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ASPECTS OF THE INTERNATIONAL TRANSFER OF TECHNOLOGY
INFORMATION RELATING TO ACTIVITIES WHICH MAY AFFECT
THE OZONE LAYER

Paper prepared by the UNEP secretariat

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I. INTRODUCTION

1. At its first session the Ad Hoc Working Group of Legal and Technical Experts for the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer recommended that a discussion paper be provided on "the need for and difficulties relating to the transfer, between countries, of technology and knowledge relating to activities concerning production, use and emissions which may affect the ozone layer". 1/ The scope advocated has been taken to include:

(a) Activities which may indirectly affect the ozone layer such as the production and application of nitrogenous fertilizers, from which nitrous oxide emissions may ensue due to biological action in the soil;

(b) Technical measures for reducing emissions of substances which may deplete the ozone layer;

(c) Replacement of such substances by alternative substances and technologies not considered liable to affect the ozone layer.

2. The provisions of the prospective convention will need to be sufficiently general and comprehensive to take account of any new hazards to the ozone layer which may be discovered in the future, as well as those of current concern. However, to provide practical examples of the nature of the information which will need to be collected and exchanged, references are made in this paper to specific substances which have already been identified as being potential ozone layer modifiers. While there is no intention to place special emphasis on any particular compounds, it is the case that most of the experience to date of devising and implementing precautionary ozone layer protection measures has been associated with certain chlorofluorocarbons (CFCs), and it is necessary to draw on this experience to illustrate some of the problems of information and technology transfer, and how they might be surmounted.

1/ UNEP/WG.69/10, para.36 (vii).

II. PRODUCTION, USE AND EMISSION STATISTICS

A. The need for global statistics

3. In the context of ozone layer protection, the relative importance of a particular compound which is being emitted into the atmosphere as a consequence of human activity depends upon a "properties - quantities" combination of factors, and especially the following:

(a) The intrinsic ozone-affecting characteristics of the compound and its derivatives when transported into the stratosphere;

(b) The tropospheric lifetime and other intrinsic properties governing the extent of transportation into the stratosphere (which may also be affected by the presence of other emissions);

(c) The historic, current and projected future rates of emission.

Data in categories (a) and (b) will be obtained from scientific research and observation, but to estimate the potential long-term effect on the ozone layer it is essential to have adequate emission data. To provide these, it is necessary to have production and use statistics relating to the compound being emitted or its precursors, together with emission factors and any other information needed to relate production and use to actual release rates.

4. In some instances, use and emission are virtually the same in terms of chemical identity, quantity and time. An example is the use of CFCs as blowing agents for the manufacture of open-cell flexible polyurethane foams: the CFCs are not chemically changed in the process, and practically the whole amount used escapes into the atmosphere within a day or so.

5. The situation is more complicated when some of the compound is "banked" for a long period in an installation or material, such as when CFCs are used as working fluids in refrigeration and air-conditioning equipment, or in the manufacture of closed-cell foam plastics for thermal insulation. In these types of application the compounds may be retained for many years before release, and a proportion may never be emitted either because it is trapped indefinitely or because it is decomposed, e.g. if discarded insulation foam is destroyed by incineration.

6. The relation between consumption and emission is also complex when the latter is chemically different from the input, as in the formation of nitrogen oxides by combustion of fossil fuel. In this case the extent of emission depends upon the nitrogen content of the fuel and the combustion conditions, both of which are subject to considerable variation.

7. The primary and paramount need, however, is for global production statistics for all substances which, directly or indirectly, may be involved in stratospheric ozone layer modification processes. Whatever the uncertainties about emission factors and patterns, it is at least possible to make "worst case" assumptions about these, and so make provisional assessments of relative importance, and of the need for further investigation.

8. The next requirement is for consumption data analysed by application category, which often equates to a sales analysis if taken over a sufficiently long period to eliminate the effects of stock changes. The provision of these data is the first step towards ascertaining emission characteristics and the development of emission control strategies.

9. From the application category analysis, initial decisions can be made as to the additional statistics needed for emission estimation and control strategy evolution. Applications involving small tonnages of material may be set aside at this stage, as may large-tonnage captive uses where the compound is used as an intermediate for the production of materials which will not give rise to suspect emissions and where there is no reason to believe that releases during conversion will be more than minimal.

10. It is impossible to generalize about the information needed at the end-use analysis stage, but the detail can be illustrated by instancing the use of a compound as a refrigerant, when it would be necessary to ascertain the different types and sizes of refrigeration and air conditioning equipment involved, and to try to assess the distribution of refrigerant losses for each category and at the successive stages of manufacture, installation, testing, operation, maintenance and repair, as well as at disposal.

11. The extent to which historic as well as current data and projections are required will depend mainly on tropospheric life-time. For short lived substances, data for the past few years may be useful only for revealing trends which may assist the preparation of forecasts. For long lived compounds, and in cases where compounds may be "banked" for long periods before release, it may be desirable to look back over many years to obtain data for assessing effects on stratospheric ozone.

12. Finally, there is the question of the geographical breakdowns required. There may be some case for regional use and emission data in order to model atmospheric mixing effects, including interactions between different emissions in the troposphere, and also if there are significant effects due to the existence of localized tropospheric sinks. But the practical aspects of implementing emission reduction measures provide much stronger grounds for a territorial analysis. In the first place, knowledge of the areas where the majority of emissions are occurring will indicate where action is most required and where persuasion may need to be applied to secure that action. Secondly, if regulatory measures were adopted they would have to be implemented by Governments, and that would require some of the statistical information to be obtained on an administrative territory basis. Lastly, where voluntary rather than regulatory action is taken, there will still be a need to co-ordinate and monitor that action, for example through industry and trade associations or federations, and it is difficult to see how that could be accomplished except on the basis of territorial division.

B. Collection of statistics : problems and possibilities

13. Experience indicates tht the following difficulties are likely to be encountered when trying to collect statistics on man-made substances in the context of stratospheric ozone layer protection.

1. Absence of data

14. By this is meant that the data needed simply do not exist, as distinct from being available but inaccessible. This may happen because appropriate records are not kept, or because there are no means of obtaining the data short of mounting a special investigation. Examples include failure to maintain records of end-use distribution when a substance is employed to perform several different functions in one organization, and lack of information about emission factors (as in the release of nitrous oxide associated with fertilizer application).

2. Resistance to disclosure

15. Governments and organizations may decline to provide information because they believe that disclosure could be harmful to political and commercial interests or because they are not prepared to spend the time and effort involved in extracting the data from their records. In some cases a number of companies may be prepared to submit figures to independent accountants for collation and to release aggregate data, but not to provide a territorial breakdown.

16. It must be remembered that in many countries there is no existing legislation under which the Government can compel firms to provide production and sales statistics, especially when a company can demonstrate that disclosure could be prejudicial, and Governments may not be prepared to introduce the necessary legislation in order to facilitate ozone protection measures because of the wider issues involved.

3. Negative motivation factors

17. Many people and corporate bodies are not convinced that it is necessary to take any measures to protect the ozone layer, and therefore see no reason to divulge information which might be useful to business competitors and would be troublesome to assemble. Firms already have to supply many statistics to government departments or other authorities, and resist any increase in this work-load.

18. Individuals who do not believe that a threat to the ozone layer has been demonstrated include some who are professionally well qualified to understand and appraise the relevant scientific evidence. In some cases this scepticism may be rationalization associated with the need to conform with the policy of their organization, or the worry that the imposition of ozone protection measures could threaten their livelihood. Undoubtedly, the fear that disclosure of information may facilitate the introduction of restrictive legislation is a potent factor in this connexion.

19. The extent to which these factors are likely to impede data collection may be highly dependent on current knowledge and predictions about the ozone layer. At the present time, when there is no observational proof that depletion is occurring, and earlier estimates of depletion rates have been revised downwards, it seems probable that resistance by industry to providing information which is at all commercially sensitive, or which would entail appreciable resource allocation to assemble, could be quite high. There might also be a high degree of inertia among governmental authorities in respect of collaboration in statistics collection programmes.

20. Negative attitudes may be transmitted from one industry sector to another, especially from primary producers to their customers, and also from industry to government. Since the materials concerned will be those which are produced in very large tonnages, the primary manufacturers are often major multi-national companies with considerable influence.

21. Another aspect is that if a predicted effect on the ozone layer is made up of contributions from a multiplicity of emissions, industry sectors relating to the smaller contributors may be particularly difficult to convince that any action on their part is necessary.

4. Source identification

22. While it is generally easy to identify primary large-tonnage producers and major distributors, it is not always so easy to identify end-users, especially where there are large numbers of firms, many of them with small intakes.

5. Expansion and geographical spread of production

23. The problems of data collection for a particular compound will increase as production and use develop, particularly when this occurs in countries which have not hitherto been significant producers, and where the companies concerned may be unwilling (or may not be permitted by their Governments) to collaborate in data-pooling schemes such as that administered by the United States Chemical Manufacturers Association (CMA) for CFC 11 and CFC-12. The rapid growth of production capacity for chloromethanes and chloroethylenes is illustrated in table 1, prepared from a recently published 2/ list of new projects in Eastern and Western Europe and the Middle East.

2/ European Chemical News, 22 February 1982, Sect. II.

Table 1. Some new halocarbon production projects in Europe and the Middle East

Company and location	Capacity	Start-up
<u>Chloromethanes</u> (CH ₂ Cl ₂ , CHCl ₃ , CCl ₄)		
PCUK: l'Estaque, France	60,000	?
Dow Chemical Iberica Huelva, Spain	CH ₂ Cl ₂ :45,000) CCl ₄ :70,000)	1984
Polimex Cekop: Wloclawek, Poland	CCl ₄ : ?	1982
Tekhmashimport, Sima, USSR	CCl ₄ :36,000	1982
<u>Chlorofluoromethanes</u>		
Tekhmashimport Javan, USSR	30,000	Completed in 1981
<u>Ethylene dichloride</u> (CH ₂ Cl.CH ₂ Cl)		
Iran-Japan Petrochemical: Banda Khomeini, Iran	300,000	?
<u>Ethylene dichloride</u> Sabic/Shell O.1:		
Al Jubail, Saudi Arabia	454,000	1985
Kema Nord: Stenungsund, Sweden	125,000 (extension to 180,000 total)	1982
State authority: Tomsk, USSR	300,000	?
Dina (Dow/Ina): Krk, Yugoslavia	150,000	1982
<u>Perchloroethylene</u> (CCl ₂ :CCl ₂)		
Perkin Petrokimya AS Aliaga, Turkey	10,000	1982
Polymer Cekop : Wloclawek, Poland	?	1982

6. Resource requirements

24. The tasks of planning and implementing global statistical exercises of this type and of securing the coverage and accuracy needed to obtain meaningful results should not be underestimated. It is unrealistic to suppose, for example, that they could be accomplished by a small central secretariat drawing up lists of data requirements, circulating them to signatory countries to the convention and collating the returns: the obstacles mentioned above would certainly frustrate such a simple approach. To support this assertion, two OECD studies on chlorofluorocarbons may be cited in which production, consumption, import and export data by country for CFC 11 and CFC 12 were sought for the years 1974 and 1979, the results for both years being compared in the report on the second study.

25. Data for 1974 are given for many more countries than for 1979, when there was much more reluctance to provide data on a national basis. Also, much of the information quoted in the OECD report was derived from substantial studies undertaken by consultants and commissioned by the United States Government and EEC. ^{3/}

26. It is believed that the volume of administrative and enquiry work which would be entailed in compiling adequate statistical pictures for substances which have not hitherto been the subject of global studies, as have CFCs, would require a substantial resource budget.

27. In addition to resources for the collection and analysis of statistics, it will also be necessary to commission research projects to fill gaps in emission factor data, and consideration will have to be given to the way in which such projects could be organized and funded. Similar questions will also arise in connexion with the development and transfer of emission reduction technology, which are discussed in subsequent sections.

28. Despite the problems, it should be possible to achieve a reasonable rate of progress provided that too much is not attempted at the outset. An over-ambitious initial programme could be balked by the resistances it would provoke, and at the planning stage of any statistical exercise exploratory discussions with Governments and industry should be held to ascertain what is likely to be practicable, having regard to the present climate of opinion. Thus, although there is a good case for obtaining statistics for individual countries, there may be a much better prospect of obtaining an early global picture by making data-pooling arrangements for groups of countries. There are now established precedents for this.

29. Information from formal enquiries can also be supplemented by the examination of published material such as import/export data, announcements of construction projects, official reports of all kinds, trade journals and a host of other intelligence sources which experienced investigators use to put flesh on rather bare statistical bones.

C. Some initial statistical enquiries needed

30. Table 2 lists the anthropogenic emissions to which it is known that particular attention must be paid in relation to stratospheric ozone modification.

^{3/} OECD (Paris) Environment Committee. Report on Chlorofluorocarbons. ENV(80)32. (2nd Revision) 1981. (Restricted).

Table 2. Anthropogenic emissions which may affect stratospheric ozone

Emission	Principal sources
Carbon dioxide (CO ₂)	Combustion of fossil fuels, vegetation and organic wastes. Fermentation processes.
Nitrogen oxides:	
Nitrous oxide (N ₂ O)	Biological activity in soil and aquatic media following application of nitrogenous fertilizers such as ammonia, ammonium nitrate and urea, also changes in land use.
Other nitrogen oxides, mainly nitrogen monoxide (NO) and nitrogen dioxide (NO ₂)	Combustion processes of all kinds including those in aircraft engines at any altitude. Chemical processes such as nitric acid manufacture.
Carbon monoxide (CO)	Combustion of fossil fuels and other carbonaceous materials
Methane (CH ₄) and other hydrocarbons	Extraction, processing, distribution, storage and use of fossil fuels. Fermentation of agricultural etc. wastes.
Halofluorocarbons, particularly the perhalogenated chlorofluoroalkanes:	
CFC 11 (CCl ₃ F)	Aerosols, foam plastics manufacture, refrigeration and air conditioning, solvents.
CFC 12 (CCl ₂ F ₂)	
CFC 113 (C ₂ Cl ₃ F ₃)	Solvent cleaning; air conditioning
CFC 114 (C ₂ Cl ₂ F ₄)	Aerosols; air conditioning
Chlorocarbons, including:	
Carbon tetrachloride (CCl ₄)	Intermediate for chlorofluoromethanes. Solvent for oils, fats, lacquers, etc., and for miscellaneous uses.

Table 2 (continued)

Chloroform (CHCl ₃)	Wide range of solvent applications. Intermediate for manufacture of CFC 22 (CHClF ₂)
Methylene chloride (CH ₂ Cl ₂)	Solvents for oils, fats, waxes etc. Paint removal. Aerosols.
Methyl chloroform (1.1.1 - trichloroethane) (CH ₃ -CCl ₃)	Cleaning and degreasing solvent. Aerosols.
Perchloroethylene (CCl ₂ :CCl ₂)	Dry cleaning; industrial solvent cleaning.

31. The exact nature of the statistics required in relation to these emissions and the priorities are matters for discussion between experts on the upper atmosphere and experts with specialist knowledge of the substances and activities giving rise to the emissions. Information which will probably be called for includes the following:

(a) Carbon dioxide

Requirements: Current and projected use of all types of fossil fuels; estimates of CO₂ releases associated with fermentation, incineration of various wastes, stubble burning and other activity causing combustion of vegetation;

Comment: Because of world-wide concern about energy and air pollution, as well as the ozone layer, a great deal of such data is already collected and published on an on-going basis. The collection of any additional data needed should be organized in conjunction with other interested bodies;

(b) Nitrous oxide

Requirements Production and consumption of nitrogenous fertilizers; details of modes of application, areas, types of soil, crops, climate and other major factors affecting emission; details of other activities linked with N₂O emission from the soil, such as changes in land use; emission factors applying to the foregoing and hence estimates of N₂O emissions;

(c) Halofluorocarbons

Requirements

- (i) Global historic data for production of perhalogenated chlorofluorocarbons manufactured in large tonnages (viz. CFCs 11, 12, 113 and 114) and corresponding consumption data by main application sector;

- (ii) Global and national data, on an on-going annual basis, for current and forecast production of all halofluorocarbons being manufactured in commercial quantities and considered to have the potential to make a significant contribution to ozone layer modification, together with corresponding consumption and emission statistics for intermediate and final use;
- (iii) Global and national statistics for products made with the aid of, but not incorporating the halofluorocarbons in category (ii) above, such as for flexible open cell polyurethane foams and their use in furniture, automobile upholstery, etc.).

Comment: The statistics collected and published on a regular annual basis under the CMA and EEC fluorocarbon producer schemes, although of great value, only partly fulfil these requirements. The main limitations are that the data relate only to CFC-11 and CFC-12 and do not cover all countries, especially those of the Eastern bloc; the sales data do not cover all the production, are not available for individual countries, and are necessarily limited to the broad application categories. A more detailed picture would require information from importers, distributors and end users, as well as from primary producers. For example, it is not enough to know that world sales of CFCs for refrigeration and air conditioning are increasing; information on the distribution of these sales is also needed - such as how much is going to the Middle East, where consumption for air conditioning in buildings and vehicles appears to be rising rapidly;

(d) Other halocarbons

Requirements: Production and use statistics as specified in (c) (i) and (c) (ii) above are needed for the chlorocarbons listed in table 2, and possibly some others. Bromocarbons should be reviewed to determine whether any should be included in the statistical surveys;

Comment: There are as yet no regular surveys for these compounds comparable in scope with those undertaken for CFC 11 and 12, and the ratio of users to producers is much higher. The starting point would be to collect production and primary sales data, utilizing the experience gained in the CFC field;

D. Ancillary data

32. When gathering statistics for the principal purpose of discovering where emission control measures are most needed, it would also be possible to seek information about employment, added value, capital investment and other data items required to evaluate the socio-economic implications of an emission reduction scenario. There are arguments, however, for separating the two types of study. The initial statistical exercise should generally precede socio-economic studies, because the results of the former are often needed to plan the latter, and while the collection of production and use figures will have to be repeated at regular intervals, socio-economic studies are often of a unique character and are likely to involve a larger set of organizations. The danger of depressing the response rate by asking for too much information at one time should also be taken into account.

III AVAILABILITY AND DEVELOPMENT OF EMISSION REDUCTION TECHNOLOGIES

A. Classification and examples

33. Starting with the assumption that the objective is to provide the same end product or service, or acceptable alternatives, as opposed to applying measures which are simply restrictive, then emission control technologies can be placed in the categories which are listed below, together with examples:

(a) Emission control and abatement measures not involving substitution of the substances which give rise to emissions affecting the ozone layer:

Examples:

Reduction of nitrogen oxides emissions in combustion processes by employing technologies which reduce NO formation or remove NO from the exit gases;

Recovery of halocarbons from solvent cleaning process emissions, e.g. by absorption of active carbon;

Techniques for reducing CFC emissions associated with refrigeration and air conditioning equipment;

(b) Replacement of materials liable to cause ozone affecting emissions by innocuous alternatives, or by substances having a much smaller effect:

Examples:

Replacement of CFCs in aerosol formulations by non-CFC propellants and solvents such as hydrocarbons and dimethylether;

Replacement of perhalogenated CFC refrigerants by non-perhalogenated CFCs such as CFC-22(CHClF_2);

(c) New or alternative technology, reducing or eliminating the need to use ozone-affecting substances:

Examples:

Miniaturization in electronics, which diminishes the scale of CFC solvent cleaning operations;

Use of adsorption-type refrigeration systems, which do not employ the CFC refrigerants used in vapour compression systems;

(d) Alternative end products, not utilizing ozone-affecting substances in their manufacture:

Example

Replacement of CFC-blown closed-cell foam plastics for thermal insulation by alternative insulating materials made without using CFCs.

34. In some cases the use of emission reduction technology may be accompanied by social or economic penalties, including the introduction of an alternative hazard of ozone depletion. To switch from CFC to hydrocarbon propellants in an aerosol filling plant, for example, entails the installation of new equipment - with the associated safety precautions which must be taken on account of the fire and explosion risks attendant on storing and handling hydrocarbons. It may not even be practicable to effect a satisfactory conversion on the existing site, and relocation will result in a transfer of job opportunities from one area to another. Another example is provided by the energy penalties which will be incurred if alternatives to CFC-blown closed-cell foams are used for thermal insulation, since all the available substitutes have significantly higher thermal conductivity. Emission control can also bring gains, however, such as savings due to lower losses of halocarbon refrigerants and solvents, and improved air quality when emissions of nitrogen oxides are reduced. These socio-economic factors are a major aspect of emission reduction, and are discussed in more detail in a separate paper.

B. Need for further development

35. There are a number of areas in which there is no immediate prospect of finding adequate substitutes for the substances whose emissions may affect the ozone layer. An important instance is refrigeration and air conditioning, where, although there may be some scope for extending the use of ammonia in situations where its toxicity and flammability are not serious disadvantages, and for more use of absorption systems, there is no foreseeable likelihood of alternatives to vapour compression systems employing CFC refrigerants being developed for many years. A similar position exists regarding CFC-113 solvent cleaning agents, for which there are as yet no prospective alternatives in many important applications, such as the manufacture of printed circuits and other electronic components. In such cases, where substitution is impracticable, attention must be concentrated on minimizing preventable emissions, and this often demands improvements in working practices as well as in equipment design.

36. There are also areas where there appears to be a good prospect of reducing emission by applying known technology, but where much development work remains to be done to establish the design parameters. An instance of this is the possibility of recovering the CFC blowing agents used in open-cell foam plastics. There is a reasonable prospect of using an active carbon adsorption process such as that already used for recovering chlorocarbon solvents, but there are a number of technical problems, and some years are likely to elapse before a proven system is available.

37. Lastly, there are emissions for which no control technology is yet available and extensive research would be needed as a preliminary to establishing one. Nitrous oxide emission from artificially fertilized land is a major example.

38. Clearly, there is much scope for further development in omission reduction technology, and consideration will need to be given to how this may be undertaken without undue duplication of effort.

C. CEC Approach to reduction of CFC emissions from non-aerosol applications

39. As an example of an approach which might be adopted on a wider international basis, it is of interest to consider the current activities of the Commission of the European Communities in seeking non-regulatory means of reducing CFC emissions from the principal non-aerosol use of perhalogenated CFCs.

40. The Commission has established four working groups to study CFC emission reduction possibilities in refrigeration and air conditioning, flexible (open-cell) and rigid (closed-cell) polyurethane foam manufacture, and solvent cleaning. The groups are composed of technical experts from industry and government, sometimes assisted by specialists from university and other research institutions, and their task is to develop sets of recommendations for submission to representatives of Member Governments and the Commission, who will consider their acceptability and how they might be implemented without recourse to legislation.

41. The main progress achieved to date by these working groups has been in the development of codes of practice for the design, construction and operation of CFC-113 solvent cleaning equipment so as to minimize solvent losses, and for the reduction of CFC-11 and CFC-12 emissions in refrigeration and air conditioning applications. In drafting these codes, the working groups have drawn attention to the importance of securing widespread adoption, since organizations which follow the codes could be placed at a competitive disadvantage by those which fail to comply, and a strong case could be made for developing and promoting the implementation of international codes of practice where there is an appropriate means of reducing emissions.

42. The working groups concerned with polyurethane foam plastics have perceived the need for more research and development before firm recommendations can be made. Some is in progress, but finance is a limiting factor, and there appears to be a case here for international action. The most intractable problem is that of the emissions from closed-cell insulating foams, which may occur very slowly over periods of many years, and at disposal. The manufacture of foam plastic insulation is a rapidly growing CFC application and, as previously remarked, there are no alternatives having comparable insulation characteristics.

D. Forms in which emission reduction technology is available

43. The principal forms in which technology is available but not always accessible are:

(a) Equipment design and process information held by organizations whose business it is to market such information, often in association with the sale of equipment and the design and installation of plant. Typical examples are the various proprietary processes available for reducing formation and emission of nitrogen oxides, and CFC solvent cleaning equipment in which low loss characteristics are built in by the manufacturer because they constitute a marketing asset;

(b) Formulations and other information, often including advice on storage, handling, safety precautions, equipment design etc. available from suppliers of materials and components, such as aerosol cans and valves, propellants and other ingredients, and the various materials used for making foam plastics;

(c) Information held by the public sector, e.g. by environmental protection departments, which may be made freely available in the public interest;

(d) Technology developed by organizations mainly for their own use, and which they may or may not be willing to sell or licence to others;

(e) Patents, which may be held by any of the types of organization mentioned in (a), (b), (c) and (d);

(f) Information held by industry and trade associations which may be made available free of charge to members and others, or for a fee, on the basis that its dissemination and implementation is in the interests of the reputation of the industry;

(g) Codes of practice and standards formulated by trade associations, alone or in conjunction with other organizations, including government departments;

(h) National and international regulations backed by legislation;

(i) The technical literature.

IV. TECHNOLOGY TRANSFER

A. Modes of transfer

44. It will be apparent from scanning the sources listed in paragraph 43 that there are many organizations with a positive motivation, often linked with economic self-interest, for transferring technology. The transfer process will often be associated with the supply of goods and the installation of plant, and the training of personnel which may be arranged in that connexion. Trade associations, technical institutes and other bodies often organize meetings for the purpose of providing information about emission control technology and kindred matters: for example the Federation of European Aerosol Associations and a number of national aerosol associations have recently organized seminars on the safety aspects of using hydrocarbon propellants.

45. Where codes of practice, standards and regulations are involved, positive action may be needed by the sponsoring organizations to identify the companies and use all appropriate means to secure compliance. Where company has a real interest in adopting "best practice", it will initiate inquiries without waiting to be approached.

B. Problems of technology transfer

46. Given that there is a positive desire to apply emission control measures and that suitable technologies are available, the principal difficulties are likely to be of a socio-economic nature. Emission control measures frequently involve extra equipment, plant modification and sometimes relocation, longer work-times and extra tasks, re-training of personnel and additional

and additional supervision, all of which cost money and may involve disturbance to employees. In some cases there may be an offsetting economic benefit to the company, as where cheaper hydrocarbon propellants are used instead of CFCs, but even here there may be difficulty in finding the capital. In the absence of any economic incentive, it may be difficult to secure the introduction of new technology except by regulation and/or the provision of government assistance. In the absence of financial aid, regulation could mean the closure of some enterprises or the abandonment of new projects.

47. It is often easier and more economic to introduce emission control technology when installing a new plant than to convert existing ones. Central and local authorities need to have the means for ensuring that they become aware at the planning stage of new projects which might generate ozone-depleting emissions, so that appropriate action can be taken.

48. The identification and selection of the most appropriate control technology may be a problem, especially for the less industrialized countries, and it may be helpful for the protection convention secretariat to provide an advisory service or, at least, to give advice as to where independent assessments may be obtained.

49. It is possible that some companies will develop technologies which merit widespread adoption in the context of ozone protection but which they do not wish to disclose except to a small selected band of licensees. Most Governments have the power to compel the granting of licences where the public interest is involved, and it might be necessary to invoke this power in support of an ozone protection convention.

50. Considerable difficulties can be foreseen in implementing codes of practice in the installation, maintenance and disposal of refrigeration and air conditioning equipment. Unsupervised operators often carry out these tasks, and there will be little or no incentive to take the extra trouble which refrigerant conservation measures often entail. The re-training of the large numbers of service personnel in this field also presents a major problem.

51. Little headway in introducing emission reduction technology will be made where government is lukewarm or apathetic towards ozone protection, or where it lacks appropriate powers and resources. The central secretariat will need an adequate budget to be able to support the investigatory action and assistance needed to try to overcome such deficiencies.
