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REGULATORY OUTLOOK FOR
U.S. CHLORINE DEMAND: FLUOROCARBONS,
VINYL CHLORIDE AND MAJOR SOLVENTS

Memorandum

Report to

Olin Corporation
Stamford, Connecticut

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Arthur D Little Inc.

TABLE OF CONTENTS

List of Tables and Figures	111
I. Introduction	1
A. Purpose and Scope	1
B. Approach	1
C. Summary of Findings	1
II. The Fluorocarbon Controversy	5
A. Background	5
B. Fluorocarbon Uses and Alternatives	16
C. Possible Regulatory Scenarios	18
D. Implications for Chlorine Demand	19
III. Regulatory Issues Relating to Vinyl Chloride	22
A. The Solid Waste Issue	22
B. Health and Air Quality Issues	24
C. Impact on Demand for VCM and PVC	32
D. VCM Impact Summary	40
IV. The Outlook for Chlorinated Solvents	41
A. Introduction	41
B. Prospects for Individual Solvents	41
APPENDIX Outlook for VCM and PVC Capacity	46

OLI 7746

LIST OF TABLES AND FIGURES

Table No.		Page
1	SELECTED PORTIONS OF U.S. CHLORINE DEMAND THREATENED BY CURRENT REGULATORY ISSUES	3
2	U.S. FLUOROCARBON END-USE PATTERN - 1974	7
3	KEY ATMOSPHERIC OZONE REACTIONS	10
4	RELATIONSHIP BETWEEN DECREASE IN STRATOSPHERIC OZONE CONCENTRATION AND ANNUAL INCREASE IN U.S. CASES OF HUMAN SKIN CANCER	12
5	U.S. CHLORINE DEMAND RELATED TO FLUOROCARBONS 11 AND 12 - 1974	20
6	AN ESTIMATE OF CHLORINE DEMAND IN MANUFACTURE OF PVC RESINS IN 1980, ASSUMING NO IMPACT OF THE VINYL CHLORIDE MONOMER ISSUE	34
7	AN ESTIMATE OF "OTHER MONOMER" CONSUMPTION IN THE MANUFACTURE OF PVC RESINS - 1974	36
8	AN ESTIMATE OF LOST CHLORINE DEMAND IN MANUFACTURE OF PVC RESINS IN 1980, CONSIDERING THE IMPACT OF THE VINYL CHLORIDE MONOMER ISSUE	37
9	AN ESTIMATE OF PVC FOOD PACKAGING MARKET (1974), ASSUMING NO IMPACT OF VINYL CHLORIDE MONOMER ISSUE	39
10	U.S. CHLORINATED SOLVENT END-USE PATTERN-1974	42

Figure No.

1	MATERIALS FLOW CHART-FLUOROCARBONS	8
2	REDUCTION IN CONCENTRATION OF EARTH'S OZONE LAYER AT VARIOUS CHLOROFLUOROCARBON RELEASE RATES	13

OLI 7747

I. INTRODUCTION

A. Purpose and Scope

Olin Corporation is currently updating its information on the outlook for U.S. chlorine demand in each of its many applications. Of particular concern at this time are the various regulatory uncertainties surrounding the outlook for chlorine demand in the production of fluorocarbons, vinyl chloride and major chlorinated solvents. To provide Olin with the most up-to-date information in these areas and aid in an assessment of likely implications for future chlorine demand, Arthur D. Little Inc. was asked to identify and, to the extent possible, quantify those factors in the current business environment which could adversely affect U.S. chlorine demand over the next five years and beyond.

B. Approach

In preparing this memorandum report, we drew on our extensive experience in the chlor-alkali industry as well as our considerable in-house knowledge relating to the various regulatory issues identified above. This extensive experience and knowledge of current issues is the result of our continuing interest and ongoing field work in the chlor-alkali and related industries.

The preparation of this memorandum report follows our participation in a round-table discussion with Olin representatives in Stamford on July 8, 1975. The report summarizes and complements our discussions with Olin on that date.

OLI 7748

C. Summary of Findings

Although more than one third of total chlorine demand is in some way related to the regulatory issues surrounding future demand for fluorocarbons,

vinyl chloride and chlorinated solvents (see Table 1), we believe, based on available information, that probable lost chlorine demand by 1980 will be five percent of normal, unhindered demand in that year.

Several concerned scientists who are involved in the fluorocarbon/ozone controversy believe that production of fluorocarbons 11 and 12 should be stopped immediately. Such drastic action would eliminate the nearly 800,000 tons (1974) of chlorine demand used in the preparation of carbon tetrachloride as raw material for these fluorocarbons. A cutback of this size represents approximately 7% of total U.S. chlorine demand. Although a considerable amount of research is now under way on the subject of environmental hazards of fluorocarbons, it is generally agreed by representatives of both government and industry that a period of at least 3 years will be required to prove or disprove current theories. At this point in time the consensus among several scientists who have been involved in the fluorocarbon/ozone question is that these theories have roughly a 70% chance of being validated by the research currently under way. We do not view total elimination of fluorocarbon 11 and 12 production to be a likely development; however, the amount of production (approximately 50%) going to aerosol propellant applications appears to be in serious jeopardy.

Vinyl chloride has recently been the subject of a series of investigations relating to both environmental and health risks issues. In examining both the environmental and health issues surrounding vinyl chloride, we believe that chlorine demand for manufacture of vinyl chloride monomer could be reduced by as much as 10% in the most pessimistic case foreseeable at this time. This is equivalent to just under 2% of total chlorine demand,

Table 1

SELECTED PORTIONS OF U.S. CHLORINE DEMAND THREATENED BY
CURRENT REGULATORY ISSUES

(Percent Demand, 1974 Basis)

<u>Threatened End Use</u>	<u>Percent of Approximate Demand^a</u>		
	<u>Related to</u> <u>Threatened Use</u>	<u>Seriously</u> <u>Threatened</u>	<u>Probable 1980</u> <u>Lost Demand</u>
<u>Fluorocarbons</u>			
Propellant Applications	4.4		
Other Applications	4.6	4	3
All Fluorocarbons	<u>9</u>		
<u>Vinyl Chloride Monomer (VCM)</u>			
Food Packaging Applications	1		
Other	16	2 ^b	1
Total VCM	<u>17</u>		
<u>Chlorinated Solvents</u>			
Perchloroethylene	3		
Trichloroethylene	2		
Methyl Chloroform	3	2 ^b	1
Methylene Chloride	2		
Total Solvent	<u>10</u>	<u>—</u>	<u>—</u>
TOTAL	36	8	5

Note: a. Calculation of threatened chlorine demand does not take into account possible increased demand for chlorine by alternatives to threatened end uses.

b. Includes demand reduction attributed to increased use efficiency achieved through emission reduction.

Source: Arthur D. Little, Inc., estimates.

OLI 7750

II. THE FLUOROCARBON CONTROVERSY

A. Background

The organic fluorocarbon industry had its beginning in 1928 when Chemists at General Motors first synthesized dichlorodifluoromethane (fluorocarbon 12, or F-12). This compound was synthesized in an effort to find a better refrigerant for the refrigeration industry. Fluorocarbon 12 was found to be ideal in many respects in that it was nontoxic, non-flammable, highly stable and exhibited good refrigeration properties at moderate pressures. By early 1931 commercial production of F-12 and F-11 was begun by Kenetic Chemicals Inc., a joint venture of DuPont and General Motors.

Other commercially important fluorocarbons, including F-12, F-22 and F-114, were introduced during the following decade. War-time needs for fluorocarbon refrigerants and the newly discovered fluorocarbon plastics provided a boost to the fluorocarbon industry during the early 1940's. The birth of today's most important application, as an aerosol propellant, was marked by a patent issued to the U.S. Department of Agriculture in 1943. This patent had to do with the discovery that the effectiveness of an insecticide could be vastly improved by formulating it as an aerosol product, propelled by a liquified gas such as F-12. As in its use as a refrigerant, F-12 had the advantages in aerosol applications of being nontoxic and nonflammable. Millions of aerosol "bug bombs" were produced during World War II as a result of this discovery. Other commercially important fluorocarbon applications include use as a plastic foam blowing agent and use as a specialty solvent in the aerospace and electronics industries. An end-use pattern for

OLI 7751

fluorocarbons in 1974 is presented in Table 2; Figure 1 shows materials flow.

For nearly three decades from the early 1940's, fluorocarbon producers experienced a period of relatively rapid and unhindered growth, with production growing from 0.3 to over 1 billion pounds between 1960 and 1974. The first storm clouds on the fluorocarbons horizon appeared in 1967 when several teenagers died as a result of inhaling fluorocarbon vapors from an aerosol product. By now, this aerosol "sniffing" fad has largely died out but as a result of the deaths associated with this fad and also reports in 1968 which linked an increase in asthma mortalities with increasing sales of aerosol asthma inhalers, public concern over the health effects of fluorocarbons, and aerosol products in general, has lingered on. (Although inhaled fluorocarbon vapors are rapidly purged from the body, a concentration of these vapors several orders of magnitude higher than would normally be experienced can show such physiological effects as cardiac arrhythmias.)

A much more recent controversy involving fluorocarbons evolved in mid-1974 when two scientists¹ at the University of California published a report in which they claimed that the commercially produced fluorocarbons (chiefly F-11, and F-12) are major sources of chlorine atoms in the upper atmosphere. The estimated atmospheric residence times of F-11

¹Molina, M.J., and F.S. Rowland "Stratospheric Sink For Chlorofluoromethanes: Chlorine Atom Catalyzed Destruction of Ozone," Nature, 249: 810, 1974.

OLI 7752

Table 2

U.S. FLUOROCARBON END-USE PATTERN - 1974

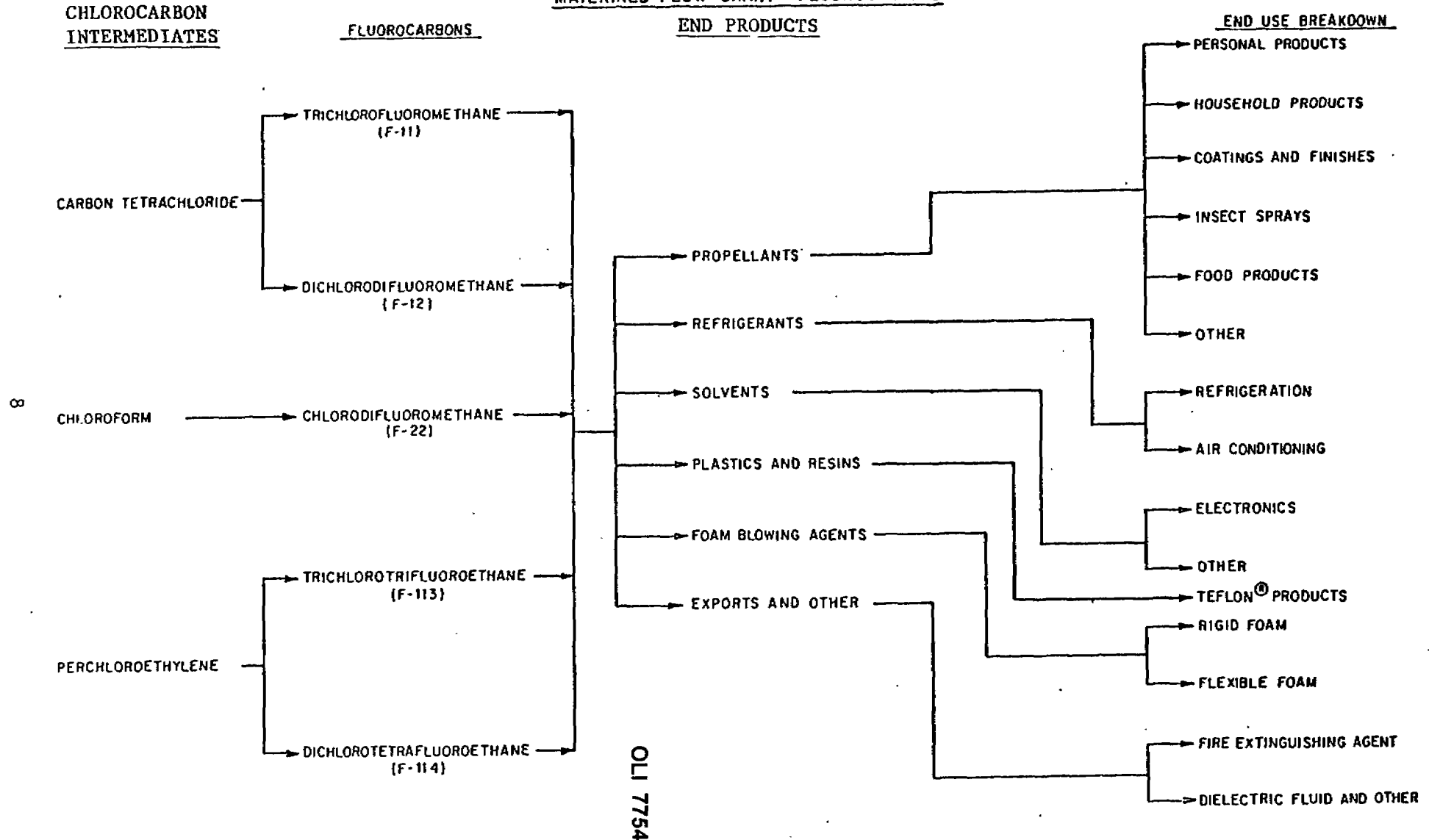
<u>End Use</u>	<u>Percent</u>
Aerosol Propellant	50
Refrigerant	28
Foam Blowing	7
Export and Other	6
Solvent	5
Plastics and Resin	4

Source: Arthur D. Little, Inc., estimates.

OLI 7753

Figure 1

MATERIALS FLOW CHART - FLUOROCARBONS



OLI 7754

Source: Arthur D. Little, Inc.

and F-12 are between 40 and 150 years, and as a result of these long lifetimes, the fluorocarbons are believed to eventually reach the stratosphere through vertical diffusion. Here they are subject to photochemical decomposition through interaction with high-energy ultraviolet radiation. This fluorocarbon decomposition releases a chlorine atom which reportedly reacts catalytically with ozone to form ordinary oxygen molecules. Key atmosphere ozone reactions are presented in Table 3.

Following publication of the work performed at the University of California, other scientists have corroborated the ozone depletion theory, and the current belief of these scientists is that a serious threat to stratospheric ozone exists as a result of the production and release (through aerosol propellant and other applications) of fluorocarbons 11 and 12. The ultimate concern is that depletion of the ozone layer would allow an increase in the incidence of ultraviolet radiation in the lower atmosphere and on the surface of the earth.

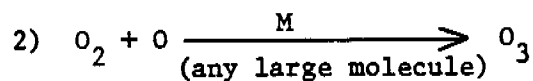
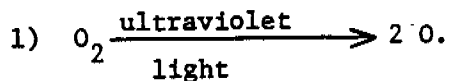
The ozone layer, which extends from approximately 10 to 20 miles above the surface of the earth, acts as a shield against excess ultraviolet radiation by absorbing light in the harmful wavelengths from 280 to 320 nanometers.¹ The possible threats of increased ultraviolet radiation in this wavelength range include an increase in the incidence of human skin cancer as well as the risk of as yet unquantified biological and climatological effects. These latter effects include possible interference with photosynthesis, cell reproduction, and the earth's

¹An nanometer is a unit of length equivalent to 1 billionth of a meter and is used as a measure of radiation wavelength.

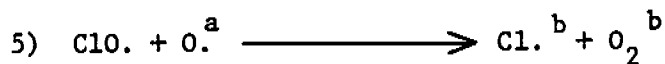
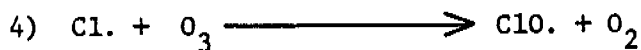
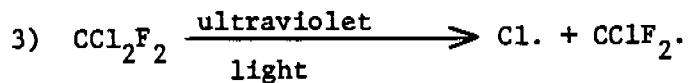
Table 3

KEY ATMOSPHERIC OZONE REACTIONS

Ozone Formation



Ozone Depletion



Net effect of reactions 4 and 5 is:



Explanation of Symbols:

O_2 = oxygen molecule

$\text{O} \cdot$ = oxygen atom

O_3 = ozone

CCl_2F_2 = F-12

$\text{Cl} \cdot$ = chlorine atom

$\text{CClF}_2 \cdot$ = F-12 radical

$\text{ClO} \cdot$ = chlorine oxide radical

Notes: a. $\text{O} \cdot$ is formed in a reaction not shown here.

b. This chlorine atom is free to react again as in reaction 4.

Sources: Crutzen, Geophysical Research Letters, Vol. 1, No. 5 (Sept. 1974) p. 205.
Cicerone, et.al., Science, Vol. 185 (Sept. 27, 1974) p. 1165.
Wofsy, et. al., Canadian Journal of Chemistry, Vol. 52 (1974) p. 1582.

OLI 7756

temperature and weather patterns. The former threat, linking an increase in skin cancer to an increase in the influx of ultraviolet radiation, has been well-documented; this relationship has been correlated with several hypothetical levels of atmospheric ozone depletion in Table 4. Although the concentration of the earth's ozone layer reportedly varies from time to time and place to place by as much as 50% or more, it is a decrease in the average ozone concentration which concerns scientists and which is expected to promote the development of skin cancer and lead to other adverse effects.

Estimates of stratospheric ozone depletion made by the university scientists involved in this controversy have ranged from 7 to 40% by 1995, although the most recent estimates fall at the low end of this range. A graphic representation of the predictions of six conceptual models of the relationship between future world fluorocarbon production and world stratospheric ozone depletion is presented in Figure 2. The alleged possibility of ozone depletion is a world-wide problem since horizontal diffusion of the fluorocarbons around the Earth is at least as fast as vertical diffusion to the stratosphere. Europe and Japan, two other major regions of fluorocarbon production and use, are closely watching developments surrounding this controversy in the U.S. and are expected to act largely on the basis of future developments here.

Uncertainties in the ozone depletion theory, as has been pointed out by industry scientists, are numerous. First, and importantly, it must be remembered that the link between ozone depletion and fluorocarbons is a theoretical one. Additional information is continually surfacing, and several ongoing research programs, funded by both industry and the

Table 4

RELATIONSHIP BETWEEN DECREASE IN STRATOSPHERIC
OZONE CONCENTRATION AND ANNUAL INCREASE IN U.S.
CASES OF HUMAN SKIN CANCER

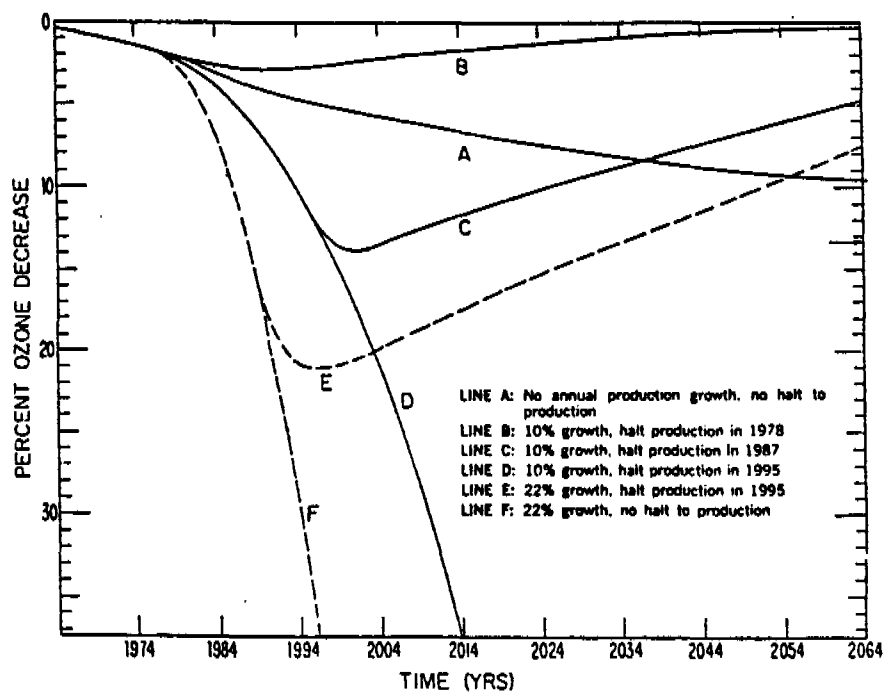
<u>Decrease in Ozone</u> <u>Concentration</u> (percent)	<u>Approximate</u> <u>Increase in Number</u> <u>of U.S. Skin Cancer Cases</u> (thousands)
5	40
10	90
20	200
40	540

Source: Dr. F. Urbach at Climatic Impact Assessment Program Conference, March 1974, Cambridge, Mass.

OLI 7758

Figure 2

REDUCTION IN CONCENTRATION OF
EARTH'S OZONE LAYER AT VARIOUS
CHLOROFLUOROCARBON RELEASE RATES



Source: Wofsy et.al. "Freon Consumption: Implications for Atmospheric Ozone," Science, Vol. 187 (Feb. 14, 1975) p. 535.

OLI 7759

Federal Government, are expected to shed additional light on the controversy during the next two to three years. Uncertainties in the current theory, which have been pointed out by industry scientists, include the possible existence of other natural processes to remove fluorocarbons from the atmosphere, and the possibility that other sources of chlorine in the stratosphere (which are naturally occurring) are large, relative to the amount of chlorine produced in the photochemical degradation of fluorocarbons. The implication here is that as yet undiscovered natural processes for removing chlorine atoms from the stratosphere may exist which have historically accommodated much larger concentrations of these atoms than would be released from fluorocarbon degradation.

Several related issues recently reported in the media could develop to the point where concern would be diverted from the current fluorocarbon ozone issue. One of these issues could divert attention from fluorocarbons, the other could put fluorocarbons in a worse position than the current one. The first issue concerns a recent report that nitrous oxide, released to the atmosphere as a result of the widespread use of nitrogen fertilizers, could pose a much more severe threat to the ozone layer than is currently attributed to fluorocarbons. A second issue revolves around the recently published report attributing to fluorocarbons the environmental hazard of setting up a so-called greenhouse effect in which infrared radiation, normally radiated by the Earth's surface, is absorbed by fluorocarbons in the atmosphere. This effect would theoretically contribute to a long-term net increase in the Earth's temperature.

OLI 7760

Other threats to stratospheric ozone include the oxides of nitrogen released in the upper atmosphere by supersonic transport (SST) jet engines, nitric oxide released as a result of high-altitude atomic bomb explosions, and stable halocarbons (other than F-11 and F-12) such as F-22, carbon tetrachloride, methyl chloroform and methyl bromide. Halocarbons which have a relatively fast rate of degradation in the lower atmosphere compared with their rates of vertical diffusion are not likely to pose a serious threat to the ozone. On the other hand, rapid photochemical decomposition in the lower atmosphere as occurs with trichloroethylene may be cause for other, unrelated, environmental concerns such as smog formation.¹

In summary, as the Interagency Task Force on Inadvertent Modification of the Stratosphere (IMOS) concluded in its report released in June of this year, there is a legitimate cause for concern about the effects of fluorocarbons 11 and 12 on the earth's protective ozone layer. We would add that there is, therefore, legitimate cause for concern on the part of the manufacturers, raw material suppliers and consumers of these fluorocarbons. Based on discussions with a scientist who is intimately involved in the current ozone depletion controversy (as a member of academia), he and several other scientists are of the opinion that the current theories have approximately a 70% chance of being validated by the extensive research programs now under way. Although industry

¹It should be noted that the ozone build-up often associated with photochemical smog formation has no connection with the fluorocarbon ozone controversy discussed above. Ozone is a strong irritant and a highly reactive chemical; there is no feasible way to balance excess ozone on Earth with the alleged stratospheric depletion.

OLI 7761

representatives would undoubtedly assign a much lower probability to this validation, it must be remembered that a mere continuation of this controversy over a span of several years is likely to have an adverse effect on growth and absolute demand levels for fluorocarbon use in such consumer products as fluorocarbon-propelled aerosol sprays.

In a recent development, the Consumer Product Safety Commission only narrowly rejected a proposal requesting a ban of fluorocarbon-propelled aerosol products. However, the Council on Environmental Quality has urged that a ban be placed on fluorocarbon propellants unless the results of work now being performed by the National Academy of Sciences (due in April 1976), show that no hazard exists. Another recent development, which may be indicative of a trend on the part of current fluorocarbon propellant users, was the action of S.C. Johnson and Son, Inc. in which Samuel C. Johnson, Chairman and Chief Executive Officer, announced plans to remove all fluorocarbon propellants from Johnson's production line on June 17 of this year as an indication of the company's concern.

B. Fluorocarbon Uses and Alternatives

Current uses of the more than one billion pounds of fluorocarbons produced in the U.S. in 1974 were presented in Table 2. Propellant and refrigerant applications are by far the most important, accounting for nearly 80% of total fluorocarbon demand. Although alternatives to fluorocarbons are available in these and other applications, the alternatives, which in most cases have existed for considerable lengths of time, have not been attractive on a cost/performance basis when compared

to the fluorocarbons currently in use. The alternatives available in propellant and refrigerant applications are discussed below.

Several alternatives to the fluorocarbons currently used as aerosol propellants exist. These include other liquified gases such as hydrocarbons and other fluorocarbons, as well as compressed gases such as carbon dioxide, nitrogen and nitrous oxide. With the exception of other fluorocarbons, all of these alternate propellants have the advantage of lower cost but have disadvantages--in terms of either performance or consumer safety, and therefore product liability threats--which outweigh the cost advantages. Other fluorocarbons would likely be more expensive and would also be likely to face strict scrutiny as possible environmental hazards.

The chief disadvantage of nitrogen is its extremely low solubility in aerosol formulations. Hydrocarbons pose a severe flammability threat in nonwater based aerosols such as in the personal products category. Carbon dioxide, despite its shortcomings relative to fluorocarbon propellants, is probably the most likely candidate for substitution in nonaqueous aerosol formulations. Recent developments by aerosol valve manufacturing companies are expected to minimize some of the shortcomings normally associated with carbon dioxide propelled aerosols such as coarseness of spray and vapor pressure drop with use. The major carbon dioxide producers are supporting and encouraging these developments.

Nonaerosol alternatives to the fluorocarbon propellants also exist and are under further development at this time. These include finger-pump hairsprays as well as roll-on, stick, and pad deodorants, which have recently experienced a strong comeback. While demand for aerosol

personal products has been depressed since early 1974, sales of non-aerosol products have nearly doubled in early 1975 relative to year-ago levels. Pump manufacturers are straining to meet demand while aerosol valve manufacturers are working rapidly to develop their engineering and manufacturing capabilities for pump units.

Alternatives to the current use of fluorocarbons as refrigerants are, in the short run, not as viable as those discussed above for fluorocarbon propellants. Alternative refrigerants exist but virtually all of them have flammable and/or toxicity problems which, in terms either of current laws or potential liability suits, are not currently feasible for the vast majority of refrigeration applications. Any shift to an alternative refrigerant would require a considerable length of time in order to allow for redesign, testing and the development of manufacturing capability for the modified refrigeration system that would be required. If the current ozone depletion theory is validated, it is indeed possible that alternative refrigerants or refrigeration technology could be developed. However, a more likely scenario over the short term (again, if the ozone depletion theory is validated) would be for Federal legislation to require improved containment and possible recycling of fluorocarbons used as refrigerants. This possibility is discussed below.

OLI 7764

C. Possible Regulatory Scenarios

As of July 1975, the IMOS Committee stated that serious cause for concern exists and IMOS is supporting the current intensive research program to gather more information relating to this controversy. In view of current and possible future developments, it is difficult to predict the nature and timing of possible regulatory scenarios to control

the production and use of fluorocarbons. In its report, IMOS mentions the possibility of a ban on fluorocarbons as aerosol propellants in 1978 in conjunction with a requirement for improved containment and the recycling of fluorocarbon refrigerants. Other possible scenarios range from a ban on all fluorocarbon production and use, at one extreme, to limitations on high volume fluorocarbon-propelled aerosol segments such as the personal products segment. We believe that the regulatory scenario incorporated in the IMOS report provides a reasonable base from which to assess implications for chlorine demand of possible regulatory action to control fluorocarbons. The IMOS recommendation was limited to possible control of fluorocarbons 11 and 12 and accordingly our analysis focuses on the possible implications for chlorine demand of action to control the production and use of these two fluorocarbons.

OLI 7765

D. Implications for Chlorine Demand

As shown in Table 5, approximately 7% of total U.S. chlorine demand (1974, somewhat less on a disappearance basis) is linked to the production of fluorocarbons 11 and 12. Propellant applications account for nearly two thirds of this demand or an estimated 4.4% of U.S. chlorine production on a demand basis. Assuming that some critical fluorocarbon propellant applications are exempted from regulations and also that some of the carbon tetrachloride used as a raw material in the production of F-11 and F-12 is produced from by-product HCl, we estimate that approximately 4% of U.S. chlorine demand (c.a. 450 thousand tons) could be in jeopardy. Assuming continuation of chlorine demand growth at recent historic rates, this percent of chlorine demand would represent approximately 600 thousand tons of chlorine in 1980. Adjusting this quantity for a

Table 5

U.S. CHLORINE DEMAND RELATED TO FLUOROCARBONS 11 AND 12 - 1974

<u>End-Use Category</u>	<u>Percent of Total Chlorine Demand</u>
<u>Propellant</u>	
F-11	2.7
F-12	<u>1.7</u>
Total	4.4
<u>Refrigerant</u>	
F-11	0.2
F-12	<u>1.2</u>
Total	1.4
<u>Other</u>	
F-11	0.6
F-12	<u>0.6</u>
Total	1.2
<u>Total</u>	
F-11	3.5
F-12	<u>3.5</u>
Total	7.0

Source: Arthur D. Little, Inc., estimates.

OLI 7766

judgemental 70% probability of actual restriction, reduces the (theoretically) jeopardized 1980 chlorine demand to slightly more than 400 thousand tons. We estimate this to be roughly 3% of chlorine demand in that year.¹

While most propellant applications of fluorocarbons may be controlled under existing legislative authority of various Federal agencies, no such authority exists for control of the use of fluorocarbon refrigerants. However, EPA would have this authority should the pending Toxic Substances Control Act be approved. If containment and recycling of fluorocarbon refrigerants is required as part of possible legislation to control atmospheric emissions of F-11 and F-12, an additional 1.4% of chlorine demand would be jeopardized. When adjusted for original equipment refrigerant sales as well as the judgemental 70% probability for legislation discussed above, this value drops to 0.6% of 1974 chlorine demand or approximately 70 thousand tons of chlorine. This would be equivalent to an estimated 90 to 95 thousand tons of chlorine in 1980. Potential restrictions on fluorocarbon 11 and 12 use in foam blowing applications would be somewhat smaller than for refrigerants. If this is taken as 45 thousand tons in 1980, total effective chlorine demand reduction from fluorocarbon restrictions could exceed 500 thousand tons in that year.

¹The loss of chlorine demand in 1980 is used as the basis for these estimates, as well as others in the report, because the timing of potential market losses is too indefinite to permit a reliable year-by-year estimate.

OLI 7767

III. REGULATORY ISSUES RELATING TO VINYL CHLORIDE

In recent years the consumption of polyvinyl chloride (PVC) has been affected by a number of societal risk factors. The solid waste, health and air quality issues are the most significant ones at this time.

A. The Solid Waste Issue

Problems for vinyl chloride first arose in 1970 when environmentalists and the U.S. Environmental Protection Agency (EPA) expressed concern about the problems of disposing of PVC, either by incineration or in landfills. With regard to incineration, hydrogen chloride gas (HCl) is the primary product of concern, because HCl evolves when PVC is heated to its decomposition temperature. In the presence of moisture, HCl becomes hydrochloric acid, which can lead to the corrosion of incinerator parts and, in the vapor state, can contribute to air pollution in the vicinity of the incinerator.

Although in the early seventies this issue received a considerable amount of press coverage, it was essentially defused not because of industry and government studies, but because other more significant issues emerged. When viewed in perspective, the solid waste issue is of relatively little significance today.

According to an earlier study for the EPA by Arthur D. Little, Inc., PVC on the average accounts for only about 0.2 % by weight of all urban and industrial solid waste, and the concentration is not expected to increase dramatically during the next decade. Furthermore, the results of incinerator studies have indicated that hydrogen chloride is generated by burning

OLI 7768

normal refuse in the absence of PVC, and HCl from this general refuse source is often more significant than HCl that comes from PVC. In any case, hydrogen chloride is not the only factor that leads to incinerator corrosion. Other factors, such as uneven heating and cooling, moisture, oxidation by air and mechanical stresses also contribute to the destruction of the grate metal and other metal parts in the incinerator. As these factors are brought under better control, the corrosion problem will be minimized. For example, European incinerator technology has advanced to the state where refuse with even higher concentrations of PVC than 0.2% can be burned with minimum damage to the incinerator.

In landfill disposal operations, PVC is stable and not biodegradable. PVC, and plastics in general, do not add to the production of leachate or decomposition gases as do most other components of refuse. To date, operators of landfills have experienced no significant problems when handling municipal refuse containing plastics. Once crushed, plastic wastes behave like any other relatively inert material such as bricks, metal or earth.

The solid waste issue was essentially put to rest in early 1973 when, in short order, the Bureau of Alcohol, Tobacco, and Fire Arms of the U.S. Department of Treasury approved PVC as a material for the manufacture of plastic liquor bottles, and the Food and Drug Administration (FDA) was called in to investigate this use, because liquor apparently extracted residual vinyl chloride monomer (VCM) from the plastic container. This and other health threats are discussed in the following section of this report.

OLI 7769

B. Health and Air Quality Issues

In January, 1973, Schenley Distillers, Inc. reported to the FDA that they detected up to 20 parts per million (ppm) by weight of vinyl chloride in distilled alcoholic beverages packaged in PVC bottles. The FDA laboratories subsequently confirmed these findings. On the basis of these data, FDA issued a proposal to ban the use of PVC for liquor bottles, because residual VCM was extracted by distilled spirits and wines, and there were no available toxicological studies supporting a safe level of vinyl chloride in food at that time. The proposal was issued on May 17, 1973, and the Treasury Department subsequently imposed this ban.

This ban halted the growth of the PVC-bottle industry. From 1971 to 1973 the annual consumption of PVC in this application increased from about 50 to 85 million pounds, but in 1974 consumption dropped to about 75 million pounds. We believe that this Government ban arrested not only the growth of the PVC-bottle market for liquors but the use of PVC bottles in other end uses, as packagers became increasingly concerned with the potential health hazards of PVC.

Occupational Safety and Health Administration (OSHA) Regulations

In 1974, a new and more serious issue surfaced: concern over the carcinogenicity of VCM. The history of this hazard goes back to 1961, when Dow Chemical reported that long term (4 1/2 to 6 month) exposure of animals to VCM levels as low as 100 ppm resulted in slight liver abnormalities. Consequently, Dow recommended that VCM working exposure levels be reduced from 500 ppm to 50 ppm. Up until this time, the American Conference of Governmental Industrial Hygienists (ACGIH) had permitted a maximum allowable VCM exposure of 500 ppm.

OLI 7770

ACGIH did not go along with Dow's recommendation, because work done at Yale University in 1962 concluded that 500 ppm offered an adequate safety margin for human exposure, and in 1971 the Occupational Safety and Health Administration (OSHA) established 500 ppm VCM as a national standard for worker exposure.

In January of 1974 the exposure issue surfaced again when B.F. Goodrich reported to Kentucky Health Officials and the National Institute of Occupational Safety and Health (NIOSH) that the company was investigating the cancer deaths of three workers at its Louisville, Kentucky PVC resin plant. Subsequently, Goodrich reported the death of two additional employees due to angiosarcoma (a form of liver cancer), and in March, 1974, Goodrich reported cases of this same disease in two living employees. At the same time, Union Carbide, Goodyear Tire and Rubber, and Firestone Tire and Rubber each notified NIOSH of the death of a PVC worker from this same ailment--also in PVC resin plants. Altogether, these manufacturers identified ten workers in their PVC resin plants who had died of angiosarcoma.

On the basis of these industry findings and laboratory experiments, the Manufacturing Chemists Association (MCA) issued a press release on April 16, 1974 announcing preliminary indications that vinyl chloride produced liver cancer at exposure levels down to 50 ppm. The laboratory experiments included inhalation studies that exposed rats, mice, and hamsters to VCM concentrations of 250, 200, and 50 ppm for one year. Also, the Industrial Bio-Test Laboratories (under contract to MCA) found in their animal exposure study that angiosarcoma was produced in mice at VCM levels as low as 50 ppm.

OLI 7771

These findings led OSHA in April 1974 to issue a temporary emergency standard of 50 ppm. However, on May 10, 1974, based on the findings of the Industrial Bio-Test Laboratories, OSHA proposed a new standard to protect employees from hazards of exposure to VCM. This proposal called for limiting employee VCM exposure to the "nondetectable level" as measured by an analytical method sensitive to 1 ppm of VCM.

The industry attempted to fight this proposal but to no avail. On October 4, 1974 OSHA set a standard limiting employee exposure to 1 ppm of VCM averaged over any eight-hour period, and a ceiling of 5ppm averaged over any period not exceeding fifteen minutes.

With the announcement of this new standard, the vinyl industry continued its efforts to modify the OSHA regulations by going to the courts, although at the same time the industry began to move toward compliance. Finally, the case reached the Supreme Court, and earlier this year the Court decided that it would not hear the case presented by the Society of the Plastics Industry (SPI) and by certain PVC manufacturers. The regulation ultimately became effective on April 1 of this year.

During the first year (to April 1, 1976) employees exposed to VCM need not use a respirator where exposures are not in excess of a 25 ppm ceiling. However, the employer must provide each employee with an appropriate respirator. Its use is at the discretion of the employee where exposures are less than 25 ppm VCM; where exposure exceed the 25 ppm ceiling, respirator use is mandatory. After April 1, 1976 respiratory protection will be mandatory below the 25 ppm level.

OLI 7772

In spite of its earlier protests, some PVC resins are now available with as little as 1 ppm of residual monomer (e.g. as bottle compounds), and many of the PVC resin plants are close to meeting the new OSHA standards. Nevertheless, in the past two months, since the standard has been in force, several citations have been made by OSHA against specific PVC resin producers. In part, this may be due to the over-aggressiveness of the OSHA inspector but, more likely, the complexity of the new regulation has led to some confusion. According to trade announcements only one resin plant was partially shut down because of these new regulations. Goodyear announced in 1974 that the PVC resin capacity of their Niagara Falls plant was reduced by 50%.

The producers of VCM and PVC resin have been able to meet this new Government standard by: a) tightening their operating procedures, b) improving resin kettle clean-up operations, c) replacing leaking valves, d) reducing the number of vent points in the process, and e) improving the ventilation systems within the monomer and resin plants. An important process change that has also aided the industry in meeting this new standard has been the introduction of a new step: vinyl chloride stripping. Typically, before the resin is dried, after the polymerization reaction is completed but while the resin is still suspended in a water medium, much of the residual monomer is removed by distillation. In most instances, the stripped vinyl chloride monomer is recycled.

Although the OSHA regulation applies not only to monomer and resin producers but also to PVC fabricators, the fabricators are not expected to have difficulty meeting the VCM exposure standards. As the PVC resin producers gradually reduce the residual monomer content of their resins,

the fabricator will be able to operate essentially VCM-free facilities.

Although it is difficult to estimate the impact of the added costs of these new standards on the VCM and PVC industry, on the basis of our understanding, we believe that in the near term the net increase in cost of resin manufacture will add only a modest increment to the current cost.

Vinyl Chloride as a Propellant

Based on the health hazards of VCM, the Consumer Product Safety Commission banned the use of vinyl chloride as a propellant in aerosol products under its jurisdiction, e.g. spray paints, household cleaners, and degreasing agents. The EPA also suspended the use of vinyl chloride as a propellant in pesticide products registered for indoor use in homes, food handling establishments, hospitals, and other enclosed areas. Finally, the FDA banned the use of vinyl chloride in aerosols containing drugs and cosmetics. In 1974 the use of vinyl chloride as a propellant was a very small factor compared to its use in other applications, and these actions had only a modest effect on VCM demand.

EPA Regulations

In late 1974, under the Clean Air Act, EPA considered the promulgation of new emission standards for vinyl chloride monomer from manufacturing facilities. The assessment of emissions from vinyl chloride monomer and PVC resin facilities was done by the Air Quality Office of EPA, and Arthur D. Little, Inc., carried out a study of the emissions of vinyl chloride monomer from PVC fabrication plants for the EPA. Our study essentially documented that there is little need for new air quality standards for PVC fabrication plants. Considering the total U.S. emissions

of vinyl chloride monomer in 1974, only about 0.4% were derived from the fabrication processes; in contrast, about 95% were evolved during resin production, and the rest during the manufacture of VCM.

Earlier this year, EPA announced a proposed standard for emissions of vinyl chloride monomer into the atmosphere from monomer and polymer plants. The EPA standards are based on the best available control systems for each of the various emission points, with the intention of reducing emissions from typical VCM and PVC resin plants by approximately 95%.

To meet this objective, the emissions of VCM from the various vent points in a PVC manufacturing facility will be limited to no more than 10 ppm. Originally, EPA proposed that all PVC resins should be stripped to a residual vinyl chloride monomer content of 400 ppm (dry basis) prior to their transfer to the drier. (Most PVC polymers are made in aqueous systems and must be isolated and dried before shipment and final processing.) However, because the manufacturers of the so-called paste or dispersion resins, which are made by emulsion processes, indicated that they could not meet this standard, the EPA backed off. At this time, EPA requires a limit of 2,000 ppm of residual VCM in the dispersion resins after stripping. Furthermore, the standard proposes that the emissions should be no greater than 6 ppm in the process water effluent from PVC plants. EPA expects to issue the revised standard early in the fall of this year, and a 30 to 60 day period will be allowed for the industry response. The standard should be promulgated by the end of this year (1975).

The VCM/PVC industry believes that it will be able to meet the proposed EPA standards. The cost of meeting these standards will probably be less than that required to meet the OSHA standard.

OLI 7775

The major impact of the emission standard appears to be its effect on certain dispersion resins that are difficult to strip. The paste resin industry is now working diligently to develop new approaches for manufacturing dispersion resins that are affected by the standard; in particular, they are attempting to modify the polymerization system to permit easier stripping of the final product.

FDA Regulations

Since 1958, a number of food-additive regulations have been promulgated by the FDA for use of PVC as a component of food-contact articles, including food packaging. These and other uses were approved largely on the basis of the original data showing low solubility of the vinyl chloride monomer in the product. As noted above, however, FDA has recently found that vinyl chloride monomer can migrate into food. FDA's first action as a result of this finding was to recommend the ban of PVC as a packaging material for distilled alcoholic beverages. Subsequently, FDA has found that vinyl chloride monomer also can be extracted into vegetable oils and into a variety of "food-simulating solvents," including water and acetic acid. The FDA has been the most cautious of the government agencies in avoiding overreaction to the vinyl chloride problem. Although FDA recognizes the findings of carcinogenicity of vinyl chloride monomer upon inhalation, the agency is only concerned with the question of whether VCM is carcinogenic when ingested.

In March of this year, an Italian cancer expert who has been actively involved in evaluating the health hazards of vinyl chloride monomer, released a preliminary report that vinyl chloride monomer induces

OLI 7776

cancer when fed to rats. Final results are not expected until late August 1975, and FDA has delayed promulgation of new standards until these results are received. However, even these preliminary results put vinyl chloride on a direct collision course with the Delaney Clause, which states that any substance which causes cancer in even one animal must be banned from contact with food or cosmetic products. Up to this point, the FDA has planned to limit the use of PVC in food applications to those applications that would leave no detectable residue of VCM in the food product. Today, it is apparently possible to detect levels of VCM as low as 50 parts per billion.

If FDA decides to propose such a standard, industry representatives feel confident that the new standard could be met with the new low-residual-monomer resins that are currently available from some PVC producers. The concern, however, is that FDA may ban outright the use of PVC as a packaging material for food and cosmetic products, and in a related development Ralph Nader's Health Research Group has petitioned (July, 1975) the FDA to ban PVC as a food packaging material. We expect the FDA to issue a proposed standard in the near future.

Concern over the use of PVC pipe for potable water also has surfaced in recent months. However, the FDA does not consider this application to represent a potential for significant levels of extractives, since such a large volume of water repeatedly comes into contact with the PVC pipe surface, as opposed to the situation with a bottle. Recently, the American Water Works Association approved PVC pipe for water distribution systems.

OLI 7777

C. Impact on Demand for VCM and PVC

When OSHA initially (1974) considered the promulgation of a standard requiring a non-detectable level of monomer in PVC and VCM plants, the concern of the PVC industry was that it would have to essentially shut down in order to meet this standard. However, based on the information we have evaluated during the past year, this prospect is considered unlikely. A few more PVC plants may be shut down during the next two years or so, but these will be cases where the PVC resin plant is considered too old and inefficient to merit the new investment required to meet the standards. We do not expect a large number of further shutdowns and the percentage of total industry capacity represented by these older plants, which may be shut down, is small. Moreover, PVC producers have expanded their resin-making capabilities substantially within the past two years and there are three new producers.

Another concern that was raised last year was that even if the PVC industry were able to meet the new standards, the costs involved would drastically increase the cost and therefore the selling price of the PVC resin. Consequently, PVC would no longer maintain its competitive position among plastic resins and other non-plastic materials. However, based on our evaluation, it is the external market factors per se that will essentially control the selling price of PVC resins rather than the effect of new government regulations. In recent months, the demand for PVC (and other plastic resins) has fallen off, not principally because of societal issues but because of the severe business recession.

As the economy picks up, we expect that the selling price of PVC resins will increase only modestly due to the new government regulations.

For example, Tenneco is now advertising the availability of a number of new PVC grades that contain no more than 10 ppm of residual monomer. This company has stated that they were able to absorb the added costs and, therefore, are selling these resins at no price premium in comparison with "regular" PVC resins. Nonetheless, these new regulations are expected to affect the consumption of vinyl chloride monomer and, consequently, the consumption of chlorine. The impact will come from two actions: a) the effect of improved efficiency by the PVC resin producer, and b) the expected loss of the food-packaging market.

Effect of Improved Efficiency

As indicated above, the PVC industry has responded to the OSHA regulations by stripping residual monomer from the PVC resin after polymerization. In most instances, this monomer is recovered and recycled. Recycling of VCM is more difficult in the case of copolymer manufacture than is true when only homopolymer is made, because the distillate would require further fractionation.

In the recent past, 105 to 106 pounds of vinyl chloride monomer were required to manufacture 100 pounds of PVC homopolymer. Today, with recycling, the industry typically will use 101 to 102 pounds of vinyl chloride monomer to make 100 pounds of PVC resin.

To calculate the effect of this improved efficiency on chlorine demand, we first estimated chlorine demand for the manufacture of PVC resins in 1980, assuming no impact of the vinyl chloride monomer issue. These estimates are summarized in Table 6. Because of the current recession, we believe that 1975 PVC production will show a drop of about 18% as compared to 1974. This would imply about 4 billion pounds of

Table 6

AN ESTIMATE OF CHLORINE DEMAND IN MANUFACTURE OF PVC RESINS IN 1980,
ASSUMING NO IMPACT OF THE VINYL CHLORIDE MONOMER ISSUE

	<u>Billion Pounds</u>
1. Actual volume of production of PVC resins in 1974	4.9
2. Estimated production of PVC resins in 1975	4.0
3. Estimated production of PVC resins in 1980	6.5
4. VCM contained in PVC resins in 1980	6.4
5. VCM consumed in manufacturing PVC resins in 1980	6.7
6. Chlorine consumed in manufacturing PVC resins in 1980	4.6

Source: Arthur D. Little, Inc. estimates.

OLI 7780

PVC resin production in 1975. If, on the average, the PVC market grows 5% annually from 1974 to 1980, then we estimate that 6.5 billion lbs of PVC resins would be produced in 1980.

To estimate the amount of vinyl chloride monomer required for PVC resin in 1980, one must consider that some PVC resins are copolymers, containing monomers other than vinyl chloride. As shown in Table 7, about 16% of the present production of PVC is as copolymer. The comonomer concentration in these copolymers varies from 3 to 25%. Assuming an average of 15% comonomer in the PVC copolymers, the estimated consumption of comonomers amounts to about 2% of total PVC resin production. When this factor is taken into account, the 6.5 billion pounds of VCM contained in the PVC resin should be reduced to 6.4 billion pounds.

On the basis of yield, if we assume 105 pounds of VCM are used to make 100 pounds of PVC, then 6.7 billion pounds of vinyl chloride monomer would be consumed in manufacturing PVC resins in 1980, if the vinyl chloride monomer issue had no impact. On this basis, the chlorine demand for this amount of VCM would become about 4.6 billion pounds in 1980, assuming 0.68 pounds of chlorine per pound of monomer.

To determine the effect of improved efficiency, we assumed that only 101¹ pounds of VCM would be used to manufacture 100 pounds of PVC. (These estimates are indicated in Table 8.) Therefore, the original 6.7 billion pounds of vinyl chloride monomer required to manufacture the PVC resins in 1980 would be reduced to 6.4 billion pounds.

¹ This conversion factor may be slightly optimistic.

TABLE 7

AN ESTIMATE OF "OTHER MONOMER" CONSUMPTION IN THE
MANUFACTURE OF PVC RESINS - 1974

PVC Resin Production By Type and Process	<u>% of Production</u>
1. Suspension & Bulk Homopolymers	75
2. Suspension Copolymers	12
3. Solution Copolymers	3
4. Latex Copolymers	1
5. Emulsion Homopolymers	9

Total Estimated Production of Copolymers 16

Assume an average of 15% comonomer in
copolymer, then estimated consumption
of comonomer is 2% by weight of total
PVC resin production.

Source: . Arthur D. Little, Inc. estimates.

OLI 7782

TABLE 8

AN ESTIMATE OF LOST CHLORINE DEMAND IN MANUFACTURE OF PVC RESINS
IN 1980, CONSIDERING THE IMPACT OF THE VINYL CHLORIDE MONOMER ISSUE

	<u>Billion Pounds</u>
I. Effect of Improved Efficiency	
Assume: (1) VCM contained in PVC resins in 1980 (includes PVC copolymers)	6.4
(2) Due to improvements in efficiency, 101 lb of VCM are used for 100 lb of PVC	
Then: (1) VCM consumed in manufacturing PVC resins in 1980 is reduced from 6.7 to	6.4
II. Effect of Loss of Food Packaging Market	
Assume: (1) Food packaging market for PVC in 1974 (see Table 9)	0.22
(2) 3% annual growth '74-'80	
Then: (1) Loss of food packaging equals	0.27
III. Net VCM Demand Loss in 1980	
(1) Improved efficiency	-0.3
(2) Loss of food packaging	<u>-0.27</u>
Total	-0.57
IV. Lost Chlorine Demand in 1980 ¹	0.4

¹ Assumed 68 lbs Cl₂ used for 100 lbs PVC

Source: Arthur D. Little, Inc. estimates.

OLI 7783

Effect of the Loss of the Food Packaging Market

Our estimates of the food packaging market for PVC in 1974 are shown in Table 9. About 65% of the present PVC packaging market is devoted to food applications; this amounted to about 224 million pounds in 1974. In the absence of the vinyl chloride monomer issue, we would have expected the food packaging market for PVC to grow, on the average, about 3% annually from 1974 to 1980. Therefore, if the entire PVC food packaging market were lost in 1980, the loss would amount to about 267 million pounds that year. On this basis, the 6.4 billion pounds of VCM projected to be consumed in 1980 to manufacture the PVC resins would be further reduced to about 6.1 billion pounds. Consequently, chlorine demand for PVC in 1980 would be about 4.2 billion pounds (2,100 thousand tons) instead of 4.6 billion pounds (2,300 thousand tons). The difference of about 400 million pounds represents an 8.7% loss in projected chlorine demand for this use (ca. 1.3% of total demand). Realistically, however, we could expect that if the food packaging market were lost, the "ripple effect" with respect to the use of PVC in other packaging applications (especially in bottles) would further increase the PVC loss within the packaging market by another ca. 80 million pounds.¹ This latter estimate assumes the complete loss of the PVC bottle market. On this basis, then, the net loss in potential chlorine demand for PVC, based on improved monomer yield and lost packaging markets, could be as high as 450 million pounds (approximately 1.5% of total chlorine demand).

¹Equivalent to 55 million pounds of chlorine.

OLI 7784

TABLE 9

AN ESTIMATE OF PVC FOOD PACKAGING MARKET (1974), ASSUMING
NO IMPACT OF VINYL CHLORIDE MONOMER ISSUE

PRODUCT	Total Packaging	
	Use	Food Use
	(Million Pounds)	
Film	125	113
Sheet	81	41
Bottles	75	8
Bottle Cap Liners & Gaskets	32	32
Coatings	30	30
Total	343	224

Source: Arthur D. Little, Inc. estimates.

OLI 7785

D. VCM Impact Summary

In conclusion, we believe that as a maximum, 1980 chlorine demand for PVC manufacture could be reduced by about 10% due to the societal issues involved in PVC consumption. Even so, future growth in the markets for PVC should be healthy. For example, use of PVC in pipe and fittings is a large application with considerable growth potential as PVC continues to replace clay and other materials. In addition to pipe and fittings, the construction industry offers opportunities for PVC use in such applications as window frames, door jambs and siding. The potential for PVC in these applications is large but growth will be limited by the rate of acceptance by the industry. Other segments viewed as having healthy growth prospects are home furnishings, flooring and transportation.

OLI 7786

IV. THE OUTLOOK FOR CHLORINATED SOLVENTS

A. Introduction

Chlorinated solvent demand for chlorine represents about 10% of current U.S. chlorine production. These solvents find wide use in such applications as textile and metal cleaning. An end-use pattern for each of the four major chlorinated solvents is presented in Table 10.

In the past decade concern has grown over the health and environmental effects of the vapors emitted during the use of these solvents. Of particular concern recently has been the recent link of trichloroethylene with tumor formation in mice. A review of the current health and environmental issues surrounding each of these solvents is presented below.

B. Prospects for Individual Solvents

Trichloroethylene

The consumption of trichloroethylene (tri) has been declining in the last several years primarily as a result of the restrictions imposed on its use by Los Angeles County's Rule 66 and similar legislation. Air pollution regulations have caused the vapor degreasing industry (by far the largest user of tri) to switch, at least partially, to other chlorinated hydrocarbons.

Earlier this year the National Cancer Institute (NCI) issued a "Memorandum of Alert" warning that a preliminary evaluation indicates that trichloroethylene induces tumors in mice. The announcement by NCI and subsequent publicity has forced General Foods to switch from tri to methylene chloride as the solvent for removing caffeine from its decaffeinated coffee products. Extraction is the only use besides vapor degreasing and cold cleaning that is of any significance.

Table 10
U.S. CHLORINATED SOLVENT END-USE PATTERN - 1974

<u>Solvent</u>	<u>End Use</u>	<u>Percent</u>
Trichloroethylene	Cleaning Solvent	87
	Export	8
	Extraction Solvent	3
	Other	<u>2</u>
	Total	100
Perchloroethylene	Dry Cleaning Solvent	67
	Fluorocarbons	15
	Export and Other	10
	Cleaning Solvent	<u>8</u>
	Total	100
Methyl Chloroform	Cleaning Solvent	68
	Exports	14
	Aerosol Formulation, Adhesive Solvent	10
	Vinylidene Chloride	<u>8</u>
	Total	100
Methylene Chloride	Paint Remover	40
	Process Solvent and Other	30
	Export	20
	Cleaning Solvent	<u>10</u>
	Total	100

Source: Arthur D. Little, Inc., estimates.

OLI 7788

The industry and various government agencies (FDA, OSHA, NIOSH) are awaiting NCI's final report. It is not clear at this time what the final ruling on tri will be, but further restrictions on its use, especially for food extraction and anesthesia are likely. If tri is definitely shown to be a carcinogen, a "no detectable" limit exposure level, similar to that for vinyl chloride, will probably be enacted. Growth prospects for tri are difficult to assess in view of the current uncertainty, however, an annual decrease in demand of from -3 to -8% (on average) seems likely between 1975 and 1980.

Perchloroethylene

The major use of perchloroethylene (per) is as a drycleaning solvent. This application has become less important recently with the advent of wash-and-wear clothing. The decline has been partially offset by an increase in the use of coin-operated drycleaning machines which are less efficient in solvent use per 100 pounds of clothing than are the professional machines.

A substantial amount of per is also used in textile processing. The use of per and other chlorinated solvents is expected to increase as textile operations change from "open-loop processing" to "closed-loop processing" in order to comply with water pollution standards. While the increase in demand for this application will be sizable, it will not have a major impact on the total per market. A much more significant boost in demand is likely to result from a partial replacement of tri in vapor degreasing operations.

While the growth prospects for per seem fairly good, especially in light of the current pressure on tri, they are based on the assumption that per itself will not be restricted. The NCI is in the process of testing

per for possible carcinogenicity, and since per is structurally similar to both vinyl chloride and tri, there is a very real possibility that per will also be found to have the capability for inducing cancer. The growth prospects for per (at an estimated annual average of 5 to 6% from 1975 to 1980) are also based on the assumption that fluorocarbon 113 and 114 demand (based on per as a raw material) will remain strong despite the current controversy surrounding fluorocarbons.

Methyl Chloroform

Methyl chloroform is used primarily in the cold cleaning of fabricated metal parts. To a somewhat lesser extent, it is used in vapor degreasing operations. Approximately 8% of current demand is used as a chemical intermediate in the production of vinylidene chloride.

As a result of the restrictions of Rule 66 and similar legislation, demand for methyl chloroform has grown rapidly over the past several years. A significant shift away from tri, and to methyl chloroform has occurred. Per and methylene chloride have also benefited somewhat from the restrictions placed on tri as a photochemical pollutant.

The growth prospects for methyl chloroform are good (estimated average annual growth of 7 to 8% between 1975 and 1980). However, growth could be severely restricted by a number of factors which could become important over the next several years. Three key factors worthy of concern are: the possible carcinogenicity of methyl chloroform, potential EPA emissions standards, and recent concern that the relatively high stability of methyl chloroform may allow it to achieve significant concentration levels in the stratosphere and thus pose a threat to the Earth's ozone shield.

OLI 7790

Methylene Chloride

Paint removal, solvent degreasing, aerosol product formulation¹ and plastics processing are the major uses of methylene chloride. Paint removal applications account for approximately 40% of current demand, with the largest market segments being use by households, the military and the airlines.

Growth prospects for methylene chloride are good, assuming that supplies of raw materials are available. Methylene chloride is likely to be a small beneficiary of the current health and environmental control pressures on trichloroethylene. While most vapor degreasing operations will switch to the cheaper per and methyl chloroform, food processors will have no immediate alternative but to use methylene chloride. Also, pressure on fluorocarbons should help boost demand in formulation of aerosol products.

No immediate EPA or OSHA pressure on methylene chloride is foreseen but it is likely that all chlorinated hydrocarbons will ultimately be investigated for carcinogenicity. Until methylene chloride is cleared of any possible link to cancer, its long-term prospects must be viewed with cautious optimism.

¹Methylene chloride acts as both a vapor depressant and a solvent.

OLI 7791

APPENDIX

Outlook for VCM and PVC Capacity

A question was raised with regard to the expected availability of capacity for the manufacture of VCM and PVC over the next 5 years. Based on our understanding, we believe that current and planned monomer and polymer capacity will not be sufficient to meet 1980 demand and could act as a constraint to the continuing growth of the PVC market.

Various estimates of the total U.S. PVC resin capacity expected at the end of 1975 indicate that about 6.5 billion pounds per year of capacity will be available. Estimates of vinyl chloride monomer capacity indicate that also about 6.5 billion pounds per year of nameplate capacity are available at this time. Borden has recently announced that it will have a new 300 million pound per year VCM plant on stream at Geismar, La. at the end of 1976. This would further increase the total annual VCM capacity to 6.8 billion pounds by 1977. If we take into account the efficiency of the monomer plants and assume that about 90% of nameplate capacity or 5.9 billion pounds is the practical operating limit, then this capacity will not satisfy the needs of the market that we have projected. However, we expect that as the market continues to grow, producers will continue to announce and install new capacity to meet growing demand for these materials.

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This topic, which was not strictly speaking within the scope of our study, is covered only briefly here--based on our current understanding of the VCM/PVC capacity situation. For a precise, up-to-date analysis of this situation further analysis is suggested.

OLI 7792