is no disposal problem for CFCs after the production process.

3.2 Assistance to Developing countries.

Know-how which could usefully be transferred, once developed, to developing countries will be both in the areas of CFC free production of polystyrene and soft and semi-hard polyurethane foams and in the destruction of the junked hard polyurethane foams where large amounts of CFCs could be kept from escaping into the atmosphere.

The possibility of burning foams in waste incinerators or cement kilns should be closely followed and once proven processes are available, the methods should be made known through the most rapid channels of communication.

Some of the measures, which could be taken are similar and complementary to those mentioned under aerosol disposal above.

Of a somewhat lesser interest are the recuperation processes during production itself unless CFCs or substitute products continue to be used in these applications.

4 Solvents

4.1 Concepts applied.

The problem of CFC entrance into the atmosphere arises here during the application of the product.

As in the other areas of application, various concepts compete with one another. In this connection, the following two are the most important: substitution and alternative approaches.

4.1.1 Substitution.

The extent for substituting CFC 113 in solvents (the main product for this application) is however still disputed. It had been considered by one of the earlier interviewees, that CFCs could be replaced in all applications except in such markets as electronic circuits where the traceless removal of the soldering liquid colofonium is required, high quality optical lenses, inertial navigation and other precision instruments which need absolutely all elimination of the specific oils used in their manufacture and laser heads where particles down to 1/2 mu must be removed. Here CFC 113 is seen as irreplaceable as it is easy to apply making training and supervision easier and guarantees the cleanliness of the end product evaporating completely. One of the interviewed companies considered, that the target times of Montreal were too short. One large applying firm producing video recorders had a special permit to use CFCs for the laser heads to keep the company competitive and conserve the 3.000 jobs presently involved in manufacturing 2 million such machines per year near Vienna, a market where productivity increases of up to 20% per year were required to keep up with competition from far Eastern countries.

CFCs (113 and 114) are also seen as difficult to replace in dry cleaning furs, high quality garments and leather products, where alternative solutions or substitutes may appear only in 1994/95. In some countries such poisonous substances like carbontetrachloride were reportedly still being used in dry cleaning processes.

The dispute on the substitution of CFCs in these applications remains unresolved. While a participant of the meeting, expert in solvents, had taken the view, that practically all CFC applications in solvents could be replaced by other processes using other CFC unrelated products, another one of the participants from the solvent applying industries in the meeting stressed that for a number of applications, no substitute nor alternative product could be used nor was in sight for the forthcoming six to seven years.

Correspondingly, the response of the potential producers of substitute products is different, depending to some extent also on the response of the authorities within their countries. One of the CFC manufacturers interviewed, considered the CFC market for such substitute products yet to be developed would correspond to only between 0 and 5 % of current consumption in the solvent field and that it was therefore too small for making the effort promising. According to this company, alternative solutions as mentioned below would be introduced before. On the other hand, at least one of the large Japanese manufacturers is said to be developing a substitute product HCFC 225, a propane derivate part halogenated with fluorine. Its toxicological characteristics would yet have to be tested for its two isomeres and this, according to other sources, may take three to four years.

4.1.2 Alternative solutions.

Independent from the earlier considerations regarding the extent of possible CFC substitution, for a number of applications the replacement of CFCs by other methods appears to be feasible. Even in the above mentioned fields some alternative solutions are apparently progressing. One large solvent using company reports, that it is presently developing a system for such special applications apparently based on alcohol, investing US$ 2 million into the process. Terpenes are not usable in some of these processes as these then have to be washed away with aqueous solutions where the surface tension would be too high. The process is still secret as patents have not yet been issued. Another company in the same field made a similar statement stressing it would not go halfway in substituting CFCs, it needed however three to four years to come to satisfactory solutions.

On other applications within one of these companies, aequeous and other methods were being developed with much smaller investments (several US $ 10.000) to replace the few 100 kg of solvents containing CFCs presently used by this company.

In dry-cleaning, except for the high quality garments and leatherware, ketones and heavy benzenes (terpenes) are now being generally used having replaced the earlier tri- and perchlorethylene which have come under the suspicion of being cancerogenous. Also methylchloroform is now being tested. The use of HCFC 22 for these applications is presently also being eliminated in some countries.

Alcohol alcalic methods for precleaning car bodies before lacquering, terpenes and aromatic petroleum derivates (requiring closed chamber applications) are also being tested.

One company stressed the higher cost of some of the alternate products and their immediate polluting capacity and the more complicated application would require difficult retraining in some cases. Big public companies like postal services and railways according to one source insisted on the use of CFCs mainly for this latter reason.

Alternative solutions will become more economical with the possible price increases of those products which are being phased out. The problems are to be seen in the investments, however small, required to be made by many companies, for an effective application and to avoid other types of potential hazards (water pollution in the case of aqueous solutions, inflammability in the case of alcohol (ketones) or heavy benzene as used in textile cleaning etc.).

An earlier observation by an interviewee from an environment ministry had been, that the industrial know-how on solvent replacement was probably not common knowledge in the industries of his country (industrialized). The available know-how was not yet much spread among appliers. This may be due to the secrecy of know-how development explained by the research cost and the commercial interests of developing firms. The ministry is producing a book on solvents for users before the London Conference.

4.1.3 Recycling

Closed chamber applications appear to be tested by a number of companies for a variety of applications, for instance the terpenes, aromatic esters and other petroleum derivates, and it was believed by some companies, that even the CFCs used in such processes could be almost fully recuperated in chambers and recycled. One of the companies present in the meeting presented the case for commercially viable recuperation of CFCs from solvent applications conditional however upon the reuse of the recuperated product by the solvent user. The method would become even more interesting in the case of the substitute products presently developed should they be allowed into the market after the toxicity tests have given satisfaction. Recycling of the controlled CFCs should however be considered only, where no other solutions are possible.

4.2 Assistance to developing countries.

Industry will probably assist developing countries only when incentives are offered.

4.2.1 In relation to CFC substitutes

According to the representatives from basic industries, the production of substitute products presently under development, joint ventures, license agreements and all other forms would be considered if commercial and in the end result less polluting than previous solutions. Where the principle of reducing pollution is one of the objectives, co-operation between UNIDO and industry in this connection could be useful if UNIDO was to act as a catalyser for the promotion and creation of such schemes.

4.2.2 In relation to alternative approaches

In the areas of finding alternative approaches, the many applications could the subject of a UNIDO technical assistance program in the area of solvents. One of the participants described the requirements for an expert in this field, who could cover a number of countries as a regional or global advisor on solvent technology. The production of a solvent handbook, the organization of specialized meetings on alternative solvent technology, the organization of fellowships in cooperating companies and institutions and even the introduction of model operations in developing countries could be of interest to UNIDO.

4.2.3 In relation to recycling

Under the condition, that CFC applications will not be eliminated soon in some countries since alternative products are not available, the spreading of recycling know-how may yet be another means of reducing the emission of CFCs into the atmosphere, particularly if recovery will be relatively complete and the far more expensive substitute products can later also be recovered and reused by the same processes. If such substitutes however should not be introduced, recycling may disincentivate the acceptance of alternative methods until the full disappearance of CFC 113. This could defeat the purpose of the effort to save the atmosphere from further charges of CFCs.

If recycling was to apply only to 5% of earlier CFC use for solvents, as suggested by one of the basic products manufacturers as an upper line estimate, the total capacity of recycling operations would be in the area of 8.000 tons per year, less than half of which in the developing countries. The present net result of the effort, which has its commercial justification, is small but promising under given conditions and should be subject to another consideration by UNIDO, which could spread the respective know-how through its usual channels of operation, mainly the use of experts, the production of a recycling hand book and the organization of visits to cooperating companies.

5 Halons

5.1 Concepts

Halons are up to ten times as damaging to the ozone layer as CFCs in general. Their elimination therefore carries a substantially higher premium than the elimination of normal CFCs.

They are seen as irreplaceable only in conditions, where human safety does not permit the use of toxic products or any sacrifice in efficiency, as is the case in closed rooms such as civil aviation, the Chunnel, submarines, tanks etc. The quantities required here are however extremely small.

According to one source, very few stationary installations require flooding entire rooms with inert gases to suffocate fires if human life is not endangered. According to one of the very informed interviewees, 10% of the present halon installations in Switzerland would be sufficient. Specifically hand held equipment is said not to require halons. Halon 1211 could therefore fully disappear since it is for hand-held fire extinguishing equipment where halons, CO2, foam and powder are presently used. Halon 1301 would be required only in 10% of installations.

Otherwise according to the persons interviewed and the presentation in the meeting, replacing halons in fire protection for most of the resent applications is basically a problem of using alternate processes.

5.1.1 Substitution

The small quantities of halons required in the future make the development of substitute products appear uninteresting to the industry.

The Common Market will only give temporary exception autnorizations.

In Germany, Halon 1211 will be prohibited starting 1992 and Halon 1301 starting 1996. Until these dates industry considers it impossible to develop replacement products which have good fire extinguishing characteristics without being toxic.

According to the environment office in Bern, halons will be completely prohibited soon in Switzerland. In Austria, a new directive was expected for May this year.

5.1.2 Alternative approaches

Alternative approaches start with better construction methods, better fire protection schemes, the use of proper materials, the careful handling of materials which are easily ignited etc..

Also specific objects could be protected by mechanisms specifically designed for their protection making it possible to use smaller quantities and in some cases also toxic materials (like CO2). Instead of flooding the room, only the immediate environment of the machine is flooded. It was even reported that such companies as Hoffmann Laroche and Swissair have replaced the halon protection of their computers with sprinkler systems.

5.2 Assistance to developing countries

Any assistance given to developing countries should focus on the subject of fire protection with emphasis on those sensitive areas presently still be protected by halons. A fire protection programme of UNIDO might be of interest even beyond the elimimation of halons.

PART II

DEVELOPMENT OF THE MEETING

A. Introduction

The director of the Division of Industrial Operations Technology, Ms. Tcheknavorian Asenbauer, opened the meeting on behalf of the Director General the UNIDO and thanked the participants for their positive response to UNIDOs invitation on short notice which illustrated the importance given to the issue by the participants. She then explained the expectations UNIDO had to receive guidance through the views obtained from practice and stressed the strength coming from cooperation.

She briefly referred to UNIDOs mandate and the Lima declaration and plan of action with its target to increase the share of industrial output in developing countries from 7 to 25 % in the year 2.000 and emphasized the importance of technology, where she said UNIDO had a coordinating role not being a technology holder itself. She pointed out the increased complexity of UNIDOs role where only a few years ago, economic viability had been sufficient as an argument for assisting industrial development, now also environmental issues and energy issues where part of the criteria to be applied.

Regarding the role of UNIDO in relation to CFCs she pointed out, that there was no duplication with UNEP on this issue but rather that the director general of UNEP, which had the overall concern with environmental questions, had urged UNIDO to participate in the discussions on the subject and to bring in its views and guidance from an industrial point of view for the benefit of the industry of the developing countries. This was possible only through familiarization with the practical issues involved which again could only be given by industry. Work had already started on the subject and UNIDO had participated in the March 1990 meeting with UNEP in Geneva.

She then explained, that UNIDO as a result of the Special Advisory Committee Meeting of May 1989 and the Industrial Development Board Meeting of December 1990 had been mandated to look into the changes, environmental issues would have on the industrialization process and what changes of technology would be required to meet with environmental objectives in order to be able to give the necessary guidance to the developing countries, where UNIDO was in direct contact with the ministries of industry and the industry itself.

In response, UNIDO had appointed a special coordinator on environmental issues since June 1 1990 and there were professionals in the Industrial Technology Division and in the Technology Promotion Division also concerned with the subject of environment. She thanked the Technology Promotion Division and its officials for organizing the meeting, pointing to the role of this division to be concerned with new technologies and referred to respectively presented other UNIDO officials concerned with environmental issues within UNIDO mentioning also the role of the consultant on the subject of financing international programmes in regard to CFC and the technical country reports for India, China, Mexico and Brasil.

She concluded her remarks referring to the expectations from the meeting, namely to obtain guidance from the industry on the various options for CFC substitution through the efforts of basic industries and in the area of the five major applications inviting the participants to introduce changes to these subjects if necessary or opportune.

The director of the Industrial Technology Promotion Division, Mr. K. Fujita, joined Ms. Tcheknavorian in her introductory remarks and pointed out, that although the necessity of technological change sometimes produced a crisis it also meant a challenge for improvement. He stated that although this was the first meeting on the subject with industry, there would be a continuation of this exchange the purpose of which was to leave a better environment to the children.

The fourteen invited participants, then presented themselves (see List of Participants) and were once again welcomed. The following is a summary of the ten papers presented and the ensuing discussion.

B. Summary of Papers and Discussions

1. Subject: Substitution of Basic Chemicals

1.1 CFC Substitution and Transfer of Technology.
Mr. Roy Breslau, Du Pont de Nemours

Mr. Breslau started out explaining the interest of Dupont in the subject and its commitment to the global effort related to the protection of the ozone layer. His company was actually investing 1 billion US dollars for finding alternatives and participated in the two industry programmes PAFT and AFEAS designed for testing new compounds for their toxicity respectively their environmental innocuousness. Both programmes were designed for getting faster results, but the normal testing time for toxicity still was in the order of 5 years and the AFEAS programme was planned for three year until 1993. Dupont was also looking at what were termed conservation methods (improving the handling, the impermeability of cooling circuits, the refill methods and recovery and recycling). The company also considered such alternatives as water for cleaning, ammonia for refrigeration, CO2 for foam production etc. However the point was strongly made, that HCFCs (ODP .02 to .10 with an average below .05) were going to account for a market of still 30% and HFCs (ODP = 0) for 9 % in the year 2.000 although tendencies were observed, that these products also were to be phased out in some countries very soon. Illustrating the development of various scenarios, some of which with potentially grave side effects to the economies of developing and developed countries (in particular with regard to refrigeration) he remarked, that the use of HCFCs on an interim basis would be more beneficial than the complete stop to all fluorocarbons, which would in any case not happen, because of the reluctance of some countries to fully participate in the global effort. A minimum of 20% would remain due to non-signing countries unless HCFCs were continued and permitted as an interim replacement by the international community. CFC 22 was present already now and 123 and 134 A would be available in 4 to 5 years followed a little later by 124 in replacement of CFC 11. He said there was no reason for panic as there was no increase in ultraviolet radiation on the ground due to other factors etc.

Dupont in the light of a probable development of 10 % per year of the developing countries and 2.5 for the industrialized countries proposed a phaseout of the HCFCs by the year 2030 for the products with a lifetime of 10 to 20 years and in 2040 for products with a lifetime of 0 to 10 years, showing the respective alternatives of development in this case.

Mr. Breslau observed that due to the shrinking of the market for substitute CFCs a scale disadvantage would result in prices 2 to 5 times as high for products like 134 A. He considered joint ventures would happen where the interest was mutual, but that guarantees on safety of the new plant in a developing country to the environment would be a "conditio sine qua non" requiring training of the staff, a point which was also made by the subsequent speaker, Mr. Harris, from ICI. He pointed also to the technology to be adopted by the user where the technical service was normally provided by the producer, an area where both closely cooperate. New producers for instance in developing countries would have to develop also the capacity to give guidance to their clients in the applications of CFCs and their substitutes or alternative processes. The investments required for producers being in the order of US$ 4 billion the necessity for users to change their installations would be several times that amount (although certainly not more than a hundred times as suggested). Trade associations normally served as clearing houses in setting quality standards, providing technology and could be used in spreading the respective know-how..

He felt that recycling would be a process of increasing importance in the future and continue even after the phaseout of the ozone depleting products if only for reasons of economy. Technologies for this would soon be available.

Summarizing he said that chemical and equipment producers want to market their products in exactly defined markets where user technology was particularly necessary. The content of Mr. Breslau's paper is contained in a well illustrated document distributed to the participants.

1.2 Perspectives of CFC substitution
Dr. Michael Harris, ICI, Runcorn UK.

Dr. Harris, in view of the time limitations, instead of presenting his own prepared paper complemented Mr. Breslau's presentation seconding parts of its conclusions and pointed to the complexity and the size of the problem and the cost involved (US$ 4 billion for the substitute development by the producing companies alone, far more for the applying companies). He observed that the goal of 2 parts per billion would only be reached in 2050. However, he stated, that if only 80 % of the world would comply with the protocol, the goal would not be reached by then. Rushing the phaseout would substantially increase the cost to the industrialized and the developing countries alike. If, to avoid the pressure of political groups, Hoechst was to close its plants in 1995 and ICI and the others would follow that example, this would easily be absorbed by the producers of basic products like ICI, but could mean the existence of many applying firms. The development of substitutes, and the interim use of HCFCs or techniques such as conservation appeared to him a better strategy. By conservation alone, 30% of the immissions could be controlled. This could be done by developing countries already now through recycling, better handling etc. The chemical companies of the developed countries could assist in this if this was commercially feasible. Recycling was also becoming more interesting because of the increases to be expected in the cost of the substitute products.

Also HCFC 22 was a product for interim use where the incremental cost was minimal. He stressed the different conditions in developing countries, where the situation would have to be studied for the best technological solution.

Regarding new technologies (alternative approaches see above) he considered these would not be available before the next century. Pointing to the ten years moratorium he considered that the developing countries, having used such methods as conservation or HCFC substitution, would then find a situation different from now to choose their definite options. His view was that the development and production of CFC substitutes in developing countries would be justified only, where large markets could be secured. ICI would gladly enter into joint ventures if the plants were viable and safe to the environment.

Another point was related to the alternative substitutes under development. Situating the various compounds in a triangle according to their hydrogen, chlorine and fluorine contents, he stressed the limited amount of options in the development of substitutes. A move in the direction of more hydrogen content tended to make the product more explosive, in the direction of chlorine there was the danger of more toxicity and in the direction of fluorine, the lifetime of the agent in the ozone layer would be increased.

He showed some of the new substances to have a far smaller lifetime and a fraction of the ODP of present products and suggested they should be adopted instead of continuing with the immission of the old products.

The new substances were not perfect but much better than the old.

He also referred to the PAFT and AFTEAS programmes, the first for toxicity and the second for environmental safety testing, and then discussed each of the products as follows:

PAFT 1 testing 134 a had given excellent results,
with regard to 123 the results had been fairly good requiring extra tests parallel to others.
PAFT 2 had been encouraging for 141 B
PAFT 3 had found 124 excellent in first testing
and the testing of 125 had not yet started for a lack of product although he understood that Dupont had announced commercial quantities of it for 1991.
PAFT 4 was being announced June 1 1990 for the product 225 ca and cb.

The testing of each compound was in the order of US$ 5 million and the total programme was reported to cost US$ 60 million.

By applications the substitutes would be:

for solvents: HCFC 123, and HCFC 141 b, the latter somewhat flammable and 225ca and cb as well as pentafluoropropanol.
in dry cleaning: 1,1,1- trichlorethane
for polystyrene foams: packaging: pentane (flammable) and HCFC 22
insulation: HCFC 22 and or HCFC 142.b
for polyurethane foams: flexible: water blowing (carbon dioxide) methylene chloride phase out ultra low density foams
rigid: HCFC 123 (no volume available before early 90ies, and 141 b (flammability and ODP unknown), vacuum panels, mineral fiber, other fluorocarbons.

for automotive airconditioning	:134 a well advanced
commercial air conditioning	:123,22,134a,(124)
industrial refrigeration	:22, ammonia, others
commercial refrigeration	:22, 134a, 125
domestic refrigeration	:134a, (HCFC 22 short term solution)
transportation refrigeration	:125, 134a

aerosols :hydrocarbons, dimethylether, ether, compressed and dissolved gas propellants, methylene chloride.

As new technologies, he mentioned
for refrigeration: new thermodynamic cycles, new compressor designs and absorption refrigeration.
for polyurethane foams: modified formulation and densities, modified polyols and water blown foams
for solvents: aqueous cleaning.

For conservation, recovery and recycling he mentioned:
solvent cleaning: in house recovery and recycling, reprocessing by specialist companies or solvent producers.
refrigerants: reliable devices for local recovery, especially with regard to automotive airconditioners.
reprocessing of (unmixed) refrigerant at manufacturing plant

For conservation, control of emission during production etc.
for solvents: enclosed and automated equipment
good working practice
for firefighting halons: no flood testing
better training and maintenance
for refrigerants: deal with leaks, capture on servicing
terminal recovery where effective

These subjects were later treated by the applying industries in greater detail.

Also in his view, in the year 2000, CFCs will have been replaced 30% by other products or processes, 30% by conservation, 31 % by HCFCs and 9% by HFCs (the latter not containing fluorine and therefore with no ozone depleting potential).

The cost of the restructuring on the level of present CFC producers were estimated to be in the order of 4 billion US dollars, the cost for restructuring in the user industries in the order of several tens of billions of dollars. The cost estimates were detailed for the US by one of the various illustrative tables presented to the audience.

To summarize, he stressed, that the production of new chemicals was one problem area where clear signals had to be given to the industry on whether to pursue its development or drop it to the disadvantage of everybody. In regard to transferring this know-how, he pointed to the necessity to accompany such a transfer with an assessment of the conditions in terms of place, time and type of operation to avoid pitfalls due to lack of viability or offensiveness to the environment. He also pointed to the huge educational effort to be made with the user industry. He suggested regional approaches and for the transfer of producer technology possibly bilateral schemes.

His suggestion was repeated, that developing countries should temporarily import and wait for the alternatives to be developed to pick the best.

Finally, he offered himself for giving further details on the activities of his company to the interested participants.

1.3 Discussion

In the subsequent discussion, the view was repeated, that a gradual phaseout would be more efficient both economically and in terms of real impact on the ozone layer. Technology transfer in the pilot plant stage was possible but of little use. One of the real problems for this transfer was the justification of the huge investment, if it was justified, for production on a large scale. The feedstock either had to be produced locally or imported presenting problems of transportation. Intermediate products, some of which potential feedstock for chemical weapons with the corresponding problems of control, some extremely poisonous, required special measures for handling. (Collateral products would have to be disposed in other forms since some of them could now not be used anymore as in earlier times before the Montreal Protocol, when production of a variety of products was complementary etc.)

To summarize, he stressed, that the production of new chemicals was one problem area where clear signals had to be given to the industry on whether to pursue its development or drop it to the disadvantage of everybody. In regard to transferring this know-how, he pointed to the necessity to accompany such a transfer with an assessment of the conditions in terms of place, time and type of operation to avoid pitfalls due to lack of viability or offensiveness to the environment. He also pointed to the huge educational effort to be made with the user industry. He suggested regional approaches and for the transfer of producer technology possibly bilateral schemes.

His suggestion was repeated, that developing countries should temporarily import and wait for the alternatives to be developed to pick the best. Clear signals should be given to the industry on whether gouvernments wanted to adopt a strategy of gradual phaseout, with the intermediate use of HCFCs, in particular HCFC 22 or whether the more drastic phaseout was preferred, where the end result would be higher cost and sacrifices and a lesser efficiency with regard to reducing the effect on the ozone layer.

2 Discussion by Applications

2.1 Use of CFCs in Foams

2.1.1 Present state of CFCs in foams, particularly polyurethane foams, and possible means of substitution.
Dr. John Hutchison, BASF

Dr. Hutchison gave a detailed account of the use of CFCs and substitutes, respectively alternative products in the manufacture of foams.

According to him, replacement of CFCs in practically all foams except the hard polyurethane foams, where the product was required as an insulator, was possible and to a large extent already done.

In the expanded polystyrene foams, CFC had been replaced by pentane, in the extruded foams HCFC 22 had started to be used.

The speaker emphasized the necessity for uniform regulations. He said, that where substitutes such as HCFC 22 or the newer materials under development would offer the qualities required for the purposes considered, the producers should get clear signals as to their desirability not as part of the problem but as a way towards its solution.

In regard to soft polyurethane foams, he considered that CFCs in mattresses and molded foams could be abandoned immediately by all producers without any problem. In flexible foam, the technology was also available. However for insulating rigid polyurethane foam, there was no replacement yet, since the CFC used contributed to the insulation. Successful results had been achieved with mixtures where the CFC had been reduced to 50 % with little loss in insulation. CO2 was not seen as a solution for this reason.

For canned foam, HCFC 22 could be used. For molded integral skin foam the substitution of CFCs was no problem.

With regard to timing, he considered, that the 1086 level of consumption could be reduced by 60% in 1993 and by 100% in 1996.

2.1.2 Total Recovery of CFCs in Foam Production ? Probable schedules, implications for developing countries and possibilities of assistance.

Mr. C. Zachariasson, AMEG, UK Ltd.

Mr. Zachariasson presented considerations regarding the recovery of CFCs in the foaming process for which AMEG supplies the equipment. These techniques are already presently interesting from a commercial point of view as investment of these installations can be recovered in two and a half years on the savings on the product alone. This only applies, of course, to those processes, where the products can be reused. His exhibition covered the technical aspects of this recovery, conditions to avoid such as dilution of the product due to additional ventilation, conditions to meet such as reducing the volume of space devoted to the curing process referring to the use of the process with block frames where the recovery process could be used moderately well etc.. Basically, the process of recovery was to be seen already now as a commercial proposition adding to the effort of phasing out ozone depleting substances.

2.1.3 Discussion

In Mr. Hutchison's view, the legislators were proceeding too fast. If CFCs were to be eliminated, there would be no use in recycling. Mr. Zachariasson, on the other hand, stressed the necessity for serious studies to be made. In his view, a recovery of up to 95 % was possible. In solvents, he stated, a recovery of 84% was possible. It was apparent from the discussion, that for at least some of the applications, in particular for rigid polyurethane foam, some insecurity persisted regarding the possibility to use HCFC 22 as an interim product while waiting for substitutes or whether the phaseout also of this product would become, as it appeared, necessary. In the latter case, doubts would be raised with regard to the future of the entire development of substitutes in this field.

2.2 CFC Substitution in Solvents

2.2.1 CFC substitution (in solvents) and the developing countries
Mr. Brian Ellis, Protonique S.A. Lausanne

Mr. Ellis gave a detailed analysis of the alternatives with regard to the use of CFCs in solvents, contained also in a paper submitted to the meeting. In his views, the large majority of operations could easily be shifted the use of non clean fluxes or to other cleaning processes, where the increased cost of the new installations would be compensated or even overcompensated by the economies achieved through lower costs of the replacement materials.

However, the decisions to use non clean fluxes or to choose among the other alternatives, could only be made by objective experts, who would be able to justfy their advice by the substantial savings a company would achieve by choosing the optimum trade-off between the required quality and the cost of production. In some areas like non clean fluxes, the advice would best be given on a plant by plant basis, in other areas, where entire branches could adopt a new cleaning system, seminars would be recommended.

He considered, that 98 % of CFC 113 used in solvents could be replaced by alternative products and processes within a few months if the capital and existing know-how were made available. New plants would cost 1.5 to 10 times the cost of present CFC 113 installations and there was no single substitute for all of these. The adaptation costs would vary according to the size of the production line between 10.000 and 1 million US dollars (a reference which had been obtained from another source seemed to indicate that an investment of approximately US$ 100 per kg solvent consumption per year was required for the smaller production units and US$ 30 approximately per kg CFC presently used in a larger unit. The latter included the developing cost and apparently a patentable closed chamber recycling process). He expressed however concern, that specifically the small cleaning operations could not be reached through international financing mechanisms used to assist only large operations.

Toxicity and inflammability of alternative products and the question of contaminating water with heavy metal residues had to be taken into account with the new installations contributing to their higher cost. He pointed out, that ancillary costs due to possible water contamination varied in degree from country to country and different standards had to be applied for instance with regard to water supply. He then referred to the requirements a solvent expert would have to fulfill to comply with a complex task of advising developing countries, some of which perhaps not interested, in the best way to eliminate CFC in solvents, the various types of studies required, the financing mechanisms necessary including the possibility of self-financing etc. In his view, the process of eliminating CFC 113 from the solvent field, would possibly be accelerated by the gradual disappearance of the product from the market, since many countries had already prepared the corresponding legislation and many manufacturers would not be willing to produce small quantities of the product if not compensated with higher prices for the loss of economy of scale. Such price increases were already happening through taxes levied on CFCs making the search for alternative solutions economically more interesting.

One of his special points of concern was also the massive use of highly toxic solvents such as carbon tetrachloride in Eastern countries.

To summarize, the technical suggestions made by Mr. Ellis, these concentrated on the execution of studies on use patterns of all polluting substances, sector specific studies, cost assessments for conversion per sector, and realistic time tables for phasing out the product (with questionnaire format added). Furthermore on the use of experts to visit countries and advice individual plants and the execution of seminars for sectors with similar problems and alternative solutions.

2.2.2 Substitution of CFC 113 in various applications in the electronics industry, Ing. Plescher, Alcatel Austria.

Mr. Plescher presented the view, that CFCs, chlorinated carbon compounds, or partly halogenated compounds could not be seen as a long term solution in replacing solvents in the electronics industry, since the quantity of immission to be expected from them, because of their high solubility in air, was not tolerable. He saw the long term future in the rapid development of in line cleaning installations which would use aqueous processes and or terpenes, alcohol or ketones.

He gave a detailed comparison of using CFCs or their substitutes versus alternative solutions in the areas of metal cleaning and degreasing, and drying of precision parts, and the cleaning of semiconductors after soldering.

In the area of metal cleaning and degreasing, aqueous processes had the advantage of not producing immissions and chlorine free old oils and the disadvantage of high energy costs for drying, expensive treatment of the water with the difficulty of splitting up the emulsions resulting in the process. Installations for such processes were produced in Austria and corresponded to international standards.

For the cleaning of precision parts cleaning only with ketones or benzenes was being discussed and possible with the advantage of not producing immissions of CFC 113 but the disadvantages that the cleaning substances were inflammable requiring explosion protection and led to emissions of organic chemicals with a global warming effect. Few horizontal installations for this process were offered by some countries like the FRG and could be imported.

For the cleaning of semiconductors after soldering, several alternative procedures were analyzed. The most common search was for the use of fluxes with little residues requiring no cleaning. While the emission problem was solved, the small activator share of these fluxes often made a great amount of finishing work necessary. Also the corrosion danger in countries with high climatic differences was substantial. The process was however already in use in Austria.

Terpenes had the disadvantage of being combustible requiring explosion protection, emitted organic substances adding to the green house effect, required aftercleaning with water and were therefore not usable for SMD technology. The installations offered from outside Austria did not find clients.

Alcohol ketones had high cleaning properties making them suitable for "SMD" technology, however they required explosion protection and their emissions had to be taken into consideration. In Austria, horizontal installations for this purpose were being offered.

Aqueous cleaning again meant high energy cost for drying and was useful only for some parts. The process cannot be used for "SMD" technology, since the high surface tension of water impedes the flushing of dissociable residues. In Austria such processes are not being used, although installations are offered from producers in other countries.

Soldering with protected gas meant high finishing costs if used without activator and pollution if used with activators. Formic and adipic acids are preferably used. Subsequent cleaning was necessary for high technology and other semiconductors used in difficult climes. Some installations for protected gas soldering were being discussed by large companies. Such installations were not produced in Austria.

Mr. Plescher concluded with the recommendation, that innovation in the area of installations using aqueous methods as well as those using terpenes, alcohol or ketones should be internationally accelerated.

At the present moment printed circuits are seen as still dependent on CFCs and only alcohols and ketones could bring a solution the problem being inflammability. An installation was already available in Germany.

The Electronic industry, according to Mr. Plescher would need mixed technology brushing and full cleaning. Water plus terpenes, alcohols and ketones could bring the solution and such processes should be developed fast. Interim substitutes according to him, as illustrated with one example, could be absorbed by the air in dangerous quantities and therefore constitute a heavy burden to the atmosphere. Partly halogenated products were not the solution for this reason.

2.2.3 Development of CFC substitutes for solvents. Dr. O. Paleta, Prague institute of Chemistry.

Mr. Paleta presented the research of the Department of Organic Chemistry in the search for an alternative to CFC 113 which should have a low potential of ozone depletion, at least comparable solvent properties, a higher boiling point to prevent evaporation and facilitate recycling and an uncomplicated production technology. He considered that these requirements could be met with chlorofluoropropanes, for the production of which a method had been developed using fluoroethylenes and CFC 11 or HCFC 21 as feedstock and aluminum chloride as a catalizer at temperatures between 10 and 30 degrees Celsius. Although the production had reached the bench plant and pilot plant level in the laboratory, no information was available yet on the ODP and GWP of these chlorofluoropropanes.

He stated that fluorination of these products could be used to lower their boiling points and that with perhalogenated compounds monohydrogen compounds can be obtained. He considered that CFC 113 versions should be substituted by monohydrogenated compounds.

2.2.4 Discussion

Recommendations were then solicited UNIDO should make to the developing countries in the area of solvents in addition to the observations made by the earlier speakers, and it appeared to be the consensus, that assistance was of interest only on a case by case basis, where the options for using substitutes versus alternative products or processes, recycling or recovery had to be weighed according to the circumstances. The main factors to be taken into account in this area were, according to the processes used, explosion and fire protection, toxicity, pollution of the soil or water by metallic residues, chlorinated oils or of the air by organic chemicals. The process requirements were different even within a subsector such as the electronics industry and an additional variable was the situation of the industry in the developing country, the existing ecology of cities versus country etc. All this would require building up an expertise specifically on the safe use of solvents.

Some of the participants felt however, developing countries may wish to continue using CFC 113 for an interim period for the most sensitive cleaning problems. However, although a replacement for CFC 113 could possibly be seen in HCFC 225 CA or DA but definite results regarding the safety of these products would not be available before 1995.

Diversity of the solutions was emphasized, the statement that 98 % of CFC 113 could be replaced with present technology was repeated, reference was made to the reduction of use by conservation as illustrated by the fact, that in the US for the same process twice as much solvent was used as in Europe. Changing the speed of lowering the steel part to be cleaned into the solvent can reduce the use of the solvent.

2.3 Substituting of CFCs in Refrigeration

2.3.1 Substituting of CFCs in Refrigeration
Dr. H. Lotz, BSHG Bosch-Siemens Hausgeraete GmbH.

The speaker covered in his exposition the situation regarding cooling liquids and insulating foams.

The comments related to the substitution of presently used CFCs, the use of alternative product, recovery and recycling and to the disposal of banked CFCs.

The amounts of CFC to be considered are the annual emission of 154.000 tons mainly through leakage of not completely hermetic systems, particularly true for mobile units, and losses during mounting and repair (figures of 1986 probably still valid), and the 1 million tons of CFCs which could be recuperated from the total 2 million tons of CFCs presently banked world wide in polyurethane hard foams (1.1 million tons), refrigerants for car air-conditioning (250.000 tons) and refrigerants in refrigeration equipment (650.000 tons).

The speaker referred to the EEC commitment to phase out CFCs and analyzed the various options in the area of cooling liquids and insulating foams, considering not only the ozone depletion potential of the CFCs but also their global warming potential several thousand times higher than the GWP of CO2. An earlier speaker, Mr. Hutchison from BASF had considered the Green House Effect to be a much greater problem than the damage to the stratospheric ozone layer.

The negative balance of certain alternative options for refrigeration in respect to their global warming potential excludes such options as the cold gas process ("helium refrigerators") at least for smaller refrigeration units or the Peltier refrigeration technique.

In regard to both the ODP and the GWP, he considered the adaptation of refrigeration equipment for HCFC 22 and Ammonia, where safety conditions could be met, steps in the right direction. On a longer term basis, the products 123 and 134 A were the most promising provided they proved innocuous in the global PAFT testing exercises.

The note of November 1989 by the International Institute of Refrigeration, an intergovernmental organization founded 1920 with seat in Paris, which was also submitted by the speaker, states that only three to four years from now sufficient information on substitute fluids will be available and recommends to permit the continued use of CFC 11 and 12 for small hermetic systems until cost effective alternatives are found. Until then, mechanics and repair-shops should be trained in non or little polluting procedures, to sanction the emission of such liquids and favor their recovery and recycling. The Institute offers its cooperation in designing such programmes.

Furthermore, the use of HCFC 22 should be permitted beyond the year 2.000, obviously to encourage the immediate adaptation of equipment to this much less nocuous product, requiring smaller compressor units and therefore not suitable for smaller machines as yet.

An earlier note by the same institute had seen a possibility of reducing emissions by 30 to 40% through such simple measures as good workmanship (less leakage), better education of operators and contractors. Specifically for automotive air-conditioning and refrigerated transportation units, where leakage is a considerable problem, up to 50 % further reductions could be achieved through sophisticated technical solutions reducing leakages, and through recovery and recycling.

Of a total world consumption of 224.000 tons of CFCs for cooling liquids, the refilling of refrigeration units corresponded to 154.000 tons of which 92.000 tons for car airconditioners, 60.500 tons for industrial and commercial units and only 1.500 tons for household refrigerators.

Regarding the reduction of emission of CFCs during foam production and the use of recovery, recycling and disposal techniques, the speaker observed that the diffusion of the CFCs from these foams had a half-time of approximately 100 years (corresponding in this connection to 5.500 tons per year globally) from which would be led to conclude, that although the amount is considerable, the early development of inexpensive disposal techniques for these foams would be preferable to the diversion of resources to introduce expensive methods if these could achieve better and more effective results regarding the larger quantities lost in other applications, in particular in regard to the 154.000 tons of cooling liquids emitted annually into the atmosphere.

The alternative solutions for insulation are still being studied. Thicker walls for refrigerators or lesser insulation meant more energy consumption and was not feasible for small kitchens. Vacuum panels had not yet been around long enough to say anything about their long term performance.

Dr. Lotz stressed the necessity for a recycling infrastructure. HCFC 22 was presently no solution in Germany because of the expected banning of the product,

2.4 Halon Substitution in Fire Protection

2.4.1 Halon Substitution in Fire Protection
Mr. Waeckerlig, Schweizer Brand Verhuetungsdienst

Mr. Waeckerlig explained the role of the two basic halons used in fire protection, halon 1301 (ODP 10) for fixed installations and halon 1211 (ODP 4) for mobile installations. The product had previously been considered fashionable and was highly appreciated for not leaving residues, not being too toxic, its capability for being used for flooding and the possibility for using it in small quantities.

It is still seen as irreplaceable for the fire protection of computers, planes, tanks, submarines, electric rooms and laboratories. Insurance companies used to encourage its use with discounts of up to 80 %. Until recently, they required users to test flood the protected installations to check the effectiveness before granting the premium discount. Although the quantities used are small (3% of CFCs), its ozone depletion effect makes it a sizeable contributor to the pollution problem since it is halogenated with bromine instead of fluor.

Mr. Waeckerlig considered the product not too difficult to be phased out. For mobile units, there was practically no problem of replacement and for the other applications new concepts were being studied like better structural designs in construction, smaller areas to protect against fire, lesser consideration to the value of computers which after all are just office machines. The behavior in case of fire could be trained, sprinklers could be improved through more sensitive trigger systems as with smoke detectors, admixing of CO_2 could be considered in other cases. Mr. Waeckerlig pointed to the working groups on the subject, the UNEP report with its matrix indicating areas of use UNEP report. and the meeting to take place on the subject October 1 through 3 1990 in Geneva.

Switzerland, according to the office for environmental protection in Bern was planning a programme for phasing out halons as follows:

A national halon bank would handle all quantities required.
In 91 exports and imports would be prohibited.
Halons could then only be used for fire fighting and all fixed installations would be registered.
In 1992 no more new installations would be permitted except those defined as impossible to be protected otherwise.
In 1994 there would be no more refilling of installations.
In 1998 the phaseout would be total.

2.4.2 Discussion

In the subsequent discussion, one of the producer representatives considered the impossibility for halons to continue in the market, since such a phaseout would mean 2% of present use and no manufacturer would produce the product anymore. This corresponds to views heard from other sources before the meeting, which had considered halons practically terminated.

2.5 Recovery and Disposal

2.5.1 Recovery and Disposal of CFCs in Polyurethane Foams
J.M.Blessing, Adelmann GmbH.

Mr. Blessing presented a degassing unit for rigid polyurethane foams from refrigerators, where the material is shred, spiral fed into a high pressure compression unit in a continuous process requiring a buffer silo. The result is a briquet with a residual CFC 11 content of .01% condensed water and pure CFC 11. He then went on to describe the testing process carried out by a neutral body, which confirmed the extremely low residual CFC and stated that the measurements around the plant had resulted in an immission of only .7% of the gas during the dismantling process resulting in a total efficiency of 99%. The experience of the company in shredding and compacting was emphasized.

Mr. Blessing then advocated dismantling instead of shredding of the entire units as most of the foam came from commercial refrigeration units, which were not standardized like household refrigerators. Dismantling had the advantage, that units with only small damages could be repaired and brought back into service and that other units would still yield valuable metals like copper, steel and aluminum, rock wool etc. The process also was labor intensive and easy to manage. He considered a combination of dismantling and degassing a better proposition then the other schemes, where only the motor, the mercury and the cooling liquid is removed before the unit is shred. He considered this proposition also better suited to the requirements of the developing countries.

2.5.2 Disposal of CFCs in Cement Kilns
Prof. Jeffreis, European Center for Pollution Research

Professor Jeffreis presented the possibility of using cement kilns as a cheap disposal method for CFC containing wastes. Their advantage was their universal availability, the long time products would have to be completely destroyed at high temperatures and even the fact, that CFCs would possibly contribute to the energy requirements of the kiln while the ashes of accompanying products such as aluminum cans, would safely be integrated into what was the end product of a Cement Kiln, ashes. He also referred to the feeding mechanisms required for waste products to be fed into the process. In subsequent discussions he mentioned the high capacity of handling waste products including metals for instance from aerosol cans and even to withstand without difficulty small explosions which might result from feeding aerosol cans into the process.

Professor Jefferis explained the functioning of Cement kilns where wet, semi-wet or dry processes are used. The wet process was particularly energy intensive and required kilns of a length of 230 meters whereas the dry and semi dry kilns could be much shorter (70 or 65 meters). The flow of the process and the requirements for the feedstock (raw meal) varied. The technology of burning cement included already substantial know-how of handling a large variety of materials as they occur in nature, which are not directly required for cement production. A great variety of waste products could therefore be accommodated either for their calorific value or for their nature as special wastes.

Cement kilns had shown in tests in the USA, that they would destroy 99.99 % of organic materials because of the high temperatures reached by the solid material (1400 degrees Celsius) and by the gases (2.000 degrees). The product could be fed into the kiln as a liquid, injected coaxially with the main burner, a procedure considered suitable for liquid wastes, as a solid material pushed into the kiln or blended with the raw material feed. The latter type of feeding would however probably not be suitable for volatile material, because it may evaporate before reaching temperatures high enough for destruction. In earlier and subsequent discussions he gave specific consideration to the possibility of injecting aerosol cans into the kiln, which would be capable of absorbing the small explosions to be expected. He had also considered mixing the material with the slurry.

Considering that probably the longer wet kilns would produce a better destruction of organic chemicals, he pointed to the necessity of tests and mentioned the conditions that waste must not reduce the quality of the cement produced, not interfere with the flow of the clinker through the kiln and not impair the dust control.

The limiting factor for the destruction of CFCs was seen as their chlorine content for which reason Mr. Jefferis estimated the input should be limited to .5% of the weight of the cement or 5 tons of chlorine contained in CFCs and other wastes for a kiln processing 1.000 tons daily. Fluorine on the other hand could even be beneficial up to a quantity of .2%.

He summarized his exposition by pointing to the necessity of studying the use of the cement kiln as a device for cheaply and efficiently destroying CFC containing aerosol cans or foams, or other. Also for developing countries, this process might offer a good solution, since cement kilns could be found everywhere and the know-how, once available, could therefore be spread rapidly. One of the obstacles to overcome, however, may be the opposition of some governments to use cement kilns for waste disposal purposes.

He pointed to the body of know-how available on burners, materials and plant operation, which could be brought to bear on a rapid development in this direction. The idea of preparing a hand book on the subject of disposing of CFC containing wastes by cement kilns was mentioned subsequently to the meeting.

2.5.3 Discussion

One objection to the process was made in respect to the preference which should be given to recycling over burning.

3 Final Discussion

The participants were told about the type of activities UNIDO could carry out and for suggestions within this framework on the basis of all prior presentations and discussions. The suggestions which were made at this moment related basically to the possible role of UNIDO as a clearing house were information on the subject was assembled and transmitted, training programmes designed, country studies undertaken on consumption patterns of CFCs. Conservation through better production, refilling, repair and disposal techniques should be promoted, and recovery and recycling know-how should be spread. Alternative solutions to the CFCs should be presented where applicable, assistance should be given particularly also to small companies, for instance cleaning operations, the assistance to countries should take an integral view of the problem including such topics as the possible contamination of land and water by alternatives.

The meeting was closed with an expression of great appreciation for the intense effort invested by all participants into the exchange.

Appendix I

PROGRAMME OF ADHOC UNIDO INDUSTRY MEETING ON PHASING OUT OZONE DEPLETING SUBSTANCES.

9.00 am	OPENING OF MEETING.
	SUBSTITUTION OF BASIC CHEMICALS
9.30 am	CFC Substitution and Transfer of Technology. Mr. Roy Breslau, Du Pont de Nemours.
10.00 am	Perspectives of CFC substitution. Dr. Michael Harris, ICI, Runcorn UK.
10.30 am	Discussion: Substitution of CFCs by new products, perspectives, probable schedules, implications for developing countries. Some questions regarding aerosols.
	FOAMS
10.50 am	Present state of CFCs in foams (particularly polyurethane foams) and possible means of substitution. Mr. Hutchison BASF Aktiengesellschaft .
11.10 am	Total recovery of CFCs in foam production? Mr. C. Zachariasson AMEG UK Ltd..
11.30 am	Discussion: The problem of alternatives for the use of CFCs in foam production. Probable schedules. Implications for developing countries and possibilities of assistance.
12.00 pm	LUNCH
	SOLVENTS
1.15 pm	CFC substitution (in solvents) and the developing countries. M. Brian Ellis, Protonique S.A. Lausanne.
1.40 pm	Substitution of CFC 113 in various applictions in the electronics industry. Ing. Plescher, ALCATEL Austria.
2.05 pm	Development of CFC substitutes for solvents Dr. O. Paleta, Prague Institute of Chemistry and Technology.
2.20 pm	Discussion: The problem of alternatives for the use of CFCs in the application of solvents. Probable schedules. Implications for developing countries and possibilities of assistance.
	REFRIGERATION
2.30 pm	Substitution of CFCs in refrigeration. Dr. H. Lotz, BHSG Bosch-Siemens Hausgeraete GmbH. and discussion.
	HALONS AND FIRE PROTECTION
3.10 pm	Halon substitution in fire protection. Mr. Waeckerlig Schweizer Brand-Verhuetungs-Dienst fuer Industrie und Gewerbe, Zuerich.
3.30 pm	Conclusions on the use of halons. Implications for and possible assistance to developing countries.
	DISPOSAL
3.40 pm	Recovery and Disposal of CFCs in polyurethane foams through pressure Mr. J.M. Blessing, ADELMANN.
3.55 pm	Disposal od CFCs in Cement Kilns. Prof. Jeffreis, European Centre for Pollution. Research, Queen Mary College London UK.
4.10 pm	Discussion: The problem of disposal. Implications for developing countries. Possibilities of assistance.
4.30 pm	Final Conclusions and Summary
5.00	CLOSURE OF THE MEETING.

Appendix II

AD HOC UNIDO INDUSTRY MEETING ON
PHASING OUT OZONE DEPLETING SUBSTANCES
31 May 1990, Vienna, Austria

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APPENDIX 3

THE COST OF PHASEOUT - A NEW ASSESSMENT

The following considerations are intended to convey a feeling for the cost of the effort required to save the atmosphere from further pollution by ozone depleting substances and to contribute to the development of a sense of proportion which could perhaps be useful for the definition of the role UNIDO will play in this effort, both as an advisory institution to the coordinating organization and as an actor of its own, assisting the industry in the developing countries to contribute effectively to this global effort. The figures given below therefore do not have to be fully exact, but should provide new insights in their relationship to one another.

It was estimated by the representatives of basic industries in the meeting that the cost of developing substitute products would be in the order of four billion US$ for the basic industries alone. In addition to this, the applying industries world-wide would be faced with substantially higher costs in the order of several tens of billions of Dollars for:

- adapting existing processes to substitutes, i.e. to new products like CFC 134 A, which are presently being developed. These costs, will be incurred in the solvent applying, aerosol manufacturing, foam producing, refrigeration and fire protection industries and services.
- CFC applications where alternative processes will now be used, for instance in the cleaning services, in some of the solvent application in industry where aqueous systems and terpenes etc. shall be used now, or in the foam blowing applications where CO2 or water vapor will now be applied.

Also, one must take into consideration the often higher running costs of the various new processes due to, at least in the beginning, higher energy consumption, more expensive raw materials, higher cost of supervision in applications where special protection methods (for instance explosion) are required, training etc.

If one adds to this the cost of the necessary disposal of the at least 2 million tons of CFCs stored in refrigeration alone without counting CFCs stored in the hard foams used in other applications several billion US$ must be added to this figure.

A conservative estimate would then mean a total cost of phaseout efforts as follows:

COST OF PHASEOUT EFFORTS	BILLION US DOLLARS
Development of substitute products:	4
Adaptation of present installations to use these substitutes:1	15
Transformation to use alternative products like pentane etc.: 2	3
Higher operating costs of new processes during the first five years3:	5
Destruction of presently "banked" products (> 2 million tons of CFC)4:	10
Total	37