ECONOMIC ANALYSIS
OF
INTERIM FINAL EFFLUENT GUIDELINES
FOR
THE ORGANIC CHEMICALS INDUSTRY
(PHASE II)

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Planning and Evaluation
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September 1975

This report has been reviewed by the Office of Planning and
Evaluation, EPA, and approved for publication. Approval does
not signify that the contents necessarily reflect the views
and policies of the Environmental Protection Agency, nor
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endorsement or recommendation for use.

ENVIRONMENTAL PROTECTION AGENCY

PREFACE

The attached document is a contractor's study prepared for the Office of Planning and Evaluation of the Environmental Protection Agency ("EPA"). The purpose of the study is to analyze the economic impact which could result from the application of alternative effluent limitation guidelines and standards of performance to be established under sections 304(b) and 306 of the Federal Water Pollution Control Act, as amended.

The study supplements the technical study ("EPA Development Document") supporting the issuance of interim final regulations under sections 304(b) and 306. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports the proposal based upon an analysis of the feasibility of these guidelines and standards in accordance with the requirements of sections 304(b) and 306 of the Act. Presented in the Development Document are the investment and operating costs associated with various alternative control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the required applications of various control methods and technologies. This study investigates the effect of alternative approaches in terms of product price increases, effects upon employment and the cont ied vi .lity of affected plants, effects upon foreign trade and ot er competitive effects.

The study has been prepared with the supervision and review of the Office of Planning and Evaluation of the Environmental Protection Agency. This report was submitted in partial fulfillment of Contract No. BOA 68-01-1541, Task Order No. 32, by Arthur D. Little, Inc., Cambridge, Massachusetts. Work was completed as of September, 1975.

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This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of interim final and proposed rule making under sections 304(b) and 306 of the Act for the subject point source category. The study is not an official EPA publication. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during proposed rule making proceedings necessary to establish final regulations. Prior to final promulgation of regulations, the accompanying study shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of the contractor who studied the subject industry. It cannot be cited, referenced, or represented in any respect in any such proceeding as a statement of EPA's views regarding the subject industry.

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I. EXECUTIVE SUMMARY

This report deals with the definition of the economic impact of
proposed water effluent guidelines for selected products of the organic
chemicals industry which are included in Interim Final Effluent Guidelines,
Organic Chemicals Industry, Phase II. For the purpose of the analysis,
the industry is defined as products produced within SIC Codes 2865 and
2869.

The economic contractor was provided with effluent abatement cost
and investment data for the evaluation·of economic impact on 49 product-
process combinations. Thirty-three of these products or product groups
were studied in detail. The remainder were eliminated from detailed
study by a prescreening process on the basis of apparently low potential
for significant economic impact. The products covered by this analysis,
including 15 of those studied in depth and those which were prescreened,
are shown in Table I-1. Others studied in depth were excluded from
the current Interim Final regulations because of potentially severe
economic impact.

INDUSTRY DESCRIPTION

The organic chemicals industry is characterized by its diversity
and large number of individual products, optional raw materials and
processes, degree of integration, and rapidly changing technology. In
total, the industry in 1972 included 674 establishments, according to
the U.S. Census of Manufacturers, accounting for sales of approximately
$5.8 billion. The great majority of these establishments were, in
reality, plant complexes many of which were integrated forward or back-
ward to products falling outside of conventional industry definition.

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Each of the products of manufacture, whether discrete finished chemicals for sale or products which are one step in the chain of conversion within a complex, generates a specific raw waste load and consequent water treatment costs and investment. Since there was no apparent manner in which to meaningfully handle these individual products or complexes in aggregate form for the definition of economic impact, this report deals with some of the individual products of the industry, on a product-by-product basis, as manufactured by the specific process for which effluent treatment cost and investment data were provided.

METHODOLOGY

As a means of assessing the economic impact of water treatment costs on those products studied in depth, we utilized a specific analytical framework to arrive at the impact judgments. In addition to providing us with a systematic approach to the individual products, the methodology provides an explicit format in which conclusions are presented.

The development of the data and judgments within the framework is based on an analysis of the factors affecting the likelihood of the producer's: (a) passing on additional costs as price increases, (b) absorbing the costs, or (c) shutting his plant down. These factors include:

1. An analysis of market characteristics including: size and growth, product uses, substitute products, captive requirements, product prices, and other product specific considerations.

2. Description of supply characteristics including: manufacturing routes, the number and capacity of producers, raw materials, and estimated manufacturing economics for a "typical producer".

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These data, in conjunction with the costs and investments required for effluent treatment, were then summarized in an impact analysis matrix and judgments made as to probable economic impact.

The guidelines contractor provided cost and investment data required for meeting the proposed guidelines on the basis of producing plants in a free standing condition; that is, not associated in plant complexes with common effluent treatment facilities. In order to more closely approximate actual industry conditions, we modified these costs, from basic data provided by the guidelines contractor, to take advantage of the economies of scale in treating a specific plant's effluent in a medium-sized complex (3 million gallons per day) and a large complex (10 million gallons per day). We then estimated how the existing plants were distributed among the three categories and developed a range of effluent treatment costs depending upon the distribution of plants.

ECONO: IC IMPACT

Table I-1 shows the annual costs for pollution control in absolute terms and as a percent of 1973 selling prices. As shown in the table, the annual costs for pollution control are equal to or less than five per-cent of 1973 selling prices for all product segments except acrylonitrile, benzoic acid, hydrazine, isobutylene, maleic anhydride, ionones, and o-nitroaniline.

Table I-2 provides a summary of estimated investment costs in pollution abatement as a percent of estimated plant investment. This is provided only for those products studied in detail where estimates of production investment were developed.

The cost estimates presented represent total pollution control costs and do not include the possibilities of investment in pollution control that have already taken place or annual costs which are currently borne. Probably the incremental costs, and therefore impact, associated with the effluent guidelines will be less than as defined in this report.

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TABLE I-1

TOTAL ANNUAL COST FOR EFFLUENT GUIDELINES AND AS A PERCENT OF SELLING PRICE

In Depth Study Product	Annual Cost as Percent of Selling Price[2]		Total Annual Cost ($MM)[1]	
	BPT	BAT	BPT	BAT
Acrylonitrile (Propylene)	0.6-0.7	4.6-5.3	.85	6.24
Adiponitrile (Butadiene Chlorination)	[3]	[3]	.75	2.85
Benzoic Acid (Toluene)	0.3-25.0	1.4-26.7[6]	4.54	4.93
Calcium Stearate (Neut. & Precip.)	3.8	5.1	.60	.80
Carbon Tetrachloride (Thermal Chl.)	0.6-2.8	1.0-3.7	.55	.83
Chloroform (Thermal Chl.)	0.6-2.6	0.9-3.3	.24	.32
Hexamethylenediamine (Adip.)	[3]	[3]	.14	.83
Hydrazine (Ammonia)	6.3	7.5	.86	1.01
Isobutylene (Sulfuric Acid Ext.)	3.3-12.3	6.7-18.5	1.58-5.76	3.14-8.64
Isopropanol (Propylene)	0.5	0.7-0.9	.55	.79
Maleic Anhydride (Benzene)	10.7	10.7	4.51	4.51
Methyl Chloride (Thermal Chl.)	0.7-3.1	1.1-4.0	.32	.41
Methyl Ethyl Ketone (Sec. Butyl)	0.4	1.8	.09	.14
Methylene Chloride (Thermal Chl.)	0.5-2.2	0.8-2.8	.21	.33
Sec-Butanol (Butylene)			.06	.50
			15.85-20.03	28.34-33.84

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TABLE I-1 (Continued)

Prescreening Study Products	Annual Cost as Percent of Selling Price[4,5]	
	BPT	BAT
BTX Aromatics (Ref. Extraction)	1.8	2.6
Chlorobenzene (Benzene)	2.6*	3.3*
Citronellol & Geraniol (Cit. Oil)	2.0	3.6
Cumene (Benz. & Propyl.)	0.03*	0.03*
Disphenylamine (Aniline)	1.6*	1.8*
Ethyl Acetate (Ethanol)	1.3*	1.4*
Hexamethylenediamine (Hexan.)	1.2	1.5
Ionone & Methyl-Ionones (Citral)	7.4*	7.4*
Methyl Salicylate (Salicylic Acid)	0.7	1.0
o-Nitroaniline (o-Nitrochl. benz.)	3.9	6.5
p-Aminophenol (Nitrobenzene)	2.1	2.5
p-Nitroaniline (p-Nitrochl. benz.)	6.6	4.3
p-Xylene (Fract. Cryst.)	1.7	2.0
Phthalic Anhydride (Napth. & o-Xyl.)	2.2	2.9
Plasticizers (Phth. Anhy.)	1.2	2.1
Tannic Acid (Extraction)	1.3	2.1

1. Annual cost includes depreciation, cost of capital, operations and maintenance, and energy costs. Depreciation and capital cost was calculated using the capital recovery method at 8% over 20 years. Cost all on 1973 basis.

2. Selling price and pollution control cost on 1973 basis except for items marked with an asterisk which are on a 1972 basis. Ranges indicate scale economies resulting from variations in the size of the treatment system required.

3. Cost-price ratio for adiponitrile not computed separately since almost all adiponitrile is used captively and has no market price. The combined cost incidence of treatment for adiponitrile and hexamethylenediamine on the price of hexamethylenediamine is 0.5% and 1.9% for BPT and BAT, respectively.

4. Selling price and pollution control cost on 1972 basis except for items marked with an asterisk which are on a 1971 basis. Ranges indicate scale economies resulting from variations in the size of the treatment system required.

5. Total annual cost for prescreening products is probably higher than reality since limited data precluded factoring in scale economy in treatment costs in most cases.

6. See discussion under *Prices*.

TABLE I-2

INVESTMENT COST AS PERCENT OF
ESTIMATED PRODUCTION INVESTMENT[1]

	BPT	BAT
Acrylonitrile (Propylene)	3.6-4.1	13.3-19.1
Adiponitrile (Butadiene — Chlorination)	[2]	[2]
Benzoic Acid — Toluene	3.2-212	6.7-227
Calcium Stearate (Neut. & Precip.)	116	158
Carbon Tetrachloride (Thermal Chlor.)	1.5-5.9	1.9-7.7
Chloroform (Thermal Chlor.)	1.5-5.9	1.9-7.7
Hexamethylenediamine (Adiponitrile)	4.4	9.2
Hydrazine (Ammonia)	18.5	19.1
Isobutylene (Sulfuric Acid Ext.)	12-47	19-68
Isopropanol (Propylene)	6.1-7.3	8.0-10.1
Maleic Anhydride (Benzene)	15.1	15.1
Methyl Chloride (Thermal Chlor.)	1.5-5.9	1.9-7.7
Methylene Chloride (Thermal Chlor.)	1.5-5.9	1.9-7.7
Methyl Ethyl Ketone (Sec. Butanol)	3.1	5.8
Secondary Butanol (Butylene)	0.6	1.9

1. Production investment based on Arthur D. Little, Inc., estimate of cost for typical production plant, installed, mid-1970 basis. Ranges indicate a spread in treatment cost across plant size categories by wastewater flow volume and related economy of scale in treatment cost.

2. Production investment estimated for the combined process of butadiene-adiponitrile-hexamethylenediamine. Figures shown are for the combined treatment cost impact.

Costs for New Source Performance Standards are intermediate between BPT and BAT (sometimes equal to one or the other). They were not addressed specifically in this study, but general observations can be made by extension of BPT or BAT data.

Economic impact deals primarily with the effects of the effluent abatement costs on prices, production, plant closures, employment, community and regional development, industry growth, and the balance of trade. It should be recognized that a precise analysis of economic impact is difficult due to numerous other economic forces at work within an industry and the great variability between plants in such factors as pollution control costs, profitability, and return on investment. In a study such as this, it is not feasible to deal with these factors on a plant-by-plant or product-by-product basis. Subject to this qualification, the major findings of the study are summarized below.

Generally the costs of compliance are low and are not expected to signif-cantly affect prices, profitability, industry production, or growth in the product-process segments covered by these guidelines. In most cases, it is expected that these costs can be passed on to the consumer through price increases ranging from 0.03 to 25 percent of 1973 selling prices for 1977 and from 0.03 to 27 percent by 1983. However, in four segments -- isobutylene, isopropanol, methyl ethyl ketone, and secondary butanol -- some producers will have to absorb these costs in their profit margins. The economic contractor does not expect, however, that this will result in any plant closures, significant output changes, or impact on employment or communities.

A trade loss of about $6 million in 1977 and $18 million in 1983 (in 1973 dollars and prices) is anticipated in the maleic anhydride from benzene segment resulting from the combination of abatement costs and changes in duty rate. Although difficult to evaluate in this study, impacts on industry growth attributable to pollution control requirements are expected to be minimal.

PRICES

In general, due to such factors as strong market conditions, low substitutibility, tight supply, concentrated production, and low foreign competition, singly or in combination, the economic contractor anticipates that the cost of proposed guidelines will be passed on to the consumer through price increases. These expected price increases (measured by the annual cost for pollution control as a percent of 1973 selling prices) range from 0.03 to 25 percent for 1977 requirements and from 0.03 to 27 percent by 1983. In four segments, prices are not expected to fully reflect pollution control costs, specifically isobutylene, isopropanol, methyl ethyl ketone, and secondary butanol. (See Table I-3).

Although price increases are anticipated in the high purity isobutylene segment, these increases will probably not be sufficient to cover the full costs of abatement for all producers. Due to high competition brought about by relatively low capacity utilization and the coproduct nature of isobutylene production, it is probable that actual price increases will approximate the nominal treatment costs for plants in large chemical complexes. Thus, the producers in relatively free standing plants who tend to have higher unit treatment costs will have to absorb part of their treatment costs. Based upon the economic contractor's estimate, it appears that isobutylene is sold below cost, but this is assumed to be due to the vagaries of coproduct cost accounting and is further complicated by a lack of published information on this product.

Producers of isopropanol from propylene will be unable to increase prices to fully cover the cost of abatement due to overcapacity because of growing competition on the major end product - acetone - from lower priced, cumene-based acetone and with isopropanol itself from other solvent alcohols. Acetone from cumene is a coproduct of phenol manufacture and must be disposed of as phenol is produced. This economic fact keeps a tight lid on acetone prices and therefore isopropanol prices. The

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TABLE I-3

PRICE INCREASES AND PROFIT REDUCTIONS[1]

Product	Affected Producers	Price Increases Required (%)		Price Increases Expected (%)		Expected Reduction in Gross Margin (%)	
		BPT	BAT	BPT	BAT	BPT	BAT
Isobutylene	Free-Standing	12.3	18.5	3.3	6.7	[2]	[2]
Isopropanol	All	0.5	0.7-0.9	0.3	0.4	0.7	1.5
Methyl Ethyl Ketone	All	0.2	0.3	0	0	0.8	1.3
Secondary Butanol	All	0.1	0.9	0	0	0.2	1.4

1. Product-process segments which are expected to completely pass on abatement costs in the form of price increases are omitted from this table. Expected price increases for those segments can be found in Table II.

2. Isobutylene appears to have a negative gross margin which may result from its nature as a co-product and a lack of published data against which to evaluate process economics estimates.

contractor estimates that treatment costs would appear in higher base prices, but would be discounted to effectively 50% pass through in a strategy of sharing treatment costs equally with consumers.

Producers of methyl ethyl ketone (MEK) and secondary butyl alcohol (95% captively used to produce MEK) will not be able to increase prices in order to pass on the costs of pollution control. Price increase for these segments is restrained by strong competition from competitive solvents, uncertainties associated with state and federal regulations concerning polyvinyl chloride polymers which currently utilize MEK in surface coating formulations, and direct competition from MEK produced by direct oxidation of butanes, both domestic and imports. Thus, it is expected that the modest increase in cost will have to be absorbed by the producers.

Two other segments merit comment because of very high costs even though full cost pass through has been predicted. The very wide range in treatment costs for benzoic acid (0.4 to 24.9% and 1.4 to 26.9% of selling price for BPT and BAT, respectively) would normally suggest a severe price increase constraint for the smaller plants. This is not the case, however, since the free standing plants, although facing much higher abatement costs, are the major producers in this industry, together controlling 87% of industry capacity. Thus, they are able to set the prices for the industry. In addition, the large plant of the free standing producers would significantly reduce costs as a proportion of investment below that defined in the guideline document. The other similar situation concerns calcium stearate with investment costs for BPT and BAT equal to 116% to 158% of in-place investment. This is considered a misleading ratio because of the batch nature of calcium stearate production. The cost for treatment (as specified by the Development Document) while accurately applying to calcium stearate during those periods when it is being produced would also apply to all other similar products manufactured in that plant. Thus, the costs would actually be spread over a number of products of esterification to

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a level which may well not appear so disproportionately large. In addition, production investment is modest compared to annual sales of the product from the facility.

PRODUCTION

Since in most cases the costs of abatement will be passed on through price increases, the guidelines should have no significant effect on plant profitability or industry production. As indicated above, the exceptions to this conclusion are the isobutylene, isopropanol, methyl ethyl ketone, and secondary butanol segments of the industry. Although plants in these segments are not expected to fully recover abatement costs through price increases and may experience reduced profit margins, the reductions are expected to be modest (see Table I-3) in most cases. As a result, no plant shutdowns are expected.

In the case of isobutylene, examination of the process economics might suggest a potential shutdown for the single plant which is not part of a major petrochemical complex. However, this is not considered a significant threat because of the coproduct nature of isobutylene. The primary product from the mixed C_4 - hydrocarbon feedstock is butadiene, a major chemical precursor. Extraction of isobutylene must be accomplished in the manufacture of butadiene, and it is suspected that this producer will not have other viable options for the removal of isobutylene. Thus, the real economics of a shutdown decision are probably masked by the complexities of coproduct cost accounting.

EMPLOYMENT AND COMMUNITY IMPACTS

Since no plant shutdowns or significant reductions in output are expected, no loss of employment or community impacts are anticipated.

BALANCE OF TRADE EFFECTS

In all but one case, because there are no significant changes in
domestic supply predicted nor price changes sufficient to encourage
accelerated import competition, no U.S. balance of trade effects are
expected. The sole exception is the production of maleic anhydride
by benzene oxidation. The combination of the incremental abatement
cost facing U.S. producers and a reduction in the rate of duty on
maleic anhydride produced from butene (a relatively new technology)
act to make foreign producers more competitive in U.S. markets. The
expected result is that U.S. producers will expand production --
perhaps by butene oxidation -- in meeting future demand growth
simultaneous with an increase in imports. The predicted result is an
increase in imports of $6 million in 1977 and $18 million in 1983, in
1973 dollars and prices.

INDUSTRY GROWTH

Attempts to assess the impact of abatement costs on industry growth
are frustrated by two conditions. The first is an analytical problem
resulting from evaluating economic impact on a product basis in an
industry characterized by large, multi-product complexes. Corporate
decisions on expansion of existing plants or construction of new ones
are not likely to be made on the basis of individual products (and
attendant pollution control costs) but rather on the basis of groups
of related chemicals. The second problem is intrinsic to the industry
itself. The chemical industry is noted for its rapid product and
process obsolescence and rapidly fluctuating supply and demand for given
products. Against this backdrop, it is difficult or impossible to
predict growth effects from abatement costs for specific products.

In general, however, it seems fair to state that the relatively
low costs and the ability to raise prices will lead to minimal effects
on industry growth. Over the long term, further concentration and over-

seas relocation are reasonable expectations, but the degree to which water pollution control regulations alone will determine these changes is probably modest in the specific products studied.

II. INTRODUCTION AND METHODOLOGY

The following report is submitted in compliance with competitive task order WA-74X-058 under Basic Ordering Agreement No. 68-01-1541. The study is intended to supply the Environmental Protection Agency with analyses of the economic impact on the certain specified organic chemicals pollution abatement requirements under the Federal Water Pollution Control Amendments of 1972. The study is Phase II dealing with the organic chemicals industry and extends the list of products considered in the Phase I study previously submitted.

The data available in the Organic Chemicals Industry Phase II Development Document for effluent limitation guidelines deals with specific product-process combinations. Some products under consideration are manufactured by more than one process. As data on effluent control are specific to the process being used, the economic impact analysis must perforce be limited to consideration of that portion of the total production accounted for by the designated process. Forty-nine product-process combinations were evaluated in detail. Those covered in this report include the following:

1. Isobutylene by Sulfuric Acid Extraction.
2. Adiponitrile Based On Chlorination of Butadiene.
3. Hexamethylenediamine from Adiponitrile.
4. Secondary Butyl Alcohol by Hydrolysis of Butylene.
5. Methyl Ethyl Ketone by Dehydrogenation of Secondary Butyl Alcohol.
6. Acrylonitrile from Propylene and Ammonia.
7. Benzoic Acid by Air Oxidation of Toluene.
8. Isopropyl Alcohol from Propylene.
9. Methyl Chloride from Methane.
10. Methylene Chloride from Methane.
11. Chloroform from Methane.
12. Carbon Tetrachloride from Methane.

13. Calcium Stearate by Neutralization and Precipitation.
14. Hydrazine by Partial Oxidation of Ammonia.
15. Maleic Anhydride by Oxidation of Benzene.

A series of other products were considered and eliminated from detailed consideration by the economic contractor or by the Environmental Protection Agency. Those products eliminated from detailed consideration by the economic contractor's prescreening process include:

1. Benzene, Toluene and Xylene by Reforming.
2. Citronellol and Geraniol by Extraction.
3. Tannic Acid by Extraction.
4. Naphthenic Acid by Extraction from Caustic Sludge of Petroleum Refineries.
5. Hexamethylenediamine from 1,6-Hexanediol.
6. O-Nitroaniline by Amminolysis of O-Nitrochlorobenzene.
7. P-Nitroaniline by Amminolysis of P-Nitrochlorobenzene.
8. P-Xylene.
9. Phthalic Anhydride from Naphthalene.
10. Phthalic Anhydride from O-Xylene.
11. Plasticizers by Condensation of Phthalic Anhydride with an Alcohol.

Other products prescreened out of consideration by the Environmental Protection Agency include:

1. Chlorobenzene by Chlorination of Benzene.
2. Cumene from Benzene and Propylene.
3. Diphenylamine by Deammonation of Aniline·
4. Ethyl Acetate from Ethanol.
5. Ionone and Methyl Ionone.

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A. PRESCREENING APPROACH

Due to the large number of individual organic chemical products for which guideline data were available, the economic contractor briefly reviewed all products being considered in order to most appropriately focus the total effort of Phase II. The general guidelines used were:

- to eliminate from detailed consideration those products in which the BAT treatment cost in a free standing plant was a minor proportion (less than 3%) of the 1972 sales price.

- to include those major products which were judged to have low manufacturing margins even if abatement costs were modest and costs might not be passed through.

- to prescreen out those products which were of minor commercial significance (less than $5 million sales per year).

In addition, several products on which guideline data had been developed were eliminated by the Environmental Protection Agency prior to prescreening by the economic contractor. These were generally products whose manufacture on the basis of the guideline document generated sufficiently low quantities of effluent so as to require no treatment to pass the effluent guideline standards contemplated.

Further description of the list of products prescreened from in-depth analysis is provided in the final section of this report.

B. GENERAL IMPACT APPROACH USED FOR DETAIL STUDY

Analysis of economic impact has been made on a product-by-product basis. The assessment of the economic impact is based on the annual treatment costs and capital investment data provided by the guidelines contractor in conjunction with analyses of the industries (this case specified as a specific product) in terms of its market characteristics,

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supply characteristics, prices, and supply/demand balance. Where a
specific product or chemical entity is made by more than one process, the
impact section of the analysis is limited to that specific process as the
effluent treatment costs and investment required vary by the type and
amount of effluent produced and this is dependent not only on the product
being manufactured but the process being used.

In order to deal with the question of economic impact in a generalized
fashion, we have developed an analytical framework to arrive at judgments
as to impact. In addition to providing us with a systematic method by
which to weigh each of the factors affecting the impact judgment, the
methodology also provides a format by which the basis for our conclusions
are clearly presented.

The basic premise behind the methodology is that a producer faced
with new investment in water treatment facilities could:

1. Continue to operate by: (a) passing on the additional cost
    through price increases, or (b) absorbing the cost (thereby
    reducing profits); or

2. Shut his plant down.

This premise, of course, reduces the impact of increased costs due
to water treatment to the simplest terms. In the real world, a result
of a higher cost for some process yielding some specific product would
most probably be some combination of these alternatives; e.g., a price
increase permitting the most efficient producer sufficient income to recover at
least part of his cost (but not enough to cover most of the cost of the
marginal producer),possibly reduced profit margins for the most efficient
producer partially offset by an increased market share resulting from
plant shutdowns by the marginal producer or producers.

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The approach we have taken in assessing the impact on each of the product-process combinations is to first examine the likelihood that the higher cost imposed on the industry by virtue of new water effluent treatment guidelines will be defrayed, totally or in part, by higher product prices. If the conclusion is that the treatment cost cannot be passed on through price increases, the second part of the impact analysis is to examine the likelihood that some or all of the plants in the industry would be forced to shut down, taking into account both economic and noneconomic factors.

1. Price Increase Constraints

The treatment cost per pound of product before taxes indicates the magnitude of the price increase necessary to fully recover all treatment costs (i.e., repay the investment and cover operating costs). The larger the ratio of before tax unit treatment cost and actual unit selling price, in general,the more difficult it will be to fully recover treatment costs, all things being equal. Most of the treatment costs described in our analysis of individual products indicate a range. This range exists because of the existence of actual plants in the industry in effluent treatment complexes as well as in free standing conditions. As detailed later in this section, we have classified the plants producing any one particular product into those which are free standing, those in small effluent treatment complexes and those in large effluent treatment complexes. Costs provided by the guideline contractor were only for free standing units. In practice, however, most of the plants we are dealing with are in either large or small complexes and we have assumed these complexes will have common waste treatment facilities with consequent economies of scale.

The first question we have addressed is whether conditions in the specific competitive situation would permit price increases. In general, the product's price history and the nature of those prices, whether historically firm or widely dispersed and discounted, provide a clue as to the possibility of price increases. More specifically, however, the following factors are those which we have used in arriving at the judgment as to whether price increases are feasible. Except in unusual circumstances, no one factor would be overriding. Rather, the judgment is based on a combination of factors.

In many cases, as illustrated in the body of this report, there is a wide difference between the treatment cost in complexes versus treatment costs of a free standing plant. In considering some products, therefore, we have had to make the judgment as to whether the price increases which will pertain in the long run will be sufficient not only to cover those producers enjoying economies of scale in complexes, but also those in free standing facilities.

The following factors, and the specified effects, were considered in judging the possibility for price increases:

(a) Substitute Products: If substitute products exist, price increases to cover the costs of water treatment would be more difficult.

(b) Capacity Utilization: If capacity utilization for the industry is low, price increases to cover the costs of water treatment would be difficult.

(c) Captive Usage: If there is negligible captive usage for the product under consideration, price increases to cover the cost of water treatment would be difficult.

(d) Demand Growth: Price increases are more difficult to achieve in a static or declining market than in a growing market.

(e) Foreign Competition: If the market has been traditionally served by foreign competitors (particularly if the foreign producers are not faced with added water pollution abatement costs), price increases are less likely.

(f) Price Elasticity of Demand: For some products, substantial water pollution abatement costs, if passed on as price increases, could result in reduced demand for the product and price increases would be less likely.

(g) Basis for Competition: If the basis for competition in the industry is primarily price as opposed to service or technology, cost increases will be more difficult to pass on. This would tend to be particularly true if there is a significant difference between unit treatment costs of producers.

(h) Market Share Distribution: If the market share distribution is fragmented (rather than concentrated in which case there often is a dominant price leader), price increases would be more difficult.

(i) Number of Producers: If the market is served by many producers (increasing the likelihood of manufacturing cost differences, abatement cost differences, etc.), a condition exists constraining price increases.

(j) Substitute Processes: In each of the individual products under consideration, we are concerned with the abatement cost associated with a particular process. If other processes exist and these are judged to incur lower effluent treatment costs, the condition exists for constraining price increases by the process under consideration.

In the final analysis, in considering all the factors specified above, the contractor reached a judgment as to whether the producers of the products by the specified process will be able to pass on effluent treatment costs as price increases. If it does not seem likely that the total costs for effluent abatement can be passed through as price increases, the judgment was made as to the amount of these costs which would be passed through as higher prices.

2. Plant Shutdown Factors

If treatment costs cannot be passed on as price increases, the matrix approach to analysis says that the producer either absorbs these costs or shuts down his plant. The shutdown decision on the part of the producer will involve both economic and strategic (i.e., noneconomic) considerations as follows:

(a) Profitability: The after tax cost of water effluent treatment per pound of product produced compared with the unit after tax net income measures the producer's ability to absorb the added cost.

(b) Cash Flow: Plants are liable to continue operating temporarily at zero profitability (if necessary) if the plant is producing a positive cash flow, particularly if it is in a stable or growing market.

(c) Ratio of Investment in Treatment Facilities and Net Fixed Investment: If the new investment in water treatment facilities is large in comparison with existing plant investment (and other factors are marginal), there will be a greater inclination for the producer to shut down plant facilities rather than make the investment in effluent treatment. In some instances the availability of capital to the producer may influence the shutdown decision.

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(d) Integration: The degree of backward or forward integration is a factor in the shutdown decision. The producer with a significant raw material position or one using the product for downstream manufacture is less likely to curtail production of the nonintegrated producer.

(e) Chemical Complex: In addition to the economies of treating effluent from a chemical complex in relation to treating the same effluent from a free standing plant, the existence of plants in complexes may tend to reduce the possibility of plant shutdown because of the effect on other elements of the complex.

(f) Other Environmental Problems: If a company faces a substantial water and air pollution abatement (and/or unusual OSHA costs), the magnitude of the environmental cost taken together may prompt plant closing whereas any one taken alone would not. Very little data were available to the contractor relative to the costs which will be incurred due to requirements to meet other environmental and safety standards.

(g) Emotional Commitment: The emotional commitment of a company to that particular product under consideration (taking into account protection of competition position, prestige, history of the product in the company's developments and importance of the product in the company's long-range strategy) may be a factor in the shutdown decision.

(h) Ownership: Other things being equal, multi-industry companies are more likely to shut down marginal plants than less diversified producers. The premise is that the multi-industry company has other (and better) investment opportunities than the single product company, particularly a privately-held family business.

In reaching decisions concerning probable future plant closures, the contractor again must utilize his best judgment taking into account all of the factors specified above. In many cases, one or two factors may assume overwhelming importance and this can change from situation to situation. As in the real world of decision making, however, in the final analysis decisions are based on judgment as to what factors are most important and how these will affect decisions by the companies relative to plant closure. A rigorous quantitative analysis to "improve" the possibility of closure is not possible within the scope of the work given the number of individual products under consideration and, we believe, would be no more reliable given the generalized history approach required by this study.

C. THE IDEAL APPROACH VS. PRACTICAL CONSTRAINTS

Most major products manufactured by the U.S. organic chemicals industry are produced under a range of conditions affecting both the products' manufacturing costs and costs of treating effluent. Products are produced in plants with significant variations in individual plant capacities providing manufacturing economies of scale. In many cases, raw materials are transferred from other manufacturing operations in the company. These transfers may be made at market price or at some other arbitrarily defined cost to the consuming plant. In addition to manufacturing cost differences, there will also be differences in treatment costs, depending on the specific treatment methods applicable, whether the plant is in a complex and the size of the complex for the joint treatment of effluents from a number of different individual streams entering the complex. In general terms, the larger the complex for effluent treatment the lower the unit cost because of the economies of scale possible.

An "ideal" approach to the problem of defining economic impact would require the detailed examination of each producer of the product under consideration in its own particular circumstance.

For each complex of plants, therefore, an "ideal" approach would require specification of the waste water treatments currently in place, under construction,or planned and the costs currently incurred as well as the cost and investment necessary to meet the specified guidelines standards. This in turn would require an analysis of the total waste water flow system, how the production of each individual plant affects this total, and the cost allocation method utilized to distribute total effluent treatment costs back to the individual plants in the complexes.

For each product under consideration in either free standing plants or complexes an "ideal" analysis would require a specific description of the process utilized and the manufacturing costs experienced by each individual producer. It would also require accurate definition of the production capacity and planned capacity changes as well as the history of production in the individual unit. Information required associated with the manufacturing cost would include the actual prices and forecast price for raw materials, expected product prices, and the degree of backward and/or forward integration of the particular product in all the particular companies under consideration.

As well as knowing manufacturing cost and degree of integration, each product market condition would be specified. This would include the significance of the product to the company in terms of supporting other product lines, existing and potential competition as foreseen by the producer, expected future growth in product demand for the particular producer,and the existence of long-term contracts for the supply of materials.

Where a product is manufactured in a complex, as is usually the case, detail would have to be developed on the effluent from the process in use. This information would include the waste water flow from the plant, the raw waste load, the requirement for a possibility of pretreatment for entering the common effluent treatment system of the complex. In addition, for each product the contractor would have to specify other regulations and the cost associated with these regulations which could affect production of the product. These could include the requirements for air pollution abatement, and the requirements to meet OSHA standards.

In addition to the detailed analysis of each individual producer, an extensive study would be required of the existing and future market and technological conditions for each product in general. This study would include an extensive analysis of competitive materials and their likely future prices as the primary determinants of the elasticity of demand in the product under consideration. This is an extremely complex job in the synthetic organic chemicals industry because of frequent broad ranges of inter-competition between end products manufactured from the synthetic organic chemicals under consideration. As the competitive materials themselves are subject to future price changes by virtue of effluent control costs or other factors such as changing raw material costs, the entire families of inter-competitive materials would have to be studied simultaneously and all the factors affecting each product taken into consideration. An "ideal" study would also, with the aid and assistance of the producers, forecast changes in process technology which could affect manufacturing costs, product quality, or effluent.

In defining the likelihood of price increases and/or plant closures, the data on waste water treatment costs by producer, manufacturing cost by producer, and general market outlook by product would have to be placed in broad context by a thorough understanding or profile of each of the firms manufacturing the product under consideration. This would require an analysis of the financial strengths of the individual companies, their history in the business, alternate plants and products, and an understanding of their general business strategy in the organic chemicals industry.

Finally, in order to define community effects of the projected plant closures, it would be necessary to obtain from the producers their employment by worker category in the plants forecast to be closed. It would also be necessary for the "ideal" study to develop a profile of the community in which these plants were contained. This would include consideration of other employers, the size and growth of the community and its capability of absorbing those workers which would be unemployed by the shutdown of specified facilities.

Constraints in approaching the ideal approach for studying economic impact as described above would include the requirement for highly confidential company data and the very extensive nature and hence high cost of the study. The managements of most, if not all, companies would be extremely reluctant to reveal confidential manufacturing cost data, marketing plans, and general business strategy. In the type of "ideal" study as described, every plant would have to be visited, and a thorough analysis made of cost and effluent treatment data. In addition, the management of every company involved in the production of the products under consideration would have to be interviewed, and would have to give their complete cooperation in order to define objectives, business strategies, etc. This would require a substantially larger budget and longer study time than that authorized for the generalized approach utilizing the impact analysis matrix as is demonstrated in the body of this study.

It would be possible to use more sophisticated financial analytical techniques given the generalized data available on effluent treatment costs and investment and manufacturing costs. The contractor believes, however, the utilization of these techniques, such as calculating the induced changes in discounted cash flow or present value of the plant caused by effluent treatment costs, would not be cost effective. Only generalized quantitative data are available on both treatment cost investments as well as manufacturing costs. The use of extensive analytical techniques does not make this generalized data any more accurate and without accurate data would not significantly contribute in refining or substantiating the judgments necessary relative to probable future plant closures.

D. SPECIFIC TECHNIQUES

1. Manufacturing Costs

As data for consideration of economic impact of application of effluent guidelines, it has been necessary to provide investment and operating costs for some 25 chemical products. Budget restrictions precluded primary work in preparation of these estimates, but we were able to provide the required data from prior studies. Two factors affect the accuracy of such data: the first, the timeliness of the prior work; the second, the detail in which the prior work was conducted. This list of 25 chemicals includes many products where our data basis is weak, about half the list falls into this category.

We have chosen to base our cost estimates on economics as prevailed in the summer of 1973. This represents a relatively stable period for the chemical industry in contrast to the depressed condition of 1972 and the chaotic condition during the fuel shortage of the fall and winter of 1973. Each element of operating cost was considered separately and a basis was adopted which is uniform for the group of products.

Utilities prices were guided by the Chemical Week annual surveys of plant site economics. We attempted to draw trend curves from this data but found too much scatter in the data due to step increases in rates in specific locations. After study of the data we adopted the following rates:

Electric Power	1.3¢/KWH
Water	3¢/M gal
Fuel	35¢/MMBTU

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Operating labor was estimated at the staffing indicated for the particular product and at a payroll cost of $5 per hour.

We used the "percent of investment" method to estimate the maintenance costs and updated the result to 1973 terms.

Labor and plant overhead were estimated at 100% of direct labor.

In order to estimate depreciation, taxes and insurance, and maintenance costs it was necessary to estimate the plant investment. The actual plants represented by this product list are of all ages, and the question of the calendar year base for depreciation became important. We decided to use an investment for each plant equal to the cost of a similar plant in 1970. Not many plants are newer than this, and older plants have been modernized. Our data for other years were adjusted to 1970 by application of the Chemical Engineering "Plant Cost Index". Depreciation was estimated at 9% of investment per year, and taxes and insurance at 1-1/2%.

The accuracy of these estimates is highly dependent on the prior estimate. Investment figures may be in error by $\pm$ 15% to $\pm$ 100%. Operating costs are less variable and probably have a range of error of $\pm$ 10% to $\pm$ 30%. The magnitude of this range of error is masked by the dependence of cost of manufacture on raw material costs, which for some products are 90% of total cost, and commonly are 75% of cost.

2. Model Water Effluent Treatment Complexes

The Development Document for Effluent Limitations Guidelines, Organic Chemicals Industry Phase II. specifies the investment and annual operating costs to meet guidelines specified for the series of synthetic organic chemicals dealt with in this report. These capital investments and annual costs were developed on the basis of a model waste water treatment facility utilizing biological treatment to achieve the BPCTCA

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level and carbon adsorption (following biological treatment) to achieve the BATEA level. The Development Document specifies the average production, waste water flow rate, BOD, COD and TSS effluent limitations per 1,000 pounds of product produced. In generating the waste treatment costs, the Development Document provides a free standing, i.e., separate and self-contained, waste water treatment facility for each of the organic chemical production units.

In fact, however, most of the total volume of products considered in the Phase II economic impact study of the organic chemicals industry are produced in complexes rather than in free standing plants. These manufacturing complexes typically employ a single large waste water treatment facility that collects, combines and treats all the waste water emanating from the individual production units within the complex. Costs and investments, therefore, as specified in the guideline document do not take advantage of the economies of scale which would exist in the real world in the joint treatment of effluents from a series of plants in a complex. In order to more closely approximate   actual waste water treatment practice, we developed effluent treatment costs and investments for the products under consideration assuming that producing plants were not only in a free standing configuration but also in a small and in a large complex. For the purpose of this analysis we have defined a small complex as one which treats 3 million gallons per day of waste water and a large complex as one which treats 10 million gallons per day (this is a typical size range for the organic chemicals industry). In our analysis for economic impact, we then classified the plants producing each of the products under consideration into the three categories under consideration: free standing, in a small complex, or in a large complex. This classification was made on the basis of our judgment and with reference to 1974 Directory of Chemical Producers issued by the Stanford Research Institute. Thus, in most of the products under consideration, there is a spread of treatment costs and investments reflecting the situation of the plants producing the product; i.e.,

whether in free standing configuration, effluent treatment in a small complex or in a large effluent treatment complex. In some instances, plants were judged to be all in the same configuration, such as all included in large complexes, and in that instance only one cost and investment for effluent treatment per unit of output is applicable.

The scale-up from the free standing case to the small and large complexes was performed using waste water treatment plant cost estimating procedures and data provided by the guidelines contractor. An allocation system was then developed for purposes of distributing costs back to the producing plant under consideration which was operating within the hypothetical complexes. In considering BPCTCA waste treatment, the total treatment cost was allocated among the individual products on the basis of the hydraulic flow rate contributed by the individual production unit. For example, if a production unit within a complex contributes 20% of the total waste water flow rate, 20% of the total investment and operating cost of the waste treatment facility would be assigned to that specific production unit.

The use of hydraulic flow rate as the basis for cost allocation is justified because in biological waste treatment systems the size of equipment (and hence its cost) is predominantly dependent on the volume of water treated. While we recognize that the cost of a biological waste treatment system is also partially dependent on the BOD and suspended solids of the incoming waste water, we have chosen hydraulic flow rate as the sole basis for allocation. To include BOD and suspended solids would necessitate the use of a rather cumbersome allocation formula that would be highly dependent on the specific type of combined waste water entering the treatment plant. Such an allocation method would be very tedious for a generalized economic impact analysis of this type.

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The results of the economies of scale in a 3 million and a
10 million gallons per day waste water treatment facility are given in
Table II-1.

Cost allocations for the BATEA treatment level in the hypothetical
complexes were performed in a somewhat different manner due to the nature
of the treatment specified by the Development Document. The Development
Document specifies activated carbon adsorption which would follow the
biological treatment system required for the BPCTCA level.

In the activated carbon treatment of waste water, practically
all of the energy and power required is associated with the thermal re-
generation of the carbon. The rate at which carbon must be used (and
hence regenerated) is almost totally dependent on the amount of total
organic carbon (TOC) removed from the waste water and is therefore
almost completely independent of hydraulic flow rate. Also, being that
upwards of 10% of the total activated carbon inventory is lost each
time the carbon is regenerated, replacement carbon also forms a major
component of the total operating cost, and, too, is almost totally
independent of hydraulic flow rate. As such, there are practically
no economies of scale associated with the energy and power requirements
and the replacement carbon requirements of carbon adsorption. Thus,
for a given product type and production rate, the allocated in-complex
energy and power cost can be taken as identical to the energy and power
cost of the free standing treatment plant set forth in the Development
Document.

In addressing the amortization cost to achieve BATEA, we
considered that the yearly amortization cost is, of course, a direct
function of the capital investment and as such will be influenced
by whatever economy of scale prevails between free standing and the
two in-complex cases considered. The operating and maintenance cost

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Product	Free-Standing					3.0 MGD Complex		10.0 MGD Complex	
	Production Rate 1000 lbs/day	Wastewater Flow Rate gpd	Annual Cost ($ yr)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)
1. Acrylonitrile	658	353,000	790,000	3.71	2,800	0.69	619	0.58	508
2. Adiponitrile	548	642,000	3,268,000	16.34	12,487	1.50	1,121	1.26	922
3. Benzoic Acid	164	56,000	1,739,000	28.94	6,582	0.44	97.9	0.37	81.0
4. Calcium Stearate	80	519,000	426,000	14.00	1,622	8.34	907	7.00	746*
5. Chloromethanes	356	120,000	120,000	1.60	634*	0.40	196*	0.34	161
6. Hexamethylenediamine	548	66,000	1,069,000	5.34	4,201	0.15	115.3	0.13	94.8
7. Hydrazine	6	21,800	209,000	95.34	609	5.04	43.3	4.24	35.5
8. Isobutylene	137	335,000	454,000	9.59	1,820	3.14	585	2.64	481
9. Isopropanol	1,370	366,000	342,000	0.72	1,249	0.34	640	0.28	525
10. [†]Maleic Anhydride	137	38,000	806,000	15.99	830	—	—	—	--
11. Methyl Ethyl Ketone	274	43,000	581,000	5.81	1,937	0.20	74.9	0.16	61.6
12. Secondary Butanol	218	16,400	650,000	8.61	2,217	0.16	44.3	0.14	36.4

1. Guideline Contractors Costs Escalated to mid-1973 (+ 16.7%).

Note: Annual Cost Includes: 1) Amortization (8% over 20 years).
2) Operating and Maintenance.
3) Energy and Power.

[†]Incineration Used.

*Adjusted in 1972 Cost Base (+ 8.8%).

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as provided in the Development Document represents a combination of operating and maintenance labor which does benefit from economies of scale and replacement carbon which does not benefit by economies of scale.

Being that the costs associated with the use of activated carbon are highly dependent on the composition of the specific waste water being treated, we could not legitimately use a generalized carbon adsorption treatment system for the in-complex treatment cases. Because of this complication, we have resorted to a construction that in an admittedly crude way adjusts the amortization cost for use in the two in-complex cases. The purpose here was to acknowledge the economy of scale between the free standing and the in-complex cases while avoiding the practice of actually specifying a raw waste load of a single composition for the entire complex. A specification of a fixed raw waste load has implicit in it the assumption of a certain type of product mix. As such it would be necessary to justify the selection of that product mix and the combined waste load. Even worse, a rather tedious allocation method based both on hydraulic flow rate and total organic carbon would have to be used and this would require an elaborate justification.

In adjusting the free s anding BATEA treatment costs to reflect the economies of scale that would result when the particular production unit resided within a complex and shared a common treatment facility, we have performed the following steps:

a. Scaled-up the size of the effluent emanating from each production unit (based on given unit water usage rates) such that the result in waste water flow rate is equal to 3 million gallons per day for the first case and 10 million gallons per day for the second case. These are the same sizes as the hypothetical complexes used in the BPCTCA allocation.

b. With all the production units now adjusted to the same
size, the capital investment for the activated carbon treatment system
was then scaled-up according to the scaling factors normally used for
waste treatment systems. For example, if the carbon system is increased
in size by a factor of 10, the cost will not increase by a factor of 10,
but rather by a factor of approximately 4.5. The scale-up was done on
the basis of hydraulic flow rate. Hydraulic flow rate is justifiable
if one is considering a single waste, because if the waste concentrations
are the same, the amount of total organic carbon that must be removed
will be directly proportional to the hydraulic flow rate.

c. The new capital costs for the enlarged fictitious 3 million
and 10 million gallons per day treatment plants were then allocated back
to the actual size production unit on the basis of hydraulic flow rate.
Thus, if a particular production unit had a flow rate of 10% of the
fictitious complex, its allocated capital cost would be 10% of that of
the fictitious complex. Being that the capital cost of the 10-fold
larger complex is only 4-5 times larger than the free standing unit,
the allocated capital cost for the in-complex case will now be 45%
of the cost of the free standing unit. This is how economy of scale
exerts itself on capital costs and related amortization costs. The
amortization costs for all the products included in this study have
been adjusted in this manner.

d. Assigned energy and power costs to the in-complex case
were taken as identical to the free standing case. As mentioned earlier,
energy and power requirements will not benefit from economies of scale.

e. We then adjusted operating and maintenance costs by means of a partial allocation method. Operating and maintenance materials and labor will benefit by economies of scale while replacement carbon will not. The Development Document does not break out the individual components of the operating and maintenance cost, but rather gives a lump sum. As such, we have arbitrarily assumed that 50% of the operating and maintenance cost will be affected by economies of scale and 50% will not. The portion that is dependent on economies of scale was allocated in the same manner as the amortization cost described in step b. The portion not benefiting from economies of scale was left as is. In this manner the operating and maintenance costs associated with the treatment of waste water from the individual production units was adjusted to take into account the economies of scale resulting from in-complex operation.

f. The above cost components were then summed up to arrive at an adjusted total annual treatment cost for each of the production units. This cost represents the incremental BATEA cost as set forth in the Development Document and adjusted to take into account the economies of scale resulting from in-complex operation. The incremental BATEA treatment costs are presented in Table II-2.

As can be seen by comparing the "in-complex" BPCTCA and BATEA treatment costs, the BPCTCA costs benefit from in-complex economies of scale far more than the BATEA costs.

TABLE II-2

ESTIMATED BATEA TREATMENT COSTS AND INVESTMENTS[1]
(All Cash Investments to BPCTA)

Product	Free-Standing					3.0 MGD Complex		10.0 MGD Complex	
	Product Rate 1000 lbs/day	Wastewater Flow Rate gpd	Annual Cost ($/yr)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)	Unit Cost ($/1000 lbs)	Capital Investment ($ 1000)
1. Acrylonitrile	658	353,000	1,551,877	6.47	4,467	4.33	2,055	3.72	1,358
2. Adiponitrile	548	642,000	109,383	5.47	2,122	4.21	1,230	3.61	806
3. Benzoic Acid	164	56,000	139,235	2.32	445	1.20	110	1.07	72
4. Calcium Stearate	80	519,000	136,539	4.68	585	3.23	316	2.54	2.09
5. Chloromethane*	356	120,000	55,750	0.42	177	0.24	58	0.21	38
6. Hexamethylenediamine	548	65,000	270,300	1.35	799	0.75	216	0.67	142
7. Hydrazine	6	21,800	39	17.50	19	8.30	3	7.66	2
8. Isobutylene	137	335,000	237,951	4.76	829	3.09	384	2.60	253
9. Isopropanol	1,370	366,000	138,406	0.28	532	0.18	256	0.12	165
10. †Maleic Anhydride	137	38,000	--	—	—	—	—	—	—
11. Methyl Ethyl Ketone	274	43,000	26,724	0.27	152	0.08	31.9	0.09	20.8
12. Secondary Butanol	218	16,400	205,000	2.58	677	1.21	108	1.10	68

1. Guideline Contractor's Costs Escalated to mid 1973 (+ 16.7%) Note: Annual Cost Includes: 1) Amortization (8% over 20 yrs.)
2) Operating and Maintenance
3) Energy and Power

*Adjusted to 1972 Cost Base (+ 8.8%).

3. Data Sources

The data included in the industry background relative to the various products under consideration were developed from the contractor's own general background in the chemical process industries and from a number of specific published sources. Information on historical sales, production and average prices was obtained from the annual issues of <u>Synthetic Organic Chemicals</u> published by the U.S. Tariff Commission. Information on exports generally came from Series FT 410 published by the U.S. Department of Commerce, Bureau of Census while information on imports generally came from FT 210 also published by the U.S. Department of Commerce, Bureau of Census. Some but not all information on capacities and industry trends was obtained from <u>Chemical Profiles</u> published by the Schnell Publishing Company. Historical list prices were obtained from the trade journal, <u>Chemical Marketing Reporter</u>. In addition, and where appropriate, background data was obtained from trade journals such as <u>Chemical Week</u> and <u>Chemical Engineering News</u>, from the <u>Encyclopedia of Chemical Technology</u> published by Kirk Othmer, <u>Chemical Economics Handbook</u> by the Stanford Research Institute and the <u>1974 Directory of Chemical Producers</u> published by the Stanford Research Institute.

4. Definition of Terms

Throughout the report a number of terms are recurrently used. For the purposes of clarity we have defined some of these terms in the introduction. Reference to a <u>plant</u>, for example, indicates a single producing unit. That is a sequence of unit operations resulting in the production of a product or coproduct. Reference to a <u>complex</u> indicates a series of plants operating in the same location. Plant <u>capacity</u> is usually the stated capacity provided by the company operating the plant. This may be "nameplate" or nominal design capacity and usually is. In some cases, capacity has been modified from nameplate or original design capacity. Where the company provides this data, this is the capacity taken. <u>List prices</u> are the prices as published

in the Chemical Marketing Reporter. Actual prices are the average prices paid during the year as specified in Synthetic Organic Chemicals published by the U.S. Tariff Commission.

Return on investment, or ROI, includes gross investment in physical plant but excludes working capital. Return on investment is normally specified as either on a before tax or after tax basis. Profitability is a more generally used term and unless specifically indicated as a percentage of sales, it is to be considered as indicating return on investment. Reference in the impact analysis sectors relative to the profitability of individual products actually indicates manufacturing margin as we have not added general sales and administrative costs or corporate burden to the plant cost. Cash flow defines plant profit or manufacturing margin plus depreciation.

5. Standard Conventions

The tables utilized in the report specify the sources of data to develop the tables. The report generally makes reference to the table where the source is indicated and hence often does not specify the source as this is obvious from the table.

Each subsection of the report dealing with a specific product contains a summary. The purpose of the summary is to provide a brief review of individual sections. In the interest of brevity, we have generally omitted references, tables or sources, and these are specified in the bodies of the sections dealing with individual products.

6. Limits to the Analysis

The analysis attempts to deal with an extremely complex industry in general and often in simplified terms. Because of the timing of the report, generally the latest available data was for the year 1973.

This concept of the model representing maximum costs and invest-
ments is reinforced by the assumption made that no treatment facilities
were in place at the time of the writing of the report. All investments
and costs, therefore, which are estimated required for 1977 and 1983
are considered additional costs.

The analysis of economic impact, however, was limited solely
to costs and investments specified for treatment of water effluent given
in the guideline document. The economic impact statement does not attempt
to deal quantitatively with other regulatory requirements such as state
and local regulations in other sections of the Federal Water Pollution
Control Act controlling water quality or toxic pollutants, the Clean
Air Act or OSHA regulations. An often voiced concern on the part of
the chemical producers is that while individual economic impact state-
ments may not indicate any serious impact, all the regulations considered
at one time are quite different and often far more significant.

Another limitation to the analysis occurs in attempts to judge
the possibility of price pass through of effluent treatment costs. Many
of the products being considered by the study encounter substantial
competition in their secondary application; that is, competition of the
products in which they are used with other products, both petrochemical
and nonpetrochemical in origin. In many cases, competition is extremely
complex and a variety of secondary applications have a variety of end
uses each facing different competitive materials. Analysis is made even
more complex by the fact that many of these competitive materials will
also experience costs for water effluent treatment or costs incurred by
other government regulatory programs. In many cases, these costs have
not yet been specified. Often the analysis has to rely on the explicit
assumption that there will not be equivalent costs associated with the
production of either primary or secondary competitive materials.

List prices often were available up through mid-1974 but production
and sales data were not available nor was average sales price for the
year 1974. In 1973 and the first half of 1974 there were highly unusual
conditions for the organic chemicals industry as well as many other
industries in the United States. Part of this time the industry
experienced price controls and during most of this period many products
were in short supply. During 1973 and early 1974 many prices rose
rapidly. This reflected both the shortage of supply relative to demand
and rising prices of raw materials, particularly petrochemical feed-
stocks. In our analysis, we have attempted to normalize conditions
and assume that demand would not continue to exceed available capacity
through 1977 and 1983 and hence more normal competitive conditions
would prevail in considering economic impact of the effluent treatment
costs and investments.

By virtue of the scope of our assignment, it was necessary
for us to consider generalized or model plants and complexes in con-
sidering manufacturing cost and waste treatment cost. Actually, these
costs probably represent a reasonable point in a range of costs actually
experienced by different producers by virtue of differences in manu-
facturing processes or capacities and by differences in the size of the
complexes in which these plants are located. In addition, the guidelines
contractor also predicted effluent treatment costs on model treatment
facilities for the effluents of all products under consideration. We
suspect that in some cases effluent treatment may be handled quite
differently than the model specified by the guideline contractor. The
model serves, therefore, the function of representing a maximum effluent
treatment cost which might actually be significantly lower due to in
process modification or other methods of effluent treatment.

In addition, except where we have explicitly recognized competitive technologies, the existence of future technological change has not been taken into account. In short, we have not attempted to predict future changes in technology which may obsolete processes or significantly change product properties. This is a particularly significant limitation in the organic chemicals industry because of the rapidly changing technology which has been characteristic of the industry.

Finally, we have utilized material costs as of mid-1973. Most of the products under consideration are sensitive to energy costs, particularly the cost of feedstock derived from natural gas or petroleum. Substantial changes in these feedstock or energy costs, such as might be caused by a collapse of the existing international price of crude oil, could significantly affect these costs. We have not attempted to develop a variety of different cases for each product reflecting different feedstock prices caused by variations in crude oil prices.

7. Employment and Community Effects

The effects on employment caused by plant shutdowns have been estimated from data presented in each section on manufacturing costs. These data include the specification of direct labor required for plant operation. We have assumed that for each job lost as direct labor in the event of plant shutdown an additional job is lost in the plant support labor.

Direct labor consists very largely of chemical operators. These skills, and hence the employability of the operators displaced are not broadly transferable. Generally speaking, a chemical operator in the organic chemicals industry would have the capability of utilizing these developed skills in other chemical manufacturing operations or petroleum refining operations. These skills would not be generally applicable, however, outside of the chemical process industry.

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Support labor in the chemical plant consists of skilled trades-
men such as electricians, sheet metal operators, pipe fitters, machinists,
and riggers as well as clerical workers and general nonskilled labor.
The skills possessed by these craftsmen should be more broadly capable
of being utilized in other types of manufacturing operations.

III. OVERVIEW OF THE ORGANIC CHEMICALS INDUSTRY

A. BASIC INDUSTRY STRUCTURE

According to the 1967 Census of Manufacturers published by the
Bureau of Census, approximately 450 companies in 665 establishments
make up the organic chemicals industry which we have arbitrarily described
as SIC Codes 2865 and 2869. Any definition of the U.S. organic chemicals
industry necessarily requires arbitrary distinctions in the actual con-
tinuation of processing raw materials to finished products. In actuality,
the industry is contained within companies many of whose operations, even
within the same establishments, extend forward into the manufacture of
upgraded products such as plastics, fibers, paints, etc., and backward
for the basic raw materials such as ethylene, propylene, benzene and
toluene; or in the case of petroleum refineries also manufacturing organic
chemicals, to crude oil.

A description of the concentration of the organic chemicals industry
by company size is given in Table III-1. The information available
from the preliminary 1972 Census of Manufacturers does not indicate any
substantial change from the total number of establishments as shown in
Table III-1. By 1972, the number of establishments in SIC category 2865 -
Cyclical Crudes and Intermediates - had decreased slightly to 171 estab-
lishments whereas the number in SIC code 2869 - Industrial Organic
Chemicals NEC - had increased to 503 establishments to total 674
establishments in 1972 as opposed to 665 in 1967 within the two categories.
No breakdown by company size is provided in the preliminary 1972 data.

As shown in Table III-1, the organic chemicals industry is quite
heavily concentrated in a relatively small number of companies. Each
of these companies, however, is involved in the manufacture and sale of
hundreds of individual organic chemical products. In terms of value
of shipments, in 1967 the four largest companies accounted for 45% of

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TABLE III-1

CONCENTRATION OF THE ORGANIC CHEMICAL INDUSTRY 1967

	Companies	Establishments		Value of Shipments		Number of Employees		Production Workers	
		No.	%	$ MM	%	thousand	%	thousand	%
Cyclic Intermediates & Crudes — SIC 2865 (formerly 2814 & 2815)									
Total industry	115	177		1,596.8		30.0		20.3	
4 largest companies		21	12	719	45	13.2	44	9.3	46
8 largest companies		44	25	1,021	64	18.0	60	12.4	61
20 largest companies		71	40	1,326	83	24.5	83	17.1	84
50 largest companies		110	62	1,550	97	28.8	96	19.7	97
Industrial Organic Chemicals, NEC — SIC 2869 (formerly 2818)									
Total industry	339	488		6,377.8		95.1		62.4	
4 largest companies		29	6	2,868	45	40.0	42	26.8	43
8 largest companies		49	10	3,700	58	50.4	53	34.3	55
20 largest companies		98	20	4,770	75	67.5	71	44.2	71
50 largest companies		175	36	5,860	92	83.7	88	54.9	88

Source: Bureau of the Census, 1967 Census of Manufactures, Concentration Ratios in Manufacturing — MC67(S) 2.1, 2 & 3.

total shipments and about 42% of total employment. The fifty largest companies in the industry described by these two SIC categories account for 93% of total shipments.

The history of the growth in sales of the organic chemicals industry as given in Table III-2 is derived from data published annually by the U.S. Tariff Commission. These data have been broken down and categorized by major product group. The sales of the industry consist normally of products which must be further upgraded by chemical or physical conversion to final consumer or industrial goods. This upgrading may take place within the industry, as categorized, or outside the industry. Tables III-3 and III-4 compare the production volume in total and that proportion of the production which is sold for further upgrading. As shown in Table III-4 over the last decade, sales volume has accounted for between 45% and 48% of total production volume, the major portion of production being captive for further upgrading within the manufacturing company.

B. RAW MATERIALS

The organic chemicals industry, based on the processing of carbon containing raw materials, became a significant entity in the mid-1800's with the invention of synthetic organic dyes based on raw materials distilled from coal tar. For the next seven or eight decades, the industry continued to rely for raw material derivatives from the coal coking process and the fermentation of agricultural products. In the 1930's and 1940's, the research was done and fundamental processes developed which led to the rapid growth of the industry to date as shown in Table III-2.

It became apparent that the growth of the synthetic organic chemicals industry could not be supported on the raw materials available from coking coal and the limited and relatively high cost fermentation techniques available. It was also obvious that large volumes of organic

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TABLE III-2

ORGANIC CHEMICAL INDUSTRY
SALES VALUE
(Millions of Dollars)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
A. Basic Organic Chemicals	529	579	648	747	728	737	815	870	833	944	1157
1. Coal Derived Basics	121	129	139	139	132	138	178	178	159	166	180
2. Petroleum Derived Basics	408	450	509	608	596	599	637	692	674	778	977
B. Large Volume Intermediates and Finished Organics	1549	1684	1764	1890	1879	2023	2198	2221	2208	2564	3104
3. Resin Intermediates	222	250	243	273	278	312	359	368	384	483	570
4. Fiber Intermediates	148	185	226	243	236	299	362	345	329	387	401
5. Chlorinated Hydrocarbons	265	292	317	339	338	339	389	407	409	468	543
6. Miscellaneous	913	958	979	1035	1027	1073	1089	1101	1086	1226	1590
C. Small Volume Intermediates and End Products	1053	1170	1305	1500	1713	1867	1873	1856	2033	2278	2293
7. Dyes and Organic Pigments	320	348	386	439	440	490	518	513	553	629	701
8. Rubber Processing Chemicals	119	123	123	138	132	151	144	149	159	178	199
9. Flavors and Fragrances	77	84	85	93	93	97	94	89	84	88	108
10. Unformulated Pesticides	369	427	497	584	787	849	851	870	979	1092	1344
11. Plasticizers	168	188	214	246	261	280	266	235	258	291	341
Grand Total Accounted for:	3131	3433	3717	4137	4320	4627	4886	4947	5074	5786	6954

D. Miscellaneous Intermediates

Note: Totals do not add up due to rounding.
    *Preliminary

Source: U.S. Tariff Commission, Synthetic Organic Chemicals, U.S. production and sales.

TABLE III-3

ORGANIC CHEMICAL INDUSTRY

PRODUCTION VOLUME
(Billions of Pounds)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
A. Basic Organic Chemicals	27.9	31.6	34.9	38.9	41.6	46.1	56.9	58.1	57.9	65.2	70.4
1. Coal Derived Basics	5.5	5.8	6.2	6.0	5.6	6.0	12.1	11.6	10.1	10.9	11.1
2. Petroleum Derived Basics	22.4	25.8	28.7	32.9	36.0	40.1	44.8	46.5	47.8	54.3	59.3
B. Large Volume Intermediates and Finished Organics	34.1	39.0	43.0	49.6	50.8	58.0	66.5	69.3	69.9	81.5	37.9
3. Resin Intermediates	6.2	7.9	8.8	9.9	10.1	12.0	14.7	14.7	15.6	18.8	19.5
4. Fiber Intermediates	3.1	3.7	4.6	5.9	5.3	6.7	7.4	6.6	7.1	8.7	9.3
5. Chlorinated Hydrocarbons	4.4	5.0	5.7	7.1	7.6	8.7	10.5	12.2	12.2	12.9	15.1
6. Miscellaneous	20.5	22.4	24.0	26.6	27.8	30.7	34.0	35.8	35.0	41.1	44.0
C. Small Volume Intermediates and End Products	2.1	2.3	2.6	2.9	2.9	3.2	3.2	3.1	3.4	3.7	4.0
7. Dyes and Organic Pigments	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.4
8. Rubber Processing Chemicals	.2	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4
9. Flavors and Fragrances	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
10. Unformulated Pesticides	.8	.8	.9	1.0	1.1	1.2	1.1	1.0	1.1	1.2	1.3
11. Plasticizers	.8	1.0	1.1	1.2	1.3	1.3	1.4	1.3	1.5	1.7	1.9
Grand Total Accounted for:	64.1	72.9	80.5	91.4	95.3	107.3	126.6	130.5	131.2	150.4	162.3

D. Miscellaneous

Note: Totals do not add up due to rounding
   *Preliminary

Source: U.S. Tariff Commission, Synthetic Organic Chemicals, U.S. production and sales.

TABLE III-4

ORGANIC CHEMICAL INDUSTRY
SALES VOLUME
(Billions of Pounds)

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
	(47.3)	(45.9)	(48.7)	(51.0)	(49.0)	(47.5)				(46.7)	(46.4)
A. Basic Organic Chemicals	13.2	14.5	17.0	19.7	20.4	21.9	25.7	27.8	26.9	30.5	32.7
1. Coal Derived Basics	3.5	3.7	4.1	3.9	3.9	4.0	6.8	6.9	5.9	6.0	5.9
2. Petroleum Derived Basics	9.7	10.8	12.9	15.8	16.5	17.9	18.9	20.9	21.1	24.5	26.8
B. Large Volume Intermediates	(41.4	(42.6)	(42.6)	(40.3)	(40.2)	(41.4)	(42.1)	(42.1)	(43.5)	(46.4)	(47.1)
and Finished Organics	14.1	16.6	18.1	20.0	20.4	24.0	28.0	29.2	30.4	37.8	41.4
3. Resin Intermediates	2.3	2.9	3.0	3.3	3.5	4.4	5.4	6.0	6.4	8.2	8.5
4. Fiber Intermediates	1.3	1.7	2.2	2.8	2.8	3.5	4.0	3.7	3.5	4.4	4.3
5. Chlorinated Hydro-carbons	2.3	2.6	3.8	3.1	3.2	3.5	4.8	5.0	5.0	5.9	6.3
6. Miscellaneous	8.1	9.3	10.0	10.8	11.0	12.7	13.4	14.4	15.5	19.4	22.3
C. Small Volume Intermediates	(90.5)	(91.3)							(88.2)	(91.9)	(92.5)
and End Products	1.9	2.1	2.3	2.5	2.6	2.8	2.8	2.7	3.0	3.4	3.7
7. Dyes and Organic Pigments	.2	.2	.2	.2	.2	.3	.3	.3	.3	.3	.3
8. Rubber Processing Chemicals	.2	.2	.2	.2	.2	.2	.2	.2	.2	.3	.3
9. Flavors and Fragrances	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
10. Unformulated Pesticides	.7	.7	.8	.8	.9	1.0	.9	.9	.9	1.0	1.2
11. Plasticizers	.8	.9	1.0	1.2	1.2	1.2	1.3	1.2	1.4	1.6	1.7
Grand Total Accounted for:	29.2	33.1	37.4	42.3	43.4	48.7	56.6	59.7	60.3	71.7	77.9
(Sale as % of production)	(45.6)	(45.4)	(46.5)	(46.3)	(45.5)	(45.4)	(44.7)	(45.8)	(46.0)	(47.7)	(48.0)

Note: Totals do not add up due to rounding.

Source: U.S. Tariff Commission, Synthetic Organic Chemicals, U.S. production and sale.

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chemical precursors existed in the petroleum and natural gas being
extracted and processed for fuel. The raw material base of the organic
chemicals business shifted to the use of petroleum, gas and gas liquids,
and currently over 85% of the organic chemicals manufactured are
derived from petroleum gas or gas associated hydrocarbons.

The organic chemicals industry has been characterized by its exten-
sive technology which has led to a proliferation of products and processes.

In recent years the raw material supply situation has become increasingly
complicated as the technology was developed to utilize internal petroleum
refinery streams either directly for chemical manufacture or as precursors
for chemical production. Refinery economics, or the determination of
competitive values of hydrocarbons for use as fuel, became inexorably
interwoven with the economics of organic chemical manufacture. The graphic
illustration of the interface between refinery operation and petrochemical
manufacture is shown in Figure III-1. As illustrated by the figure, the
integration of basic petrochemical manufacture (olefins and aromatics)
into a refinery produces a proliferation of jointly manufactured products
many of which can be used either as fuels or as petrochemicals. The
refinery operator normally attempts to optimize the total slate of
products produced but in so doing is faced with a complex series of inter-
related choices involving not only what products to make but the effect
of any change on the total system.

C. INDUSTRY ECONOMIC CONSIDERATIONS

1. Cyclicality

Organic chemical manufacture was recognized during the 1950's
and much of the 1960's as an opportunity for participation in a rapidly
growing and relatively profitable sector of the U.S. economy. A history
of earnings of the Basic Chemical Industry is shown in Table III-5.
As a consequence, those firms in the business were interested in at least
holding their existing market shares and a number of firms not involved

PURCHASED NGL   LPG'S

C1/C2
C3
< C4
n C4

SATURATED GAS RECOVERY

LIGHT NAPHTHA

NATURAL GASOLINE

HEAVY NAPHTHA

CRUDE DIST

CRUDE OIL & CONDENSATES

CATALYTIC REFORMING

REFORMATE

REFORMATE

EXTRACT

EXTRACT

BENZENE

EXTRACTION PLANT

AROMATICS FRACTIONATION

DEALKYLATION

TOLUENE

MIXED XYLENES

C8 AROMATICS SEPARATION

ORTHO - X
PARA - X
META - X
EB

RAFFINATE

RAFFINATE

PYROLYSIS GASOLINE

PYROLYSIS GASOLINE

MIDDLE DISTILLATES

OLEFINS PLANT

ETHYLENE

BUTADIENE

PROPYLENE

BUTYLENE

ETHYLENE

BUTADIENE

PROPYLENE

BUTYLENE

KEROSENE/HEAVY GAS OIL

LIGHT NAPHTHA

LIGHT NAPHTHA

LONG RESID

HEAVY NAPHTHA

FUEL GAS

FUEL GAS

HYDRO CRACKING

LIGHT ENDS

CRACKED GAS RECOVERY

PROPYLENE/ PROPANE

BUTANE/ BUTYLENE

ALKYLATION/ POLYMERIZATION

GASOLINE

BUTYLENES / BUTANES

PROPYLENES / PROPANES

VACUUM DISTILLATION

CATALYTIC CRACKING

GASOLINE

GASOLINE

CRACKED GAS OIL

CRACKED GAS OIL

COKER OR VISBREAK

GASOLINE

GASOLINE

CRACKED GAS OIL

CRACKED GAS OIL

CAT CRACKED SLURRY OIL

CAT CRACKED SLURRY OIL

REFINERY FUEL
LPG
GASOLINE
CHEMICALS
MIDDLE DISTILLATE
RESIDUAL FUEL

REFINERY / PETROCHEMICAL INTERFACE

ARTHUR D. LITTLE INC.   4/1/74

74903

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TABLE III-5

PROFITABILITY OF U.S. BASIC CHEMICAL INDUSTRY

Year	Net Sales ($ billion)	Net Profit[1] ($ billion)	Return on Equity[2] (percent)	Return on Total Capital[2] (Percent)
1960	12.7	1.1	11.1	8.6
1961	13.0	1.1	10.5	8.2
1962	14.3	1.2	11.6	8.8
1963	15.8	1.3	12.5	9.2
1964	18.4	1.6	14.2	10.1
1965	20.9	1.7	14.3	9.7
1966	23.6	1.9	14.0	9.5
1967	24.4	1.6	10.9	7.3
1968	26.2	1.7	11.1	7.4
1969	27.1	1.6	10.5	7.0
1970	27.4	1.4	8.6	5.6
1971	29.5	1.5	8.7	5.8
1972	33.2	1.8	10.0	6.7
1973	39.6	2.6	12.9	9.2

1. After Tax.

2. Total capital employed = long-term debt (+ other nonrecurring liabilities) + stockholders' equity.

Rounding of profits, equity and total capital does not permit checking against above figures.

Source: Securities & Exchange Commission 1960-1973.

in organic chemical manufacture were anxious to enter for reasons of
diversification or forward or backward integration. As shown in
Table III-6, capital expenditures rose from a range of around $400-$500
million per year in the late 1950's and early 1960's to close to
$1 billion per year from 1966 through 1970. This rapid expansion
led to overcapacity and declining prices and profit margins starting
in 1967. The situation was exacerbated by the decline in the rate of
growth in demand brought about by the recession in 1970 and 1971. This
led to a significant decline in returns and subsequent declines in in-
vestment as shown in Table III-6. As shown, decreases in investment
lagged the substantial decline in profitability by two years or about
the length of time required for major plant construction.

As demand increased rapidly with general economic conditions
during 1973, producers' capacity utilization rates substantially improved
though prices and profit margins were partially restrained by price
controls. The actual capacity available relative to the growing demand
was then significantly reduced by restraints imposed by the oil embargo
in late 1973.

Demand continued to increase through the first half of 1974. By
the spring of 1974, price controls had been removed. Prices rose rapidly
both because of the increase in costs generated by higher petroleum prices
and because of shortages generated by lack of capacity to meet the rising
demand. By the fall of 1974, demand for many organic chemical products
declined precipitously and by early 1975, prices had again begun to
soften due to overcapacity. By this time, however, the industry was
experiencing substantially higher feedstock costs than existed prior
to the increase in the international price of crude oil. So long as
crude oil prices and alternate energy values remain at current high levels,
it is highly unlikely that petrochemical prices will return to previous
levels. It is not unlikely, however, that the petrochemical industry will
repeat its cycle of overexpansion which occurred in the late 1960's with
consequent future pressure on industry profit margins.

TABLE III-6

CAPITAL EXPENDITURES
MILLION $

(Current $)

	Cyclic Crudes and Intermediates SIC-2865	Ind. Organic N.E.C. SIC-2869	Total SIC 2865 & 2869
1958	78.0	330.3	408.3
1959	73.3	224.3	297.6
1960	98.6	297.7	396.3
1961	69.6	380.6	450.2
1962	80.3	267.9	348.2
1963	106.8	401.0	507.8
1964	103.5	496.4	599.9
1965	91.9	641.2	733.1
1966	88.4	886.2	974.6
1967	136.1	781.2	917.3
1968	99.3	884.8	984.1
1969	140.4	711.7	852.1
1970	283.2	738.1	1066.3
1971	279.6	659.4	939.0
1972	151.8	565.2	717.0

Source: 1972 Census of Manufactures.

2. Prices

Prices for organic chemicals are quoted weekly in the Chemical
Marketing Reporter and other published sources. These are list prices
for spot sales of specified quantities for shipment such as carload lot.
As most large volume organic chemical materials are sold under contract,
these list prices have not normally been the same as actual prices paid
in any period of time.

The U.S. Tariff Commission prints an annual summary, Synthetic
Organic Chemicals, which specifies the production, sale and average
price of most large volume organic chemicals. The actual average price
paid during any year is derived simply by dividing the total volume of
sales by the total quantity of sales of any specified product. In most
instances where products are sold in large volumes under contract, the
average actual prices have been significantly lower than the quoted
list prices during the year. A history of both list prices and actual
prices is provided in the individual sections of this report dealing
with the economic impact on specific chemical products.

3. Coproducts

In many cases a specific organic chemical process will result
in the production of more than one product of commercial value. The
cumene process for the production of phenol, for example, yields both
phenol and acetone as coproducts. Similarly, styrene and propylene
oxide are yielded by the new Oxirane process described further in the
body of this report. If one product is of minor value, either because
of low unit value or quantity yield, it is usually referred to as a
byproduct and disposed of at whatever price the market will bear. If
two or more products of significant value are yielded by a process,
these are normally termed coproducts and can present both problems
and opportunities to the manufacturer. A problem exists to the extent

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that in order to derive one coproduct, the manufacturer necessarily gets
the other and hence looses the flexibility of operating his plant relative
to total market needs. An opportunity may exist in that if the process
has inherent cost advantages over the manufacture of products derived
by other routes, the manufacturer retains a measure of flexibility in
that he is able to consider returns available from the total output of
the plant and is not rigorously constrained by the total cost of plant
operation being placed against one product. Operators of coproduct processes,
therefore, may have the potential capability of pricing individual co-
products to gain the market desired for that specific product while sale
of the other products satisfies the overall return on investment require-
ment for the plant.

4. Captive Usage

By its very nature, the synthetic organic chemicals industry
lends itself to a relatively high degree of vertical integration and
hence captive use for the output of individual processing units.
Usually, there are a series of processing steps involved from the basic
raw material to the finished products. For example, the manufacture of
polystyrene housewares starts with the isolation of benzene from a
catalytic reformer in a refinery and the production of ethylene through
cracking ethane, propane, naphtha, or gas oil. Ethylene and benzene
are then synthesized to ethylbenzene. Ethylbenzene is next dehydrogenated
to styrene. Styrene is polymerized to polystyrene resin. This resin is
then fabricated into the final article of use. The chemical company
might be involved in any one or all of these processing steps. Usually
the chemical industry has focused its interest on the chemical conversion
activities taking place between isolation of the feedstock and the final
formulation or fabrication of the end product. In the case of styrene,
therefore, chemical companies, with the exception of chemical affiliates
of petroleum companies, will not be involved in isolation of benzene
or olefin cracking stock for ethylene nor would they be involved in the
final fabrication of polystyrene into finished products.

The degree to which a particular company integrates forward and/ or backward in its processing steps depends on a variety of factors often in unique combinations in any particular situation. These include the availability of capital, security of markets for the intermediates being sold, technological capability for forward or backward integration, security of supply, and general corporate strategy or philosophy as to how the management of the company wishes to position the company given the available corporate resources. In most products examined within the body of this study, there is at least some degree of captive consumption. In a number of cases, captive consumption constitutes a considerably larger proportion of total production than merchant sale. In very few cases, however, are the products being produced entirely consumed within the producing organizations.

5. International Trade

Within the past decade, the United States has been a net exporter of organic chemicals. As shown in Table III-7, the U.S. net export position increased from around $600 million in 1966 to an estimated $1.7 billion in 1974.

There is currently serious question as to whether the United States can continue to increase its long-term favorable trade balance in view of the emphasis being put by the oil producing nations on the development of petrochemical manufacturing plants. In almost all cases, manufacturing facilities will be devoted principally or entirely to export as the nations planning the facilities do not have sufficient domestic demand to absorb the output of the world-scale plants under consideration. Once these plants are built and on stream, presumably by the early to mid-1980's, oil producing nations will be seeking markets for large quantities of petroleum and gas-derived organic chemicals and, should the oil producers cartel hold until this time, would be able to supply these chemicals in world markets at prices substantially below prices based on purchased crude oil. Quite probably, once the investment is

TABLE III-7

U.S. BALANCE OF TRADE IN ORGANIC CHEMICALS
(Million Dollars)

Total Trade	1965	1966	1967	1968	1969	1970	1971	1972	1973	Preliminary 1974
Exports	759.0	802.7	864.8	992.3	1016.4	1183.2	1143.0	1219.5	1683.8	2845.0
Imports	144.4	189.0	184.6	221.9	263.3	298.7	345.3	432.5	546.5	1098.5
Balance	+614.6	+613.7	+680.2	+770.4	+753.1	+884.5	+797.7	+787.0	+1137.3	+1746.5

Source: U.S. Department of Commerce, Bureau of the Census, FT 135 and FT 410.

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made in petrochemical facilities, oil producing states will seek to insure the continued viability of these facilities by transferring gas, gas liquids or crude oil at whatever price is necessary above their production cost to obtain necessary markets. These markets are the same as those currently served by U.S. exports. In addition, the United States, which is short of the hydrocarbons required by its own economy, presents the largest single market in the world for the import of petrochemical intermediates or finished products.

IV. HIGH PURITY ISOBUTYLENE BY SULFURIC ACID EXTRACTION

A. SUMMARY

Data on total isobutylene production or the production of high purity
isobutylene from sulfuric acid extraction are not published by the U.S.
Tariff Commission. Consumption for chemical manufacture is believed to
be about 600 million pounds per year for high purity isobutylene.

About two-thirds of total high purity isobutylene production is used
in the manufacturing of butyl polymers. The remainder is used in a
variety of applications for the manufacturing of specialty chemicals.
Butyl rubber competes on a price basis with other specialty rubbers
such as neoprene or nitrile rubber. The industry's forecast average
consumption growth rate is low - in the order of 2% per year. A sub-
stantial proportion of total production of high purity isobutylene is
used captively in the manufacturing of polymers and specialty chemicals.

Historically, high purity isobutylene has been manufactured by
sulfuric acid extraction from a C_4 hydrocarbon fraction resulting from
thermal cracking. Isobutylene is separated from n-butane which is
later used in the manufacturing of butadiene. The leading manufacturer
is Exxon followed by Petro-Tex. Under a new process patented by Oxirane
Corporation, isobutylene is produced as a coproduct of propylene oxide
when isobutane is used as a raw material. This is a highly competitive
process, which has made Oxirane probably the leading manufacturer of
isobutylene. The industry is concentrated in the Gulf Coast area.

Capacity utilization can only be subjectively evaluated since
production of isopropylene depends on its market demand and demand for
n-butane and propylene oxide, not necessarily on potentially available

capacity. List prices of isobutylene have remained stable at 38¢ per gallon from 1963 to 1974. Actual average prices are not available in the literature.

We estimate that producers of high purity isobutylene will be able to pass through treatment costs associated with the treatment of effluent in a 10 million gallon per day complex. This will be equivalent to 3.3% of 1973 prices to achieve BPT and approximately 6.7% of 1973 prices to achieve BAT. We forecast no plant shutdowns chiefly because of the necessity for the free standing producer to remove isobutylene in the butadiene manufacturing process. We expect no impact on the U.S. balance of payments.

A summary of the factors affecting economic impact is provided in the impact matrix given in Table IV-1.

B. INDUSTRY BACKGROUND

    1. Market Characteristics

        a. Size and Growth

                Data on high purity isobutylene production are not published by the U.S. Tariff Commission and so total production volumes are uncertain. Calculations made in 1967 and published in the Chemical Economics Handbook, based on capacities of petroleum refineries and feedstocks used by ethylene producing operations, indicate that there were 7,700 million pounds of total isobutylene potentially available from petroleum refining operations and 350 million pounds from ethylene plants. Only a small portion of this total is isolated for chemical applications. The Chemical Economics Handbook estimates consumption of total butylenes for conversion to chemicals at 642 million pounds in 1967. Of this total, butyl elastomers required 255 million pounds (40%) and polybutenes required 276 million pounds (43%).

TABLE IV-1

ISOBUTYLENE BY SULFURIC ACID EXTRACTION
(High Purity)

All Processes:			
1972 Production (Million Pounds)			600
1972 Unit Value (¢/Lb)			7.8
1972 Production Value ($MM)			47
Number of Plants (Current)			5

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	3.3 – 12.3% 6.7 – 18.5%
Substitute Products	High Occurrence		Direct: Low Secondary: Moderate
Capacity Utilization	Low		Not Applicable: Co-product Manufacture
Captive Usage	Low		High
Demand Growth	Low		Low: 3-4%/yr.
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Concentrated
Number of Producers	Many		Few
Substitute Process	Many		1: Oxirane Process

TABLE IV-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	See Text
Cash Flow (Including Treatment Costs)	Negative		See Text
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	12 – 47% 19 – 68%
Integration	Low		Moderate to high
Chemical Complex	Isolated Plant		Primarily large complexes
Other Environmental Problems (Including OSHA)	Multiple		Few
Emotional Commitment	Indifference		Moderate
Ownership	Multi–Industry Companies		Multi-Industry

A relatively new process, commercialized by Oxirane in 1970, utilizes isobutane and propylene to produce propylene oxide and tertiary butyl alcohol. As there is only a small market for tertiary butyl alcohol (according to Chemical Economics Handbook,14 million pounds were produced in 1967) the great majority of the tertiary butyl alchohol is dehydrated to high purity isobutylene. According to trade estimates 1.6 pounds of isobutylene are produced per pound of propylene oxide produced. Oxirane currently operates a plant with a capacity of 560 million pounds per year of propylene oxide. No data were publicly available from Oxirane, the operations of this proprietary process, as to the quantities of high purity isobutylene produced.

The U.S. Tariff Commission reports the production of iso-butylene and judging from the average price of 2.9¢ per pound this is low purity isobutylene utilized in chemical manufacture. During 1973 a total of 771 million pounds were produced. Of this total 497 million pounds, or 64% was sold. Low purity isobutylene (80-95% isobutylene content)was reported by the U.S. Tariff Commission to have been produced at a rate of 213 million pounds in 1963 and hence, production was given at a rate of approximately 13.5% per year over the ten year period.

b. End Uses

Low purity isobutylene, obtained as part of the cracking operations, in the manufacture of gasoline, is used in alkylation for the production of alkylate gasoline and in the manufacture of polybutenes. Polybutenes are used as components of sealants, caulking compounds for architectural applications, adhesives and as the basis for lube oil additive manufacture. Consumption of isobutylene for these chemical uses grew at an average rate of 13.5% per year from 1963 to 1973.

High purity isobutylene is obtained by isolation from other
hydrocarbons by sulfuric acid extraction and by the Oxirane process.
About 75% of total production is used in the manufacturing of butyl
polymers (butyl rubber and polyisobutylene). The remaining 25% is used
in the production of a variety of miscellaneous specialty chemicals.
Total production is estimated by trade sources at about 600 million
pounds per year.

At one time butyl rubber was commercially promoted for use
in tire carcasses. The product has extremely low gas permeability and
is presently used in the production of truck and tire inner tubes and
liners for tubeless tires. The market for passenger car tire inner tubes
has declined but butyl rubber is still used as an inner liner or sealant.
In the past few years, growth in total demand has declined to about 3%
per year. Butyl elastomers also find diverse markets as a specialty
rubber in a variety of applications where gas permeability and good aging
characteristics are critical.

Polyisobutylene, a chemical derivative, is used in lubricating
oils where it acts as viscosity index improvers. It is manufactured and
sold by Exxon, an isobutylene producer. Polyisobutylene is also used
in small amounts in adhesives. waxes, tank linings, pressure-sensitive
tapes.

Growth in the consumption of high purity isobutylene is fore-
cast to grow at 2% per year over the next five years. Growth of butyl
rubber in tire and tube manufacture will be restrained by the production
of longer wearing radial tires. Growth of polyisobutylene will be re-
strained as the market has matured and will be directly related to increases
in consumption of automotive lubricating oil.

c. Substitute Products

Products made from high purity isobutylene are less price sensitive than those made from low purity isobutylene. In the elastomer area, butyl elastomers compete against neoprene, nitrile rubber, and other specialty rubbers. These are elastomers with unique combinations of properties, and their end-use applications are not very price sensitive. These products, however, do compete among themselves on the basis of price for the same end-use market. There is no substitute for isobutylene in butyl rubber manufacture.

Similarly, there is no good substitute for polyisobutylene as a viscosity index improver in motor oils. Polyisobutylenes constitute a relatively modest proportion of the total volume and cost of the oil sold and viscosity index improved oils sell at a premium over competitive lubricating oils. We expect that demand is quite inelastic for relatively small price changes (<10%) in the price of isobutylene and polyisobutylene.

The isobutylene content in specialty chemicals is small. Consequently, isobutylene price changes do not have a major effect on the final price of the specialty product. This reduces the need to find substitute products with more competitve prices.

d. Captive Requirements

According to trade estimates about 85% of total production of high purity isobutylene from the sulfuric extraction process is used captively in the manufacturing of chemical derivatives, such as butyl elastomers and polyisobutylene. Isobutylene derived as a coproduct from the Oxirane process is not used captively.

2. Supply Characteristics

a. Manufacturing Routes

Isobutylene is basically a byproduct from thermal cracking of petroleum for gasoline manufacture. Large amounts of butenes are produced in petroleum refineries during the catalytic cracking of gas oils and heavier fractions to gasoline. Generally, the butenes, as recovered by conventional refinery distillation operations, are present in a C_4 fraction (four carbon atoms) along with isobutylene and the two saturated C_4 hydrocarbons, n- and iso-butane. If the refiner wishes to produce butadienes, the catalysts customarily employed for dehydrogenating butenes do not appreciably convert isobutylene and the butanes; hence, these must be removed from the butenes which are fed to a dehydrogenation process to produce butadiene.

Isobutylene is generally removed from the other C_4 hydrocarbons by treatment with aqueous sulfuric acid, of a concentration carefully controlled so that the isobutylene is dissolved selectively by the acid phase, while only small amounts of the butenes react. The extract is treated with steam to liberate a 96% (volume) isobutylene product. (The mixture could also be processed to produce diisobutylene, which is a chemical intermediate instead of isolating isobutylene.) Subsequent purification by distillation yields greater than 99% pure isobutylene.

After isobutylene is eliminated, n-butane is dehydrogenated to butene which is further processed to butadiene.

b. Producers

Principal producers of high purity isobutylene using the sulfuric acid extraction process are: Exxon in Baton Rouge, Louisiana; and Petro-Tex in Houston, Texas.

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Annual production volumes are not available and capacity was not defined by our investigation. Oxirane Corporation is now probably the major producer of isobutylene.

c. Manufacturing Costs

Estimated manufacturing costs for high purity isobutylene are given in Table IV-2. As shown, estimated costs exceed the list price of 7.8¢ per pound. This may be due to assumed refinery values for C_4 hydrocarbons or the general complexity inherent in coproduct cost accounting which often fails to reflect the true marginal cost of marketing the coproduct, and/or pressure on prices from excess capacity.

3. Prices

Actual average prices for high purity isobutylene are not available in the U.S. Tariff Commission. List prices of 99% isobutylene, (Tank-car, f.o.b.) are listed in the Chemical Marketing Reporter at 38¢ per gallon from 1963 to 1974. One of the reasons for apparent price stability is Oxirane's new process, which probably results in lower cost product than the sulfuric acid extraction process, although in both cases, isobutylene is a coproduct and, hence, cost of manufacture is necessarily somewhat arbitrary.

4. Supply/Demand Balance

The production volume of high purity isobutylene depends not only on demand for isobutylene but also on demand for n-butane. Both products, isobutylene and n-butane, are present in the same C_4 fractions produced within a refinery. Production capacity and production volume, when the Oxirane method is used, are not reported.

In summary, there would appear to be an ample supply of high purity isobutylene available from byproduct sources. Even should butadiene production eventually be curtailed, we expect large quantities are available from Oxirane.

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TABLE IV-2

ESTIMATED MANUFACTURING COST FOR PRODUCTION OF HIGH PURITY ISOBUTYLENE BY SULFURIC ACID EXRACTION

Production Economics (Summer 1973)
Process Sulfuric Acid Extraction of Mixed C_4's
Location Gulf Coast **Capacity** 50 MM lb/yr. **Invest.** $2.8 MM (1970 construction)

	Cost	
	$/Yr.	¢/lb. Product
C_4 **Hydrocarbons** 2.8 lb @ 2.9¢/lb. (38.5% Isobutylene)	4,060,000	8.12
Catalyst, Chemical, Supplies	50,000	0.10
Utilities	110,000	0.22
Direct Labor 20 men @ $5.00/hr.	213,000	0.43
Maint. Labor & Materials	168,000	0.34
Labor & Plant Overhead	213,000	0.43
Depreciation 9%/yr.	252,000	0.50
Taxes & Insurance 1-1/2%/yr.	42,000	0.08
	5,108,000	10.22
Crude Butene Credit 1.7 lb @ 0.7¢ (80% Butene)	(595,000)	(1.19)
Factory Cost	4,513,000	9.03

C. ECONOMIC IMPACT

1. Treatment Costs

The costs required to achieve BPT and BAT guideline specifications are presented in the guideline document for a free standing plant with 137,000 pounds per day of production capacity. These costs total 0.96¢ per pound to achieve BPT and 1.44¢ per pound to achieve BAT. Significantly lower costs are possible for those plants which are part of a large complex having an effluent volume of 10 million gallons per day. These costs total 0.26¢ per pound to achieve BPT and 0.52¢ per pound to achieve BAT guideline specifications.

Investment for a waste treatment facility for a free standing plant is given as $1.82 million to achieve BPT guidelines and $2.65 million to achieve BAT guidelines. Investment to handle the same effluent in a 10 million gallons per day treatment facility is estimated at $0.48 million to achieve BPT guidelines and $0.73 to achieve BAT guidelines.

High purity isobutylene is produced by two routes: extraction with sulfuric acid from a mixed hydrocarbon stream and by Oxirane's process of dehydrating tertiary butyl alcohol which has been produced as a coproduct with propylene oxide.

According to the guideline contractor, these processes should have about equal waste treatment costs. Two types of plants are found in the U.S. industry utilizing the sulfuric acid extraction process. One is essentially a free standing plant which, although large in size, produces mainly petrochemical products that require relatively small quantities of water processed. The remaining two or three plants are, we believe, associated with large waste treatment complexes; large because of the production of many chemicals requiring larger amounts of

process water. Significant cost differentials exist between the free standing and the large complex plants, as described above, handicapping the producer in the smaller waste treatment complex -- essentially a free standing condition.

2. Price Impact

Actual prices paid for high purity isobutylene are not reported by the U.S. Tariff Commission in Synthetic Organic Chemicals. The fact that isobutylene is reported in this journal priced at 2.9¢ per pound indicates this to be low purity material. List prices for high purity isobutylene have been stable at 38¢ per gallon or 7.8¢ per pound from 1963 through 1974. In all probability, list prices have been restrained as isobutylene is a coproduct or byproduct in both of two manufacturing processes: production of butadiene and production of propylene oxide. The price has probably been kept low by existing potential capacity for production beyond existing demand.

Normally, price increases, as shown by the impact matrix, would be restrained as capacity utilization is probably relatively low, competition is on a price basis, and most importantly, isobutylene is the coproduct with other materials presenting the option for increased costs on the process to be passed through the isobutylene coproduct. There are, however, a few large producers of a product for which there are no substitutes for its major use, and its major end-use product, butyl rubber, has relatively low price elasticity of demand. We expect, therefore, there will be pass through of both BPT and BAT treatment costs. We judge the producer in a free standing plant, however, will be limited to the pass through of only that amount of price increase as defined by the cost of producers in large complexes. As shown in the impact matrix, this will be equivalent to 3.3% of the price of BPT costs and 6.7% of the price to cover BAT costs.

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3. Plant Shutdown Decision

Estimated manufacturing costs indicate the production of high purity isobutylene by sulfuric acid extraction to be an unprofitable activity given the hydrocarbon feedstock and the coproduct values shown in our manufacturing cost economics.

In spite of the illustrated economics, processors have continued the removal of isobutylene in the production of high purity butylene. This has probably been due to both the necessity for isobutylene removal to purify the normal butene fraction in butadiene manufacture, the capability of producers' coproducts to absorb losses in one product while enjoying an overall profit on the total plant operation, and the vagaries of coproduct cost accounting.

If there is a plant shutdown, in all probability it would be limited to one free standing producer. Other producers in large effluent treatment complexes would, by virtue of full pass through of treatment costs, be in the same profit position as prior to the imposition of effluent treatment guidelines. It is difficult to say with certainty, within the scope of this assignment, whether the one free standing plant will shut down. Were isobutylene not a coproduct of butadiene, the differentials in costs would appear sufficiently great so as to dis-advantage the producer to the point that a plant closure would ensue in anticipation of meeting BAT guidelines. Costs of meeting the BAT guidelines would be equivalent to close to 19% of total selling price and require an investment of about 68% of the existing net fixed invest-ment for the sulfuric acid extraction process. We suspect, however, this producer will not have other viable options for the removal of isobutylene from the butene feedstock to produce butadiene and, hence, will be forced into sulfuric acid extraction of isobutylene. Under these circumstances, therefore, there will be no plant shutdowns or loss of employment, but rather loss of profits by the free standing producer equivalent to the difference between effluent treatment costs in the complex, which we

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estimate will pass through, and his own treatment cost. These differ-
ences would be equivalent to 0.70¢ per pound to achieve BPT and 0.92¢
per pound to achieve BAT.

4. Foreign Trade

We expect no impact on foreign trade balance by the imposition
of either BPT or BAT effluent guidelines.

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V. ADIPONITRILE VIA CHLORINATION OF BUTADIENE AND HEXAMETHYLENEDIAMINE VIA HYDROGENATION OF ADIPONITRILE

A. SUMMARY

Virtually all adiponitrile is used captively in the production of nylon 66 salt. In this process, adiponitrile is hydrogenated to hexa-methylenediamine (HMDA), which is then reacted with adipic acid to produce nylon salt. Since adiponitrile, hexamethylenediamine, and nylon salt production often are found at the same plant location, we have treated the two products together in considering the economic impact. However, the industry backgrounds for the two products are described separately to facilitate a more thorough review of each inter-mediate for nylon salt.

U.S. production of adiponitrile derived from butadiene was estimated by trade sources to have been 500 million pounds in 1973. E.I. DuPont de Nemours Co., Inc. (DuPont) is the sole U.S. producer of butadiene-based adiponitrile and consumes its entire production internally, as do all other adiponitrile producers. There are no imports or exports of adiponitrile and apparent consumption is equivalent to production.

The sole end use of adiponitrile is the production of hexamethylene-diamine (HMDA), a principal raw material for the production of nylon 66 fiber and nylon 66, 610 and 612 fibers and resins. The production of adiponitrile is normally an integral part of an HMDA production facility. Capacity utilization is probably high since nylon capacity utilization has been over 90% and expansions in HMDA would match nylon capacity expansions.

The major foreseeable determinant of growth in the production of adiponitrile based on butadiene is the growth of DuPont's sales of nylon 66, 610 and 612.

Total U.S. hexamethylenediamine (HMDA) production in 1973 was 918.3 million pounds, of which 94% was made from adiponitrile. HMDA production has experienced an average annual growth rate during 1967-1973 of close to 11%. Imports and exports have been nonexistent or negligible, so U.S. production closely approximates apparent consumption.

HMDA's sole end use is a raw material for the production of nylon 66, 610 and 612 fibers and resins. Virtually all HMDA production is used captively for the production of nylon salt, which is then polymerized to nylon polymer. HMDA capacity utilization, therefore, has probably closely followed nylon polymer capacity utilization, normally in the range of 80%-85% of nominal capacity.

The major determinant of growth in the production of HMDA will be the demand for nylon 66, 610 and 612 fibers and resins in the future. We expect approximately 6% per year growth in the demand for nylon over the next five years.

Only one impact analysis for adiponitrile and hexamethylenediamine together is considered, since all adiponitrile is consumed captively and converted to hexamethylenediamine. This impact analysis matrix is provided in Table V-1. A summary of the joint effluent treatment costs for the two products and applicable to hexamethylenediamine production costs is given in Table V-2.

We believe that these costs can be fully passed through and will cause no severe dislocations in this industry. The guidelines indicate a cost increase of only 0.17¢/lb to achieve BPT effluent control and only 0.67¢/lb to achieve BAT effluent control of both adiponitrile and he·amethylenediamine. The potential for nylon 66, 610 and 612, and therefore hexamethylenediamine, is near nameplate capacity. Moderate growth is forecast for hexamethylenediamine in spite of projected price increases. Market share distribution for both products is concentrated. These factors suggest a firm market for nylon resins and fibers receptive to small price increases.

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TABLE V-1

ADIPONITRILE FROM CHLORINATION OF BUTADIENE
HEXAMETHYLENEDIAMINE FROM ADIPONITRILE

All Processes:			
1972 Production (Million Pounds)			458
1972 Unit Value (¢/Lb)			36
1972 Production Value ($MM)			—
Number of Plants (Current)			3 (butadiene based)

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.5% 1.9%
Substitute Products	High Occurrence		Direct — Low Secondary — High
Capacity Utilization	Low		High
Captive Usage	Low		High
Demand Growth	Low		Moderate (5%/yr. forecast)
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Low — Direct
Basis for Competition	Price		Totally Integrated
Market Share Distribution	Fragmented		Concentrated
Number of Producers	Many		3
Substitute Process	Many		3 to adiponitrile: acrylonitrile, butadiene and adipic acid plus 2 processes utilizing butadiene.

TABLE V-I (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	2.8% 11.0%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	4.4% 9.2%
Integration	Low		High
Chemical Complex	Isolated Plant		Medium Complex
Other Environmental Problems (Including OSHA)	Multiple		Few
Emotional Commitment	Indifference		High
Ownership	Multi-Industry Companies		Multi-Industry

TABLE V-2

**ESTIMATED EFFLUENT TREATMENT COST IN MEDIUM COMPLEXES FOR
ADIPONITRILE AND HEXAMETHYLENEDIAMINE
(1972 Basis)**

	(¢/lb)		
Medium Treatment Complex[1]	**Adiponitrile**	**HMDA**	**Total**
BPT	.15	.02	.17
BAT	.57	.10	.67
Free Standing Plant			
BPT	1.6	0.5	2.1
BAT	2.2	0.6	2.8

1. 3 million gallons per day effluent treatment facility.

Further, the impact of the projected price increases on the relatively high value added nylon 66, 610 and 612 products will be very small.

We expect no plant shutdowns and no effect on the U.S. balance of trade caused by the proposed treatment costs.

B. INDUSTRY BACKGROUND FOR ADIPONITRILE BASED ON CHLORINATED BUTADIENE

1. Market Characteristics

a. Size and Growth

We estimate that in 1973, 500 million pounds of adiponitrile were made from butadiene (see Table V-3). This represents an average annual growth rate of 8.4% during 1963-1973. Since adiponitrile is normally made at the same plant where it is further processed into HMDA, exports and imports are nonexistent. Apparent consumption per year, therefore, is equivalent to production. We estimate production of nylon will increase at 6% per year. DuPont, however, has introduced a new adiponitrile process, and we do not expect the company to expand adiponitrile production by the route of butadiene chlorination.

b. Uses

Adiponitrile's sole use is the production of HMDA, which is used in the manufacture of nylon 66, 610 and 612 fibers and resins for molding and extrusion.

c. Substitute Products

HMDA can be produced from either adiponitrile or hexandiol. Celanese Corporation at the present is the only firm pursuing the hexandiol/HMDA route and represents 6% of total HMDA production in 1973. The other 94% of HMDA made in 1973 was derived from adiponitrile which

TABLE V-3

**PRODUCTION, EXPORTS, IMPORTS AND APPARENT CONSUMPTION OF ADIPONITRILE
BASED ON BUTADIENE RAW MATERIAL**

(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	222	Not Reported	Not Reported	222
1964	—	Not Reported	Not Reported	—
1965	264	Not Reported	Not Reported	264
1966	—	Not Reported	Not Reported	—
1967	312	Not Reported	Not Reported	312
1968	356	Not Reported	Not Reported	356
1969	350	Not Reported	Not Reported	350
1970	322	Not Reported	Not Reported	322
1971	372	Not Reported	Not Reported	372
1972	458	Not Reported	Not Reported	458
1973	500	Not Reported	Not Reported	500

SOURCE: Chemical Economics Handbook Estimates.

can be produced from various raw materials – butadiene, adipic acid, or acrylonitrile (see Table V-4 for a percentage breakdown for adiponitrile capacity by raw material in 1973). Historically, firms which have chosen a raw material for adiponitrile production base further expansions on the same raw material. The one known exception is Monsanto Company, which makes adiponitrile from adipic acid and acrylonitrile and is expected to base further expansions only on acrylonitrile. No changes of present capacity from one raw material to another are expected due to the high capital cost involved. The share of adiponitrile production derived from the chlorination of butadiene should, therefore, relatively remain constant for the near future. It will change as DuPont's market share of total nylon 66 varies in the future and as DuPont brings on its new adiponitrile process based on treating cyanide with butadiene.

d. Captive Requirements

All adiponitrile production is used captively. No sales of adiponitrile are reported by the U.S. Department of Commerce and it has been industry practice to use 100% of adiponitrile capacity internally.

2. Supply Characteristics

a. Manufacturing Processes

Adiponitrile can presently be made from butadiene using two processes. The older process is to chlorinate butadiene into a mixture of 1,4-dichlorobutene-2 and 3,4-dichlorobutene-1; subsequent reactions of each of a mixture of these products with sodium cyanide, derived from hydrogen cyanide, yields mixed isomers of 1,4-dicyanobutene-1 and -2. The dicyanobutenes are then isomerized and hydrogenated to adiponitrile utilizing a palladium-on-charcoal catalyst. The newer process avoids the chlorination step. The dicyanobutenes are produced by a two-stage reaction of hydrogen cyanide with butadiene. In the first reaction, hydrogen cyanide reacts with butadiene in the presence of a zero-valent catalyst to form mixed unsaturated mononitriles which are isomered to mixed linear pentene-nitriles. A second hydrogen cyanide reaction forms mixed dinitriles from which adiponitrile is isolated.

TABLE V-4

ADIPONITRILE BY RAW MATERIAL

Raw Material	% of Adiponitrile
Butadiene	63
Adipic Acid	26
Acrylonitrile	11
	100

SOURCE: CEH Capacity Estimates.

According to the trade literature, DuPont's adiponitrile production at Victoria, Texas and LaPlace, Louisiana is based entirely on chlorination of butadiene. Within the last year the company has introduced the new direct hydrocyanation process into its existing plant at Orange, Texas, presumably to supplement its existing production of adiponitrile at that location.

b. Producers

The sole producer of adiponitrile from butadiene is DuPont (see Table V-5). The plants in LaPlace, Louisiana, and Victoria, Texas are based on the older process while the plant in Orange, Texas uses the improved two-stage reaction process for at least a portion of its production. The plants are located close to the butadiene raw material rather than the nylon fiber plants.

3. Prices

Since all adiponitrile is used captively, there are no actual prices reported by the U.S. Department of Commerce or list prices. Probably adiponitrile is transferred at cost or cost plus return on adiponitrile plant investments to the HMDA production facilities.

4. Supply/Demand Balance

Capacity utilization cannot be accurately determined since DuPont does not publicly report its adiponitrile production rates or capacities. Production, therefore, has to be derived from DuPont's estimated nylon production. Capacities are also estimated using the same method. During 1973 and the first half of 1974, U.S. nylon fiber production, which accounts for about 90% of nylon 66, 610 and 612, was operating at or close to capacity. During this period, nylon fiber was in short supply. We assume, therefore, that adiponitrile production, keyed to nylon 66, 610 and 612 capacity, was also operating at high capacity levels.

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TABLE V-5

ADIPONITRILE PRODUCERS USING BUTADIENE

Company	Location	Capacity – 1972 (MM lbs.)
E. I. DuPont de Nemours & Co., Inc.	La Place, Louisiana Victoria, Texas Orange, Texas	440

SOURCE: Chemical Economics Handbook

Over the past decade, nylon fiber production has become a cyclical business. In periods of reduced demand, capacity utilization for fiber spinning has dropped to levels of 70-75%. Probably capacity utilization for adiponitrile was similarly reduced.

C. INDUSTRY BACKGROUND FOR HEXAMETHYLENEDIAMINE FROM ADIPONITRILE

1. Market Characteristics

a. Size and Growth

According to the U.S. Department of Commerce data, production of HMDA from all processes totaled 918.3 million pounds in 1973 (see Table V-6) and has increased at an average annual growth rate of close to 11% during 1967-1972. Production was not reported by the U.S. Tariff Commission prior to 1967. Imports and exports, although they were reported in 1970-1972 are minimal, especially since they are normally between subsidiaries of the same corporation. Apparent consumption in the United States is equivalent to production and we estimate will increase at an average rate of 6% per year over the next five years.

b. Uses

All HMDA is used for the production of nylon fibers or resins. As shown in Table V-7, 90% of the HMDA produced in 1972 was used in the production of nylon 66 staple and filament fibers. Eight percent of HMDA production was used in nylon 66 resin production. The remaining 2% was utilized in the production of other nylon fibers and resins (nylon 610 and 612).

TABLE V-6

PRODUCTION, IMPORTS, EXPORTS AND APPARENT CONSUMPTION OF HMDA
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	Not Reported	.7	Negligible	--
1964	Not Reported	Negligible	Negligible	—
1965	Not Reported	Negligible	Negligible	—
1966	Not Reported	Negligible	Negligible	—
1967	497.9	Negligible	Negligible	497.9
1968	649.8	Negligible	Negligible	649.8
1969	663.1	Negligible	Negligible	663.1
1970	613.4	.2	Negligible	613.6
1971	709.5	.1	Negligible	709.6
1972	854.4	.4	.2	854.6
1973	918.3	—	—	918.3

SOURCES: Chemical Economics Handbook, U.S. Tariff Commission

TABLE V-7

CONSUMPTION OF HMDA BY END USE

End Use	% — 1972
Nylon 66 Fibers	90
Nylon 66 Resins	8
Other Nylon Fibers & Resins[1]	2
	100

1. Nylon 610 and Nylon 612

SOURCES: Contractor's Estimates, Chemical Economics Handbook

C. Substitute Products

There is no substitute in the production of nylon 66 for
HMDA, although nylon 6 made from caprolactam competes directly with
nylon 66 in most of its end uses as fiber and molding resins. There
are, however, presently two routes to HMDA available. In 1972, 94%
of the HMDA produced used adiponitrile as a raw material. The other
6% was made from hexandiol. Celanese Corporation is the sole user at
the present time of the hexandiol/HMDA route. Other processes are
in the development stage to produce HMDA from still other raw materials
than adiponitrile. An example is Toray Industries' reported process
to manufacture HMDA using as a raw material aminocapronitrile produced
from caprolactam. It is improbable, however, that current producers
of HMDA from adiponitrile will change current manufacturing processes
due to the high capital cost of conversion and the risk inherent in
the new processes. HMDA from adiponitrile should, therefore, continue
to be the major form of HMDA produced.

d. Captive Requirements

According to the U.S. Tariff Commission data, there has
been no reported sales of HMDA until 1972 (see Table V-8) when 1% of
the year's production was sold. Therefore, virtually all of HMDA pro-
duction is used captively for the production of nylon resins or fibers.

2. Supply Characteristics

a. Manufacturing Processes

HMDA is produced from adiponitrile by hydrogenation which
is carried out in a liquid phase at high pressures and temperatures.
Ammonia is added as a solvent for the adiponitrile, and catalysts,
such as copper or cobalt, are used in the process. Byproducts produced
are hexamethylene amine, 1,2-diaminocyclohexane, and heavy tars.

TABLE V-8

PRODUCTION, SALES AND CAPTIVE USE OF HEXAMETHYLDIAMINE

(million pounds)

Year	Production	Sales	Captive Use
1963	—	Not Reported	—
1964	—	Not Reported	—
1 '65	—	Not Reported	—
1 66	—	Not Reported	—
1 67	497.9	Not Reported	497.9
1968	649.8	Not Reported	649.8
1969	663.0	Not Reported	663.0
1970	613.4	Not Reported	613.4
1971	709.5	Not Reported	709.5
1972p	854.4	8.4	846.0
1973	918.3	Not Reported	918.3

P — Preliminary

SOURCE: U.S. Tariff Commission

b. Producers

Table V-9 lists the producers who manufacture HMDA from adiponitrile and their estimated capacities. Exact capacities are not known since they are not reported by the companies, and therefore, must be derived from their nylon production. Note that these facilities are all located near the source of raw materials – butadiene, adipic acid, or acrylonitrile; i.e., Texas predominently. Also noted in Table V-9 is the raw material used to produce the adiponitrile that is hydrogenated into HMDA. DuPont, which is by far the largest of the three producers, uses butadiene; El Paso uses adipic acid; and Monsanto uses both adipic acid and acrylonitrile. Probably further capacity expansions at Monsanto will be based on adiponitrile from acrylonitrile.

c. Manufacturing Economics

Estimated manufacturing costs for adiponitrile and hexamethylenediamine based on chlorination of butadiene are given in Table V-10. Capacity for this plant is about 5% greater than that specified in the guideline document. We estimate that net capital investment for the plant specified in the guideline document is $29.3 million.

3. Prices

Since virtually all HMDA produced is used captively, published prices are nonexistent. Only in 1972 were external sales reported to the U.S. Tariff Commission when 8.4 million pounds were sold at a unit value of 36¢ per pound. The great bulk of HMDA is probably transferred to the nylon manufacturing facility at cost or cost plus some specified return on the investment in HMDA facilities. We do not expect this to change within the foreseeable future.

TABLE V-9

HMDA PRODUCERS USING ADIPONITRILE – 1971

Company	Location	Capacity (MM lbs)	% of Total	Process
E.I. DuPont de Nemours & Company, Inc.	Orange, Texas Victoria, Texas	440	63	Butadiene
El Paso Natural Gas Co.	Odessa, Texas	30	4	Adipic Acid
Monsanto Company	Decatur, Alabama	75	11	Acrylonitrile
	Pensacola, Florida	155	22	Adipic Acid
		700	100	

Note: Celanese makes approximately 45 million pounds per year of HMDA at Bay City, Texas from hexanediol, not adiponitrile.

SOURCES: Chemical Engineering Handbook, Contractor's Estimates

TABLE V-10

ESTIMATED COST OF MANUFACTURING
ADIPONITRILE AND HEXAMETHYLENEDIAMINE

Production Economics (Summer 1973)

Process From Butadiene

Location Gulf Coast Capacity 200 MM lb/yr[1] Invest. $30.4 MM (1970 Construction)

	Cost	
	$/Year	¢/lb Product
Butadiene 0.74 lb @ 8.1¢/lb	11,980,000	5.99
Chlorine 0.96 lb @ 3.8¢/lb	7,300,000	3.65
Hydrogen Cyanide 0.65 lb @ 10.0¢lb	13,000,000	6.50
Hydrogen 0.018 MSCF @ $2.11/MSCF	7,580,000	3.79
Ammonia 0.02 lb @ 2.0¢/lb	80,000	0.04
$CaCO_3$ 1.48 lb @ 1.0¢/lb	2,960,000	1.48
Catalyst, Chem., Supplies	6,000,000	3.00
Utilities	4,200,000	2.10
Direct Labor 100 men @ $5.00/hr	1,040,000	0.52
Maintenance, Labor & Materials	1,500,000	0.75
Labor & Plant Overhead	1,040,000	0.52
Depreciation 9%/yr	2,736,000	1,37
Taxes & Ins. 1-1/2%/yr	456,000	0.23
Factory Cost	59,872,000	29.94

1. Of hexamethylenediamine; all adiponitrile converted to hexamethylenediamine.
   A plant with capacity to produce 189 million pounds per year is estimated to
   require an investment of $29.3 (1973 basis).

4. Supply/Demand Balance

As shown in Table V-11, we estimate that the industry was operating at 97% capacity in 1972. Again, this judgment is based on trade estimates since capacities are not reported. Since the vast majority of HMDA produced is used captively, capacity utilization is probably directly related to nylon fiber capacity utilization. In the recent past, nylon fiber capacity utilization has been high due to rapid increases in nylon fiber demand. Over the past five to ten years, capacity utilization has probably averaged around 85%.

D. ECONOMIC IMPACT ON ADIPONITRILE BY CHLORINATION OF BUTADIENE AND HEXAMETHYLENEDIAMINE BY HYDROGENATION OF ADIPONITRILE

1. Treatment Costs

The guideline document presents separate waste treatment costs for adiponitrile and hexamethylenediamine. Since all adiponitrile based on chlorination of butadiene is captively consumed to produce hexamethylenediamine, these costs should be considered together to determine the economic impact on hexamethylenediamine and consequently on adiponitrile. The treatment cost data were determined, as shown in Table V-2, by summing the data for separate facilities.

The costs required to achieve BPT and BAT guideline specifications as presented in the guideline document for a free standing plant with a 548,000 pounds per day production capacity of both hexamethylenediamine and adiponitrile, are 2.1¢ and 2.8¢ per pound respectively. We estimate that all adiponitrile and hexamethylenediamine production facilities are located in medium-sized complexes leading to substantial economies of scale. Our estimation of BPT and BAT costs for medium-sized complexes are 0.17¢ and 0.67¢ per pound respectively.

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TABLE V-11

ESTIMATED CAPACITY, PRODUCTION, AND CAPACITY UTILIZATION OF HMDA
(million pounds)

Year	Capacity	Production	% Utilization
1963	—	—	—
1964	—	—	—
1965	—	—	—
1966	—	—	—
1967	—	497.9	—
1968	—	649.8	—
1969	—	663.1	—
1970	—	613.4	—
1971	742	709.5	96
1972	900	854.4	95
1973	950	918.3	97

SOURCES: U.S. Tariff Commission, Contractor's Estimates

There are three processes for production of adiponitrile: chlorination of butadiene, hydrocyanation of butadiene - a variant of the chlorination route, and oxidative coupling of acrylonitrile. DuPont is the only major producer using the chlorination route, and even they are supplementing this old technology with the newer hydrocyanation route. It is doubtful, however, that they will abandon their existing chlorination route facilities because their investment in these is quite large.

The treatment costs for the alternate routes are estimated by the guideline contractor to be about the same as for the chlorination route. Therefore, no cost differentials will be introduced by the alternate processes for adiponitrile.

All adiponitrile is converted to hexamethylenediamine by catalytic hydrogenation. This is the principal production process accounting for about 94% of production in 1972. The remaining 6% was produced directly from hexanediol by reaction with ammonia. This alternate production route is not attractive to those already committed to adiponitrile reduction. The guideline contractor estimates that the latter process has a comparable waste load to hydrogenation of adiponitrile. It may have a somewhat lower treatment cost than the combined adiponitrile, hexamethylenediamine production process. However, we do not believe that this cost differential will affect this industry because the amount of hexamethylenediamine produced from hexanediol is so small and virtually all hexamethylenediamine is consumed captively to make nylon salt and is not sold in the merchant market.

2. Impact on Prices

Virtually all hexamethylenediamine is captively converted to nylon salt then to nylon fibers or resins. Since little or none is sold, the costs will be passed along to nylon 66 purchasers in periods of high demand or in view of the high commitment to nylon 66 production

and the small impact on prices (0.5 to 1.9%) and on net income (2.8 to 11.0%) will be absorbed in nylon 66 resin or fiber margins in periods of demand and oversupply. We do not feel that major dislocations in the market will occur as the result of water treatment costs. Some small percentage of consumers may switch to polyester fibers or resins - nylon's largest competitor - however, this should be offset by consumers switching from nylon 6 (from caprolactam) to nylon 66.

For certain applications where the physical property differences between nylon 6, nylon 66 and polyester resins or fibers are not important, there is a continual reevaluation of the raw material used based on price and availability. If waste treatment cost for these products is large enough, some market dislocations could occur. However, we do not expect much, if any, market switching because all the competitive products will incur waste treatment costs and while the absolute costs for nylon 66 are very low, the cost differentials, if in favor of competitive fibers, will be even less or, if in favor of nylon 66, support the current market. Therefore, we do not expect any adverse reactions if the full treatment costs are passed through.

The price impact matrix suggests that the full treatment costs can be passed through as the economic recession reverses and as growth returns to the textile industry. The market for nylon 66 fibers and resins should remain strong because the demand potential for nylon 66 is near nameplate capacity. Moderate growth is forecast even with higher prices caused by water treatment costs. Foreign competition continues to be low, and the market share distribution is highly concentrated. Further, the impact of the waste treatment costs on the higher value added nylon salt, resin, or fibers will be even less than that estimated for hexamethylenediamine.

3. Plant Shutdown Decisions

All adiponitrile and hexamethylenediamine producers are vertically integrated from basic raw materials through nylon resins or products. Therefore, the commitment to their product is high. Further, the capital costs required to switch from their current technology to another – assuming the waste treatment costs were substantially less – is very high, therefore, there is little chance that these manufacturers would switch to a new technology with concurrent plant relocation. Finally, the costs associated with waste treatment are relatively small even to achieve BAT waste level specifications and the capital investment required – $1.24 million for BPT and $2.69 million for BAT facilities – is not large. We do not expect that the adiponitrile/hexamethylenediamine producers will be severely affected by the proposed effluent specifications and we predict no plant closures or production curtailments.

4. Foreign Trade

Historically, foreign trade has been negligible for both adiponitrile and hexamethylenediamine. Since the duty rate is 5% ad valorem for HMDA versus a 0.5% and 1.9% price increase from BPT and BAT treatment costs respectively, it is not likely that foreign trade will change significantly because of waste treatment costs. Therefore, we expect no effect on the U.S. balance of payments.

VI. SECONDARY BUTYL ALCOHOL BY HYDROLYSIS OF BUTYLENE AND METHYL ETHYL KETONE BY DEHYDROGENATION OF SECONDARY BUTYL ALCOHOL

A. SUMMARY

An estimated 95% of all secondary butyl alcohol produced in the United States is utilized by the producers at manufacturing locations as raw material for the production of methyl ethyl ketone. We have, therefore, treated the two products together in considering the economic impact as we are essentially talking about the two steps in one method for the production of methyl ethyl ketone. The industry backgrounds for the two products, however, are described separately to facilitate a more thorough review of the total subject matter.

There are no reliable data in the U.S. Tariff Commission, or elsewhere which we have been able to determine, defining the production of secondary butyl alcohol. Based on the production of methyl ethyl ketone by the secondary butyl alcohol process and industry comments, we estimate consumption at approximately 400 million pounds per year with an average historical growth rate of 7% per year. We forecast future growth in the demand for secondary butyl alcohol at 7% per year. This growth is tied to forecast increases in demand for methyl ethyl ketone.

Secondary butyl alcohol is manufactured by three companies with an estimated total annual capacity of 416 million pounds in four plants. The industry is concentrated in two companies which hold 84% of total capacity. All companies use the normal butylene process in which normal butylenes are converted to secondary butyl sulfate and subsequently hydrolyzed with water to secondary butyl alcohol. Based on our estimates of industry demand and capacity, we believe the industry has been operating in recent years at over 85% of capacity and was at approximately 96% of capacity in 1973.

About 5% of total secondary butyl alcohol is sold by the producers for application as a solvent. Actual prices are not reported by the United States Tariff Commission but industry sources interviewed estimate prices at around 9¢-10¢ per pound during 1970-1972, approximately 4¢ below list prices. List prices were stable at 12.5¢ per pound from 1963-1969. Since then they increased to 13.5¢ per pound in 1970 through 1972. In 1973 list prices increased to 14.5¢ per pound and 16.5¢ per pound by mid-1974.

Methyl ethyl ketone is produced by the direct oxidation of butane as well as by the dehydrogenation of secondary butyl alcohol. The butane oxidation process yields a variety of products depending on conditions and methyl ethyl ketone is one of the major products of the process.

Total production of methyl ethyl ketone reached a high point of approximately 541 million pounds in 1973. Production has grown since 964 at an average annual rate of 7% per year. Exports have been a igni⊥cant portion of total U.S. producers' sales since 1966. Imports became significant in 1968, peaked at approximately 57 million pounds in 1972, and declined to 42 million pounds in 1973.

Over the nine year period of history examined, apparent consumption of methyl ethyl ketone has increased from 288 million pounds to 536 million pounds or at the same rate of increase as production or 7% per year. Future growth in domestic demand is uncertain because of both the uncertainty surrounding the changes in prices of a variety of competing materials used as solvents as well as by changes in energy and feedstock costs and more importantly because of government regulations affecting the use of solvents.

About two-thirds of the methyl ethyl ketone finds application as a solvent in a variety of uses. Relatively smaller amounts are used in lube oil dewaxing, adhesives and miscellaneous uses. Its major competitive product is ethyl acetate, a solvent with very similar characteristics. Captive

requirements represent about 5% of total production volume.

According to one of the producers, total methyl ethyl ketone capacity in the United States is 591 million pounds. About 70% of this total is produced by the dehydrogenation of secondary butyl alcohol by three companies. Another two producers manufacture methyl ethyl ketone by oxidation of normal butane. This process also produces acetic acid as a coproduct. Assuming the accuracy of the industry estimates on capacity, the industry was working at 91% of available capacity in 1973. In fact, according to industry commentary, the industry was working at about 100% of effective capacity due to limitations on the availability of feedstocks.

Methyl ethyl ketone prices have deteriorated largely because of pressure from imported materials through 1973. Actual prices declined from 11¢ per pound in 1964 to 8¢ per pound in 1973. During the same period, list prices declined from 12.5¢ per pound in 1963 to 9.75¢ per pound in 1973. By the end of 1974, however, list prices were posted at 17¢ per pound reflecting increasing raw material costs and an apparently relatively tight supply/demand situation.

The impact analysis for methyl ethyl ketone is controlling for both products being considered as the production of secondary butyl alcohol is essentially one step in the production of methyl ethyl ketone starting with isobutylene going to secondary butyl alcohol and then the dehydrogenation to methyl ethyl ketone. This impact analysis matrix is provided in Table VI-1. A summary of the joint effluent treatment costs for the two products and applicable to the manufacture is given in Table VI-2.

We do not believe producers of methyl ethyl ketone by the route under consideration will be able to pass through increased prices because of foreign competition, competitive materials and competitive processes. The guideline indicates a cost increase of 0.030¢ per pound to achieve BPT effluent control if both secondary butyl alcohol and methyl ethyl ketone which will have to be absorbed by the methyl ethyl ketone producers.

TABLE VI-1

**MEK BY DEHYDROGENATION OF
SECONDARY BUTYL ALCOHOL**

All Processes:	
1972 Production (Million Pounds)	509
1973 Unit Value (¢/Lb)	8.4
1972 Production Value ($MM)	41
Number of Plants (Current)	6

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost of MEK & Sec. Butyl Alcohol to Selling Price of MEK (%)	High	B.P.T. B.A.T.	0.4% 1.8%
Substitute Products	High Occurrence		High
Capacity Utilization	Low		High: 85%
Captive Usage	Low		Low
Demand Growth	Low		7%: Moderate
Foreign Competition	High		High
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		High
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Mod. Concentrated
Number of Producers	Many		5
Substitute Process	Many		1: MEK from n-butane

TABLE VI-1 (Continued)

PLANT SHUTDOWN DECISION				
Factor	Condition for Shutdown	Treatment Level		
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.		1.6% 7.9%
Cash Flow (Including Treatment Costs)	Negative			Positive
Ratio of Investment in Total Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.		3.1% 5.8%
Integration	Low			Moderate
Chemical Complex	Isolated Plant			Large complex
Other Environmental Problems (Including OSHA)	Multiple			Multiple
Emotional Commitment	Indifference			Strong
Ownership	Multi-Industry Companies			Multi-Industry

TABLE VI-2

ESTIMATED EFFLUENT TREATMENT COST IN LARGE COMPLEXES FOR SECONDARY BUTYL ALCOHOL AND METHYL ETHYL KETONE
(¢/pound)

Large Treatment Complex[1]	Sec. Butyl Alcohol	MEK	Total
BPT	0.014¢	0.016	0.030
BAT	0.124	0.025	0.149
Free-Standing			
BPT	0.861	0.581	1.442
BAT	1.12	0.608	1.728

1. Ten million gallons per day effluent treatment facility.

Our economic analysis indicates that this is possible and thus we foresee no significant price effect or do we expect any plant shutdowns.

The achievement of BAT effluent control levels will result in cost increases specified at 0.149¢ per pound for secondary butyl alcohol and methyl ethyl ketone together. We estimate, according to our manufacturing cost estimates, that those costs would also be absorbed without plant shutdowns. This estimate is predicated on the transfer of secondary butyl alcohol at cost to the methyl ethyl ketone manufacturing facility.

B.   INDUSTRY BACKGROUND FOR SECONDARY BUTYL ALCOHOL BY HYDROLYSIS OF BUTYLENE

1.   Market Characteristics

a.   Size and Growth

Production data for secondary butyl alcohol is not available in U.S. Tariff Commission reports. Production of secondary butyl alcohol on the assumption that all methyl ethyl ketone facilities operated at an average capacity during 1973 of 91% is approximately 400 million pounds assuming a 5% yield loss in conversion. Total growth in demand is estimated at about 7% per year, the same as for methyl ethyl ketone for the 1963-1973 period.

Secondary butyl alcohol is a chemical intermediate in the production of methyl ethyl ketone. Sales for other uses are very limited. Future of growth and consumption of all methyl ethyl ketone is expected to remain at around 7% per year. We expect that growth in demand for secondary butyl alcohol will continue to parallel the growth in demand for methyl ethyl ketone.

b. End Uses

As previously mentioned, 95% of the total production of secondary butyl alcohol is used in methyl ethyl ketone manufacture. The remainder is used either directly or as an ester in the manufacture of such items as lacquers, paint removers and adhesives.

c. Substitute Products

There is no direct substitute for secondary butyl alcohol in its significant end use in the manufacture of methyl ethyl ketone. There is another process for the production of methyl ethyl ketone. This product is dealt with in more detail in the following section on industry background for methyl ethyl ketone.

d. Captive Requirements

Ninety-five percent of the secondary butyl alcohol that is produced is consumed captively not only by the same companies but at the same points of manufacture. As previously described, only relatively small amounts are sold for other purposes.

2. Supply Characteristics

a. Manufacturing Routes

Secondary butyl alcohol is manufactured from normal butylenes contained in refinery C_4 fraction. In order to produce secondary butyl alcohol the C_4 fraction is first separated and the isobutylene removed from the normal butylene. Normal butylenes are first absorbed by concentrated sulfuric acid (75%) to form isobutyl sulfate. This is subsequently hydrolyzed with water to secondary butyl alcohol in dilute sulfuric acid. The mixture is separated by distillation and as sulfuric acid reconcentrated for recycle.

b. Producers

Producers are listed in Table VI-3. The data in Table VI-3. were obtained by industry interviews with the major producers. As shown by the table, this is a highly concentrated industry with two companies accounting for 72% of total productive capacity. Shell Chemical has closed one 50 million pounds per year plant producing secondary butyl alcohol in Domingues, California, in mid-1971. We believe this was done to optimize manufacture at its larger facility in Houston, Texas.

c. Manufacturing Economics

The economics of producing secondary butyl alcohol are shown in Table VI-4. Capacity for the plant is the same capacity as specified in the guideline document.

3. Prices

Actual prices for secondary butyl alcohol are not available in the U.S. Tariff Commission and are largely academic as the material is transferred in one plant to the manufacture of methyl ethyl ketone. Industry reports of the relatively small amount sold between 1971 and 1973 were at 9¢-10¢ per pound. As shown in Table VI-5, list prices were stable at 12.5¢ per pound from 1963 to 1969. In 1970, they were increased to 13.5¢ per pound and this price held until 1973 when they were increased to 14.5¢ per pound. By mid-1974, prices had increased again to 16.5¢ per pound. Price increase appeared to reflect the increasing costs of the raw material, for refinery alternate use values, and quite possibly a relatively tight supply/demand situation.

4. Supply/Demand Balance

Producers of secondary butyl alcohol were operating close to capacity in 1973. Increasing demand for methyl ethyl ketone implies a continuing growth in demand for secondary butyl alcohol as the major

TABLE VI-3

SEC-BUTYL ALCOHOL PRODUCERS

Producer	Location	Annual Capacity (MM lbs)	Raw Material
Atlantic Richfield	Channelview, Texas	66	n-Butylene
Exxon Chemical	Bayway, New Jersey	200	n-Butylene
Shell Chemical	Deer Park, Texas	100	n-Butylene
Shell Chemical	Norco, Louisiana	50	n-Butylene
Total		416	
Capacity from n-Butylene		416	

SOURCE: Industry estimates

TABLE VI-4

ESTIMATED MANUFACTURING COSTS FOR
SECONDARY BUTYL ALCOHOL

Production Economics (Summer, 1973)

Product Secondary Butyl Alcohol

Process Hydration of n-Butenes

Location Gulf Coast **Capacity** 75 MM lb/yr **Invest.** $3.2 MM (1970 Construction)

	Cost	
	$/Year	¢/lb Product
n-Butenes — 0.80 lb @ 3.0¢/lb	1,800,000	2.40
Catalyst, Chem., Supplies	75,000	0.10
Utilities	1,155,000	1.54
Direct Labor 20 men @ $5.00/hr	213,000	0.28
Maintenance, Labor & Materials	150,000	0.20
Labor & Plant Overhead	213,000	0.28
Depreciation 9%/yr	288,000	0.38
Taxes & Ins. 1-1/2%/yr	48,000	0.06
Factory Cost	3,942,000	5.24

TABLE VI-5

LIST PRICES FOR
SEC-BUTYL ALCOHOL
(cents per pound)

Year	¢ per lb
1963	12.5
1964	12.5
1965	12.5
1966	12.5
1967	12.5
1968	12.5
1969	12.5
1970	13.5
1971	13.5
1972	13.5
1973	14.5
1974	16.5

Note: Synthetic, tanks, delivered

SOURCE: Chemical Marketing Reporter

existing route to the production of methyl ethyl ketone. Whether the
production of secondary butyl alcohol will continue to rise with methyl
ethyl ketone demand is directly related to the amount of production by other
routes (direct oxidation of butane) and increasing competition from imports.
Import competition will in itself be partly controlled by the costs which
must be borne by the secondary butyl alcohol/methyl ethyl ketone producers
controlling effluents providing that foreign points of production do not
experience similar control costs.

C. INDUSTRY BACKGROUND FOR METHYL ETHYL KETONE

1. Market Characteristics

a. Size and Growth

According to data published by the U.S. Tariff Commission,
production of methyl ethyl ketone increased from about 290 million
pounds in 1964 to approximately 541 million pounds in 1973 or at an
annual average yearly growth rate of 7% for the period. As shown in
Table VI-6 production volume increased rapidly from 1964 to 1969, then
leveled off at the rate of 2% per year growth from 1969 to 1972.
Production grew by about 6% in 1973. During this period of time,
apparent consumption in the United States grew fairly steadily at an
average rate of approximately 7% per year. The variations in production
in growth rate were due principally to developing imports into the
United States which peaked in 1972 at 57 million pounds. Imports in 1964
totaled less than 9 million pounds.

Future growth in U.S. demand for methyl ethyl ketone is
difficult to predict because of the impact of a variety of regulations
concerning its application and the use of products in which it is con-
sumed. California has issued regulations relative to the use of solvents
in the manufacture of industrial products. Methyl ethyl ketone is an
exempt solvent and hence may benefit in demand of the expense of other

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TABLE VI-6

PRODUCTION, FOREIGN TRADE AND APPARENT CONSUMPTION OF MEK
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1964	288.9	8.8	9.3	288.4
1965	317.5	8.7	29.1	297.1
1966	399.1	12.6	32.7	379.0
1967	400.4	8.8	47.2	362.0
1968	451.2	18.3	33.2	436.3
1969	484.4	29.7	29.8	484.3
1970	480.2	33.0	22.1	491.1
1971	483.8	29.3	26.0	487.1
1972	509.0	57.1	21.8	544.3
1973	540.7	41.6	37.3	545.0

SOURCES: Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff
Commission, Washington, D.C.

Preliminary Report on U.S. Production of Selected Synthetic
Organic Chemicals, S.O.C. Series C/P-73-1, U.S. Tariff Commission,
Washington, D.C.

nonexempt solvents. On the other hand, potential hazards in the
manufacture and use of vinyl chloride products, which consume approxi-
mately one-third of the total methyl ethyl ketone required, may
negatively affect future consumption growth rates unless vinyl chloride
surface coatings are replaced by other coatings containing the equivalent
amount of methyl ethyl ketone. Our best estimate is that over the next
several years, demand for methyl ethyl ketone will continue to grow at
a rate of approximately 7% per year.

Productive capacity for methyl ethyl ketone is close to the
1973 rate of demand. Capacity, if fully utilized, could support an
additional 10% growth in methyl ethyl ketone demand. There have been no
announcements to date of plant expansions or new capacity production.
Failing expansions, by 1976, increases in domestic demand will have to be
satisfied either by additional imports of MEK or by substitute products.

b. End Uses

As shown in Table VI-7, about two-thirds of methyl ethyl
ketone applications are as solvents in coatings. Relatively smaller
amounts are used in the manufacture of adhesives, lube oil dewaxing
and a variety of miscellaneous applications. Methyl ethyl ketone has
broad applications in synthetic surface coating preparations versus uses
as a solvent along with vinyl resins, nitrile cellulose, acetate butarate,
acrylic resins, vinyl acetate. It is also used as a dewaxing solvent
for lubricating oils and is favored as a solvent in lacquer preparation
because of its capability of providing low viscosity, high solids con-
centration and great diluent tolerance. Methyl ethyl ketone is one of the
solvents exempt by Rule 66 specified by the state of California for con-
trolling solvent applications. Enforcement of Environmental Protection
Legislation for air pollution may favorably affect the consumption of
methyl ethyl ketone at the expense of solvents which are excluded by
this legislation.

TABLE VI-7

MEK CONSUMPTION BY END USE IN 1972

End Use	% of Total	Million Pounds
Vinyl Coatings	34	185
Nitrocellulose Coatings	14	76
Adhesives	14	76
Acrylic Coatings	12	65
Miscellaneous Coatings	7	38
Lube Oil Dewaxing	7	38
Miscellaneous	8	43
Exports	4	22
Total	100	533

SOURCE: Chemical Marketing Reporter 1/14/74

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As a solvent, methyl ethyl ketone competes with a variety
of other products in formulating surface coatings. Ethyl acetate is
the major potential substitute product for methyl ethyl ketone,
especially as a low boiling solvent for nitrile cellulose formulations.
The two products sell at approximately the same price with ethyl acetate
sold at an average actual price of 8¢ in 1972 and 9¢ per pound in 1973.
Significant price changes in either product alone would tend to lead
to reformulation in the greater use of these others. This conclusion
is based on qualitative statements by the industry and the detailed
examination of price elasticity of methyl ethyl ketone in view of ethyl
acetate competition is beyond the scope of this assignment.

c.   Captive Requirements

According to the production and sales data given by the
U.S. Tariff Commission the great majority of methyl ethyl ketone
produced is sold on the merchant markets. About 5% of production is
used captively in refinery operations, principally in lube oil dewaxing
and by some of the manufacturing companies in the production of surface
coatings.

2.   Supply Characteristics

a.   Manufacturing Routes

About 70% of the total methyl ethyl ketone manufactured in
the United States is produced by dehydrogenation of secondary butyl
alcohol. In the process, preheated vapors of secondary butyl alcohol
are passed through a reactor containing a catalytic bed of zinc oxide
or brass maintained at 400°C to 550°C. The vapor phase dehydrogenation
reaction takes place near atmospheric pressure with methyl ethyl ketone,
byproduct hydrogen, and unreacted secondary butyl alcohol subsequently
separated. The condensed product stream containing methyl ethyl ketone
and unreacted alcohol is taken from the reactor and sent to two distillation

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columns. The first dehydrates the product mix by removing water and light hydrocarbons overhead. Methyl ethyl ketone is separated from recycled alcohol in the second column.

Methyl ethyl ketone is also produced by the direct oxidation of butanes. There is no guideline data concerning effluent control costs for the direct oxidation route. The process involves oxidation of normal butanes over catalysts and separation of the new products produced. The principal coproduct with methyl ethyl ketone is acetic acid. The guideline contractor estimated qualitatively that the butane oxidation process would produce a larger waste load than the vapor based oxidation of secondary butyl alcohol. He did not, however, consider the cost associated with secondary butyl alcohol itself as a necessary adjunct to the manufacture of methyl ethyl ketone. Hence, the route utilizing secondary butyl alcohol may be at a small cost disadvantage to the direct oxidation route when both components of the process are considered together as we have done in our impact statement.

b. Producers

As presented in Table VI-8, there are three producers and four plants manufacturing methyl ethyl ketone from secondary butyl alcohol. Total capacity is reported by our industry contacts at 416 million pounds or 70% of total methyl ethyl ketone capacity as identified by the same contacts. In 1971, Shell closed its Domingues, California, plant to optimize manufacture at their own facilities. The facility at Domingues was one of Shell Chemical's oldest plants which first began producing the solvent in the early 1930's. This may have contributed to its being selected for closure as well as the desirability of concentrating manufacture.

TABLE VI-8

METHYL ETHYL KETONE PRODUCERS

Producer	Location	Annual Capacity (MM lbs)
Sec-Butyl Alcohol Process		
Atlantic-Richfield	Channelview, Texas	66
Exxon	Bayway, New Jersey	200
Shell	Deer Park, Texas	100
Shell	Norco, Louisiana	50
Subtotal		416
Butane Oxidation Process		
Celanese	Pampa, Texas	90
Union Carbide	Brownsville, Texas	85
Subtotal		175
Total Capacity		591
Capacity from Sec-Butyl Alcohol		416
% of Total		70%

SOURCE: Industry estimates

There are two other producers of methyl ethyl ketone both
of which utilize the butane oxidation process. Celanese and Union
Carbide produce methyl ethyl ketone by the direct oxidation of butane.
As cited above, this process yields coproducts, the most significant
of which is acetic acid. Recently these producers have tended to maximize
acetic acid production because of high current demand. There may,
however, be some flexibility in the plants which would permit additional
production of methyl ethyl ketone if acetic acid demand drops while
the requirement for methyl ethyl ketone continues to rise.

In addition to the major producers listed on Table VI-8,
we understand that Dixie Chemical in Bayport, Texas, recovers a small
amount, estimated at 3 million pounds per year, of methyl ethyl ketone
from butadiene.

c. Manufacturing Economics

Estimates for the production of methyl ethyl ketone by
dehydrogenation of secondary butyl alcohol are given in Table VI-9
In constructing this table we have taken into account that this production
is carried out by manufacturing plants integrated back to the manufacture
of secondary butyl alcohol. We have, therefore, transferred the secondary
butyl alcohol at our estimated cost into the process. As indicated in
the table, the supply of secondary butyl alcohol accounts for approxi-
mately 84% of total manufacturing cost.

3. Price

As indicated in Table VI-10, prices for methyl ethyl ketone have
declined significantly over the last decade. The price decline began in
1968 when actual prices were reduced from 11¢ per pound to 10¢ per pound
and continued through 1972 when actual prices reached 8¢ per pound. In
1973, actual prices as reported by the U.S. Tariff Commission were
8.4¢ per pound. We believe one of the significant pressures leading to

TABLE VI-9

ESTIMATED COST OF MANUFACTURING METHYL ETHYL KETONE

Production Economics (Summer, 1973)

Product Methyl Ethyl Ketone (MEK)

Process Dehydrogenation of Secondary Butyl Alcohol

Location Gulf Coast **Capacity** 85 MM lb/yr[1] **Invest.** $1.7 MM (1970 Construction)

	Cost	
	$/Year	¢/lb Product
Sec. Butyl Alcohol 1.05 lb @ 5.24¢/lb[2]	11,602,500	5.50
Catalyst Chem., Supplies	50,000	0.06
Utilities	170,000	0.20
Direct Labor 14 men @ $5.00/hr	150,000	0.18
Maintenance Labor & Materials	150,000	0.18
Labor & Plant Overhead	150,000	0.18
Depreciation 9%/yr	153,000	0.18
Taxes & Ins. 1-1/2%/hr	26,000	0.03
Factory Cost	12,451,500	6.51

1. A plant with capacity to produce 95 million pounds per year is estimated to require investments of $1.8 million (1970 Basis).

2. Sec. Butyl Alcohol — Transferred at cost.

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TABLE VI-10

ACTUAL VERSUS LIST PRICES FOR MEK
(cents per pound)

Year	Actual	List Price[1]
1963	—	12.5
1964	11	12.0
1965	11	12.5
1966	11	12.5
1967	11	11.5
1968	10	11.5
1969	10	11.5
1970	9	10.5
1971	8	10.0
1972	8	10.0
1973	8	9.75
1974	N.A.	17 (12/74 - F.O.B.)

Notes: N.A. — not available
Tanks, delivered east
1974 list price 16.00¢/lb

SOURCES: Chemical Marketing Reporter

Synthetic Organic Chemicals, U.S. Production
and Sales, U.S. Tariff Commission, Washington,
D.C.

Preliminary Report on U.S. Production of
Selected Synthetic Organic Chemicals, S.O.C.
Series C/P-73-1, U.S. Tariff Commission,
Washington, D.C.

this steady erosion of prices has been competition from abroad with consequent increase in imports as shown in Table VI-6.

By December 1974, methyl ethyl ketone list prices reached 17¢ per pound. We believe this reflects not only the raw material price increases but also both tight supply/demand situation domestically and availability of imports.

4. Supply/Demand Balance

In spite of the "best estimate" provided by the industry as to methyl ethyl ketone capacity, capacity is in fact somewhat flexible. It is flexible on the downside in that Shell Chemical Company and Exxon Chemical Company can produce acetone as an alternative to methyl ethyl ketone production. This has not been desirable with the pressure on acetone prices. It is flexible on the upside in that in some degree, the capacity of Celanese Corporation and Union Carbide Corporation for oxidizing butane can, we believe, be converted to the greater production of methyl ethyl ketone with the sacrifice of the production of acetic acid. This complex situation defined in terms of supply/demand in 1973 indicates a relatively tight supply position for the existing methyl ethyl ketone producers. No new capacity has been announced and as methyl ethyl ketone demand continues to rise, this may prompt the greater production of methyl ethyl ketone from Union Carbide and Celanese as well as increasing levels of imported material. This condition of short supply would, we believe, maintain until either general economic conditions decrease demand below projected trend rates or new capacity is built. If world production cannot satisfy U.S. methyl ethyl ketone demand in the near term and no additional capacity is devoted the production of the product, this may lead to substitution by other solvents notably ethyl acetate.

D. ECONOMIC IMPACT ON METHYL ETHYL KETONE BY DEHYDROGENATION OF
    SECONDARY BUTYL ALCOHOL AND SECONDARY BUTYL ALCOHOL BY HYDRATION
    OF NORMAL BUTENE

1. Treatment Costs

The guideline document presents separate waste treatment costs
for methyl ethyl ketone and secondary butyl alcohol. However, since
about 95% of secondary butyl alcohol is captively consumed at the same
plant complex in the production of methyl ethyl ketone, these costs
should be considered together to determine the economic impact on methyl
ethyl ketone and consequently on secondary butyl alcohol. The treatment
cost data were determined, as shown in Table VI-2, by summing the data
for the separate facilities. We estimate that all methyl ethyl ketone
production by dehydrogenation of secondary butyl alcohol and all secondary
butyl alcohol production facilities are located in large plant complexes
leading to significant economies of scale.

The guideline document specifies waste treatment cost for free
standing facilities producing 218,000 pounds per day of secondary butyl
alcohol and 274,000 pounds per day of methyl ethyl ketone. As shown
in Table VI-2, effluent treatment costs associated with these two activities
total 1.44¢ per pound to achieve BPT and 1.73¢ per pound to achieve BAT.
When these plants are located in complexes for the treatment of 10 million
gallons per day, the combined cost including the effluent of the secondary
butyl alcohol and methyl ethyl ketone plants totals 0.03¢ per pound to
achieve BPT and 0.149¢ per pound to achieve BAT levels of treatment.

The direct oxidation of butane is an alternate process for the
production of methyl ethyl ketone. This process, therefore, competes
not only directly with existing methyl ethyl ketone plants dehydrogenating
secondary butyl alcohol but also with secondary butyl alcohol plants
in view of the fact that an estimated 95% of the total secondary butyl
alcohol produced is consumed in the manufacture of methyl ethyl ketone.

Imports also compete with the production of methyl ethyl ketone from secondary butyl alcohol. U.S. import duties are at 4% ad valorem. In 1973 average prices, this is approximately 0.3¢ per pound. These relatively low rates of duty have, no doubt, facilitated the growth of imports of methyl ethyl ketone into the United States over the past nine years.

2. Price Impact

Both list prices and actual prices for methyl ethyl ketone declined steadily from 1966. Actual prices totaled 11¢ in 1966 and 8.4¢ in 1973. List prices declined 12.5¢ to 9.75¢. By the end of 1974, however, list prices had risen substantially and totaled 17¢ per pound. Actual average prices are not available for 1974 from existing data but quite probably increased significantly above the 1973 levels. This increase in price appears likely in view of the increase of raw material costs, specifically normal butylene and the relatively tight domestic supply of methyl ethyl ketone.

Review of the impact analysis matrix indicates that the secondary butyl alcohol/methyl ethyl ketone producers will not be able to pass on waste treatment costs. Factors mitigating in favor of cost pass through are the extremely modest effluent treatment cost as specified by the guideline document, relatively high probable demand growth and currently high capacity utilization. More significantly, however, there is a very substantial degree of uncertainty associated with future growth and demand because of the potential uncertainties of state enforced air standard regulations and federally enforced regulations affecting the loss of polyvinyl chloride polymers which currently utilize methyl ethyl ketone in surface coating formulations. Methyl ethyl ketone also faces com-petition from competitive solvents, most notably ethyl acetate, and con-sequently experiences a relatively high price elasticity of demand.

Most significant, however, is the fact that methyl ethyl ketone from secondary butyl alcohol faces direct competition with methyl ethyl ketone produced by direct oxidation of butanes and from imported products. Foreign producers have assumed an increasing share of the U.S. market for methyl ethyl ketone. Prices in the past have, we believe, been held down by virtue of this competition and future price increases would serve only to accelerate competition.

It is our judgment that the factors acting as restraints on price increase will prevail over the long term. By virtue of this, relatively modest increases in cost, as specified by the guideline document, will have to be absorbed by the producers rather than passed through as price increases.

3. Plant Shutdown Decision

We expect no plant shutdowns by virtue of the producer's methyl ethyl ketone and secondary butyl alcohol being unable to pass through effluent treatment costs. Costs as specified are a relatively modest proportion of the estimated net income. As shown in the impact matrix these costs will total 1.6% to achieve BPT levels and 7.9% of net income estimated for 1973 to achieve BAT levels. In addition, the investment cost is a modest proportion of the existing fixed investment for the production of secondary butyl alcohol and methyl ethyl ketone. With the existing producers this is estimated at 3.1% total investment in the two processes to achieve BPT and 5.8% to achieve BAT levels of effluent production. The companies involved in production are all major petroleum companies and should not be restrained by lack of access to capital required for treatment as specified in the guideline document.

4. Balance of Trade

It would not appear that the modest costs and capital investments required would, in themselves, be sufficient or would be a precipitating cause altering future balance of trade in methyl ethyl ketone. Prices

are not forecast to rise by virtue of pass through of effluent treat-
ment cost and the only fashion which effluent treatment would affect
future trade would be through the discouragement of domestic capacity
expansion either by virtue of reduced profit margin or high capital
requirements for effluent treatment facilities. As indicated in the
impact matrix the effect on profit and the capital requirements is
very modest given the effluent treatment cost as specified. We expect,
therefore, no influence on future balance of trade.

VII. ACRYLONITRILE FROM PROPYLENE AND AMMONIA

A. SUMMARY

Acrylonitrile production from propylene and ammonia in 1973 was
1,115 million pounds. This is equivalent to total acrylonitrile pro-
duction since only the propylene/ammonia route was utilized to produce
the product. Total acrylonitrile production experienced an annual
growth rate of 11.5% during 1963-1973. Exports have been sizable over
this period, usually in excess of 100 million pounds per year, while
there has been only a negligible amount of acrylonitrile imported.
Apparent consumption, therefore, is derived by subtracting exports
from production each year.

The majority of acrylonitrile production is used in acrylic fibers,
ABS and SAN resins, and nitrile elastomers. Over 50% of acrylonitrile
is used captively to produce these end products since all acrylonitrile
producers are also integrated forward into one or more of these end
uses. Capacity utilization has been increasing and in 1972 it was over
90%. It declined to 85% in 1973 because of significant capacity expan-
sions.

Prices, which had declined from 1963 to 1972, have recently (August
1974) increased due to increased costs of raw material and a high level
of demand and capacity utilization. Probably a significant portion of
this price increase is temporary and more normal pricing will be re-
instated in the near future when additional acrylonitrile capacity ex-
pansions come on stream.

A summary of factors affecting price increases and plant shutdowns
is provided in Table VII-1. Effluent treatment costs required to meet
both the BPT and BAT guidelines are moderate and can probably be passed
through in the form of higher prices. Approximately a 0.6% increase in the
1973 price will be required to cover the cost of meeting the BPT regula-

TABLE VII-1

ACRYLONITRILE FROM PROPYLENE AND AMMONIA

All Processes:		
1972 Production (Million Pounds)		1115
1973 Unit Value (¢/Lb)		9.4
1972 Production Value ($MM)		123
Number of Plants (Current)		6

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.6 – 0.7% 4.6 – 5.3%
Substitute Products	High Occurrence		Direct – Low Secondary – High
Capacity Utilization	Low		High – over 90%
Captive Usage	Low		High (Over 40%)
Demand Growth	Low		5% Forecast
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		–
Price Elasticity of Demand	High		High – Moderate
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Moderate
Number of Producers	Many		5
Substitute Process	Many		None, competitive but two other options

TABLE VII-1 (Continued)

PLANT SHUTDOWN DECISION				
Factor	Condition for Shutdown	Treatment Level		
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.		3.7 – 4.3% 26.4 – 30.7%
Cash Flow (Including Treatment Costs)	Negative			Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.		3.6 – 4.5% 13.3 – 19.1%
Integration	Low			High
Chemical Complex	Isolated Plant			Complexes
Other Environmental Problems (Including OSHA)	Multiple			None apparent
Emotional Commitment	Indifference			High
Ownership	Multi-Industry Companies			Multi-Industry

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tions. About 5% of the 1973 price will be required to comply with
BAT guidelines. The price increases will not significantly effect
the demand for acrylonitrile. We do not anticipate any plant
shutdowns. Also, we foresee no effect on the U.S. balance of
payments.

B. INDUSTRY BACKGROUND

   1. Market Characteristics

      a. Size and Growth

         According to the U.S. Tariff Commission data, production of
acrylonitrile in 1973 was 1,354 million pounds (see Table VII-2).
Acrylonitrile production by all processes has grown at an average annual
rate of 11.5% during 1963-1973. Imports since 1963 have been negligible
while a significant portion of production has been exported in every
year except 1972. Therefore, apparent consumption in the United States
is assumed to be equivalent to production net of exports. We expect
future growth in domestic demand to be at a rate of about 5% per year over
the next five years. Export growth is less certain because of expansions
abroad and we forecast no growth in exports over the next five years
and more likely a decline of 25-50 million pounds per year.

      b. Uses

         As shown in Table VII-3, over half of the acrylonitrile
consumed is used in the production of acrylic fibers. ABS and SAN
resin producers consumed 18% of acrylonitrile production in 1972 while
producers of nitrile elastomers, which are used in seals, gaskets, and
specialized paper due to their oil resistance property, consumed 5%
of acrylonitrile production. Five percent of acrylonitrile production
is exported. The remaining portion of acrylonitrile production was
used in making adiponitrile (for nylon 66), acrylamide, and minor
end uses such as grain fumigants, chemical reactants, and gasoline
anti-stall additives.

TABLE VII-2

PRODUCTION FOREIGN TRADE AND APPARENT
CONSUMPTION OF ACRYLONITRILE — ALL PROCESSES
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	455.3	Negligible	100	355
1964	594.2	Negligible	165	429
1965	771.6	1.2	160	613
1966	716.1	Negligible	115	601
1967	670.8	Negligible	100	571
1968	1,021.0	Negligible	175	846
1969	1,156.6	Negligible	—	—
1970	1,039.3	Negligible	—	—
1971	978.9	Negligible	100	879
1972	1,114.7	Negligible	52	1,063
1973	1,354.2p	Negligible	105	1,247

P — Preliminary

SOURCES: U.S. Tariff Commission, U.S. Department of Commerce, Chemical Economics Handbook

TABLE VII-3

CONSUMPTION OF ACRYLONITRILE

End Use	% of Total — 1972p
Acrylic Fibers	58
ABS and SAN Resins	18
Nitrile Elastomers	5
Exports	5
Miscellaneous[1]	14
	100

1. Used to make adiponitrile for Nylon 66 resins, acrylamide, and minor uses as a grain fumigant, chemical reactant, and anti-stall additive for gasoline.

SOURCE: Chemical Economics Handbook

We estimate growth in acrylic fiber consumption between 1973 and 1978 at 3% per year, ABS and SAN at 12% per year, nitrile elastomers at 3%, exports at 0% and other uses at 5% per year.

c. Substitute Products

In each of its major end uses, acrylonitrile is a critical and nonsubstitutable raw material. The percent of acrylonitrile used in the end product can change, but this would also alter the end product's properties. There are, of course, secondary levels of competition as acrylic fibers compete with nylon, polyester and wool; acrylonitrile-based resins compete with polyvinyl chloride and other polymers; and nitrile elastomers compete with neoprene rubbers.

d. Captive Requirements

According to Table VII-4, captive requirements have been continually greater than 50% of production (64% in 1973) since most of the producers of acrylonitrile also produce acrylic fibers, ABS resins and/or SAN resins.

2. Supply Characteristics

a. Manufacturing Process

Acrylonitrile can be made from the following sets of raw materials:

- Propylene and ammonia,
- Acetylene and hydrogen cyanide,
- Ethylene oxide and hydrogen cyanide, or
- Propylene and nitric acid.

Presently all of acrylonitrile being produced uses the propylene and ammonia route to acrylonitrile, as shown in Table VII-5.

TABLE VII-4

PRODUCTION, SALES AND CAPTIVE USE OF ACRYLONITRILE — ALL PROCESSES
(million pounds)

Year	Production	Sales	Captive Use
1963	455.3 (100)[1]	212.4	242.9
1964	594.2 (194)	311.1	283.1
1965	771.6 (352)	303.3	468.3
1966	716.1 (426)	318.2	397.9
1967	670.8 (577)	270.5	400.3
1968	1,021.0 (908)	—	—
1969	1,156.6 (1,037)	561.6	595.0
1970	1,039.3 (984)	547.1	492.2
1971	978.9 (978.9)	429.2	449.7
1972	1,114.7 (1,114.7)	460.0	654.7
1973	1,354.2 (1,354.2)	480.7	873.5

1. (—) represents production of acrylonitrile from propylene/ammonia.

SOURCES: U.S. Tariff Commission, Chemical Economics Handbook

TABLE VII-5

% PRODUCTION OF ACRYLONITRILE BY PROPYLENE/AMMONIA ROUTE
(million pounds)

Year	Production of Acrylonitrile (all processes)	Production (from propylene and ammonia)	%
1963	455.3	100	22
1964	594.2	194	33
1965	772.6	352	46
1966	716.1	426	59
1967	670.0	577	86
1968	1,021.0	908	89
1969	1,157.6	1,037	90
1970	1,039.3	984	95
1971	978.9	978.9	100
1972p	1,114.7	i,114.7	100
1973	1,354.2	1,354.2	· 100

P — Preliminary

SOURCES: U.S. Tariff Commission, Chemical Economics Handbook

(1) Propylene and Ammonia

The SOHIO process is used in the United States to
produce acrylonitrile. It introduces refinery propylene, fertilizer
grade ammonia, and air into a fluidized-bed catalytic reactor. Recent
improvements in catalysts made by SOHIO have acted to increase the
rate of conversion and actual capacity and reduce the level of by-
products. The principal byproducts are hydrogen cyanaide and acetonitrile
which are produced approximately at a rate of .10 and .05 pounds
respectively per pound of acrylonitrile.

Other processes using propylene/ammonia are in develop-
ment outside of the United States using a fixed-bed reactor and a
different catalyst system. With the recent licensing in Europe and
Asia of the SOHIO process, though, it seems that this process will
continue to be the dominant propylene/ammonia route throughout the
world for production of acrylonitrile.

(2) Other Routes/Raw Materials

In the United States, no route other than propylene
ammoxidation is being used due to higher costs of alternative routes.
Some plants using other routes, however, are on standby which could
become operational if they were economically feasible (e.g., Union
Carbide's ethylene oxide/hydrogen cyanide plant). In the near term,
however, this does not seem probable.

b. Producers

Table VII-6 lists the producers of acrylonitrile in 1972
and 1973 and their capacities. Capacities depend in part on the type
of catalyst used and the figures given are our best estimates for actual
capacities in the years under consideration. DuPont, Monsanto and
American Cyanamid - all acrylic fiber producers - control 76% of acrylon-

TABLE VII-6

ACRYLONITRILE PRODUCERS

| Company | Location | Capacity million pounds/year | |
		1972	1973
American Cyanamid	Fortier, Louisiana	175	200
E.I. DuPont de Nemours	Memphis, Tennessee	180 ⎫ 380	235
	Beaumont, Texas	200 ⎭	265
B.F. Goodrich	Calvert City, Kentucky	45	45
Monsanto	Alvin, Texas	370	460
Vistron (SOHIO)	Lima, Ohio	240	390
		1,210	1,595

itrile capacity. At Vistron's plant (a part of SOHIO), 800 million pounds of capacity can be shifted over to methacrylonitrile production by switching the feedstock from propylene to isobutylene. An additional 500 million pounds per year of capacity is planned by Monsanto.

c. Manufacturing Economics

The estimated manufacturing cost by the SOHIO process is shown in Table VII-7.

3. Prices

Table VII-8 compares the actual versus list prices for acrylonitrile from 1963 to 1972. The list price for 1974 is also given. As shown in the table, actual average prices have generally been 1¢ to 3¢ lower than list prices. The actual price of acrylonitrile has gradually declined from 16¢ in 1964 to under 10¢ per pound in 1972-1973. In 1974, however, the list and probably the actual price of acrylonitrile increased from 13¢ in mid-1973 to 23¢ in August 1974. We expect that prices will not remain this high with new capacity coming on stream and reduced exports.

4. Supply/Demand Balance

According to Table VII-9, the plants producing acrylonitrile from propylene/ammonia have increased their capacity utilization from 50% in 1966 to 92% in 1972, and to 85% in 1973. This high capacity utilization was brought about not only by increasing demand but also by the phasing out of acrylonitrile production by other processes during this period.

Probably increased capacity will be installed overseas and will reduce the amount exported. This may modestly reduce capacity utilization over the near term.

TABLE VII-7

ESTIMATED COST OF MANUFACTURING ACRYLONITRILE
SOHIO PROCESS — TYPE 41 CATALYST
Mid-1973

Physical Investment: $14.0 MM (1970 Construction)

Capacity: 100 MMlb/Yr[1]

Variable Costs	Quantity/100 lb	$/Unit	$/100 lb
Raw Materials			
Propylene	96 lbs	0.028	2.14
Ammonia	60 lbs	0.02	1.80
Catalysts			.49
Utilities			
Power	25 kwh	0.013	0.34
Water	9 Mgal	0.03	0.27
Natural Gas	0.8 MMBtu	0.35	0.28
			5.32

Semi-Variable Costs			
Operating Labor & Super.	20 men	$5.00/hr	0.21
Maintenance	4% of Investment/yr		0.56
Labor & Plant Overhead	100% of Labor & Supervision		0.21
			0.98

Fixed Costs			
Depreciation	9% of Investment/yr		1.26
Taxes & Insurance	1-1/2% of Investment/yr		0.21
			1.47

Factory Cost			7.77

1. Investment in plant with capacity 658,000 pounds per day equals $25 million.

TABLE VII-8

ACTUAL VS. LIST PRICES FOR ALL ACRYLONITRILE

Year	Quantity Sold (MM lbs)	Value ($ MM)	Actual Unit Value (¢/lb)	List Price[a] (¢/lb)
1963	212.4	29.5	14	14.5
1964	311.1	48.8	16	17.0
1965	303.3	48.4	16	17.0
1966	318.2	40.3	13	14.5
1967	270.5	31.9	12	14.5
1968	Not reported	—	—	14.5
1969	561.6	66.0	12	14.5
1970	547.1	59.8	11	14.5
1971	429.2	44.4	10	14.5
1972p	460.0	49.3	9.3	13.0
1973	480.7	50.9	9.4	13.0
8/15/74	—	—	—	23.0

[a] Note: Terms, tanks/works

P — Preliminary

SOURCES: U.S. Tariff Commission; CEH; Oil Paint and Drug Reporter

TABLE VII-9

CAPACITY, PRODUCTION AND CAPACITY UTILIZATION
FOR ACRYLONITRILE FROM PROPYLENE/AMMONIA
(million pounds)

Year	Capacity	Production	% Capacity
1963	—	100	—
1964	—	194	—
1965	—	352	—
1966	875[1]	426	48.7
1967	795[1]	577	72.3
1968	1,025[1]	908	88.6
1969	—	1,037	—
1970	1,125[2]	984	87.5
1971	—	979	—
1972	1,210[2]	1,115	92.1
1973	1,595[3]	1,354	84.9

SOURCES:

1. Chemical Economics Handbook

2. U.S. Petrochemicals, Arthur M. Brownstein

3. Contractor's Estimates

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C. ECONOMIC IMPACT

1. Treatment Costs

The development document supplies the treatment cost for plants producing acrylonitrile by the ammonoxidation of propylene for a plant with the capacity of 658,000 pounds per day of product. The document specifies that a free standing plant of this size would incur a cost of 0.37¢ per pound to achieve BPT and 1.02¢ per pound of product to achieve BAT guidelines. The plant would require an investment of $2.8 million to achieve BPT guidelines and an additional $4.5 million to achieve BAT guidelines.

There are no free standing acrylonitrile plants operating on the propylene and ammonia process in the United States. The six U.S. plants are in plant complexes; they have been classified either in hypothetical 3 million gallons per day effluent complexes or 10 million gallons per day effluent complexes. On the basis of being located in effluent treatment complexes of these two sizes, we estimate BPT treatment costs range from 0.06¢ per pound to .07¢ per pound of product depending in which size complex the plants are located. BAT treatment costs vary between 0.43¢ per pound to 0.50¢ per pound depending on complex size.

2. Price Impact

The list price for acrylonitrile increased from 13¢ in 1973 to 23¢ per pound by August 1974. The actual average price was 9.3¢ in 1972 and 9.4¢ per pound in 1973. The average prices are not available for 1974 but we expect that actual prices have risen sharply with the high demand relative to capacity during the first half of 1974.

We believe producers of acrylonitrile will be able to pass through as price increases the costs necessary to meet both BPT and BAT standards. Most factors are favorable for cost pass through as prices increase. Capacity utilization has been high, captive usage is very significant and there are only a relatively small number of producers of this major organic chemical product. The principal problem in increasing acrylonitrile prices under normal competitive conditions is in the intercompetition from other fibers and polymers to the products made from acrylonitrile (acrylic fibers and ABS resins).

Producers of these competitive products such as nylon will also experience some increased costs for their intermediates and the cost to reach BAT will, we judge, be sufficient in other products to permit acrylonitrile producers to increase their prices sufficiently to cover the relatively modest cost increases imposed to meet BPT guidelines and quite probably the 5% additional price necessary to offset the costs of achieving BAT guidelines.

We do not expect that these relatively modest cost increases will significantly affect the demand for acrylonitrile. One of the conditioning factors leading us to this assumption is that by the time acrylonitrile reaches the final consumer in the form of acrylic fibers or plastics, the product is substantially upgraded in value. Acrylic fibers sell for six or seven times the price of acrylonitrile and ABS resins three or four times the price of acrylonitrile. Thus, absolute increases in the cost of acrylonitrile become proportionately less significant in the form of the finished product.

3. Plant Shutdown Impact

As we expect cost pass through for effluent treatment in the form of higher prices, we do not anticipate any plant shutdowns as a direct result of the requirement for meeting BPT or BAT effluent guideline standards. The only potential constraint would be the requirement for the additional capital to meet these standards. As this capital requirement is no more than a maximum of 19.1% of the net fixed investment, we have assumed capital will be available for the necessary investment.

4. Balance of Payments

We anticipate no balance of payments effect to meet BPT guidelines
in 1977. The achievement of BAT guidelines is more difficult to judge.
It is possible that 5% price increase may restrain exports to some degree
against competitors for export markets which are not required to carry
effluent treatment costs. It is our best judgment that these costs will
by 1983, be overweighed by other factors such as raw materials costs and
increasing world capacity and there will be no significant effect on
the U.S. balance of payments.

VIII.   BENZOIC ACID BY AIR OXIDATION OF TOLUENE

A. SUMMARY

Benzoic acid production is reported by the U.S. Tariff Commission
at 156 million pounds and since trade volume is considered negligible,
apparent consumption is equal to production. About 50% of total
reported production is used captively in the manufacturing of phenol,
the remainder is used in the manufacturing of chemical derivatives.
Consumption for phenol manufacturing has been rather static but it will
increase as a result of new plant construction announced by a producer.
Apparent consumption for other end uses than phenol has been increasing
at about 10% per year and is expected to remain in the order of 7%.
Almost 40% of this total not used to produce phenol is used in the
manufacturing of sodium benzoate, a food preservative which competes
with other food preservatives for the same market; plasticizers which
compete with phthalate plasticizers; and benzoyl chloride, a chemical
intermediate.

Benzoic acid manufacture is based principally on the air oxidation
of toluene. One producer reportedly also uses a process based on chlorine
oxidation of toluene. There are five producers of benzoic acid reporting
a total capacity of 208 million pounds for 1972. The industry is heavily
concentrated in two producers: Kalama Chemical and Velsicol, which
combined, had together held 90% of total industry capacity in 1972.
About 90% of total reported production is used captively, over 50% for
phenol manufacturing by Kalama Chemical. The industry is believed to be
working close to available capacity.

Actual prices have declined from 18¢ per pound in 1963 to 11.6¢
per pound in 1973 reflecting Velsicol's entry into the market in 1968
and an oversupply situation created when benzoic acid used for phenol
manufacturing was diverted to commercial use. List prices declined from

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20¢ per pound in 1963 to 19.5¢ per pound in 1973. For July 1974, list prices show an increase of 60% from 1973 levels to 31.5¢ per pound. The major reasons for this increase were higher prices of raw material and a tight supply situation.

The costs required to achieve BPT and BAT guideline specifications for the major producers in this industry are moderate: 2.9¢ and 3.1¢ per pound respectively. Competitive environmental factors – high captive usage, low foreign competition and high concentration of competition – are estimated to permit full cost pass through.

These factors are summarized in the impact matrix given in Table VIII-1.

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size and Grow_h

Published production volumes of benzoic acid were substantially understated until 1971 due to the reporting procedures of the manufacturing companies. Most of the captively used volume was excluded from the re or.ed number. Production volume for 1971 and 1972 includes, 'or the first time, production data fro... ..e major manufacturer .alama Chemical, Inc., previously owned by Dow Chemical Company. r 1972, production volume, which is still probably understated, reported at 155.5 million pounds. We believe actual production is close to 180 million pounds. Since trade is negligible, apparent consumption is equal to production (see Table VIII-2).

TABLE VIII-1

BENZOIC ACID BY AIR OXIDATION OF TOLUENE

All Processes:			
1972 Production (Million Pounds)			180
1973 Unit Value (c/Lb)			11.6
1972 Production Value ($MM)			25
Number of Plants (Current)			5

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	.3 – 25.0% 1.4 – 26.7%
Substitute Products	High Occurrence		Direct: Low Secondary: High (inc. phenol)
Capacity Utilization	Low		High
Captive Usage	Low		50% – High
Demand Growth	Low		7% – Moderate
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Moderate
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Conc. (2 prod. with 85%)
Number of Producers	Many		5
Substitute Process	Many		1: Oxidation by chlorine

TABLE VIII-1 (Continued)

PLANT SHUTDOWN DECISION				
Factor	Condition for Shutdown	Treatment Level		
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	.6 – 42.5% 2.3 – 45.4%	
Cash Flow (Including Treatment Costs)	Negative		Positive	
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	3.2 – 212% 6.7 – 227%	
Integration	Low		High	
Chemical Complex	Isolated Plant		Dominant Producer – isolated plant; Others – medium complex	
Other Environmental Problems (Including OSHA)	Multiple		Few	
Emotional Commitment	Indifference		High	
Ownership	Multi-Industry Companies		Multi-Industry	

TABLE VIII-2

**PRODUCTION, FOREIGN TRADE[1] AND APPARENT CONSUMPTION OF
BENZOIC ACID[2]**

(million pounds)

Year	Production	Apparent Consumption
1963	15.3	15.3
1964[3]	15.9	15.9
1965	16.2	16.2
1966	20.5	20.5
1967[4]	22.3	22.3
1968[4]	21.9	21.9
1969[4]	23.9	23.9
1970[5]	—	—
1971[6]	142.9	142.9
1972	155.5	155.5

Notes:
1. No data on foreign trade — Imports and Exports are considered negligible.

2. Technical grade, production of medicinal-grade is negligible.

3. Excludes production of Pfizer plant brought on-stream in 1964.

4. In 1967 Dow's plant at Kalama, Washington reportedly began producing benzoic acid for sale as well as for captive use in the manufacture of phenol. Data for production or sales of benzoic acid from this plant have not been reported. In 1971 the facility was sold and the Kalama Chemical, Inc. company was formed.

5. Data for 1970 was not published.

6. Volume understated until 1971 because data excludes major quantities that are captively consumed.

SOURCES: Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Cyclic Intermediates, U.S. Tariff Commission, Washington, D.C.

Apparent consumption of benzoic acid, for other than phenol manufacturing, is reported by trade literature as increasing at an average annual rate of 10% from 1962 to 1972. This growth is expected to decline to about 8% per year.

b. Uses

Over 50% of total benzoic acid produced is used in the manu-facturing of phenol (see Table VIII-3). By-and-large, this end use is considered isolated from the others. Most publications, when discussing benzoic acid, exclude that segment of the industry. Consumption of benzoic acid for phenol manufacture will probably increase. Kalama Chemical has recently announced an expansion of current plant capacity which includes about 100 million pounds of additional phenol production based on benzoic acid produced by the oxidation of toluene.

Consumption of benzoic acid in end uses other than phenol manufacturing should incr ,e at about 8% per year. Consumption of sodium benzoate, used primarily as food preservatives, is forecast to grow at about 4% per year for the next five years. Benzoate plasticizers are forecast to become the leading end use for benzoic acid. Estimates of growth in consumption range from 7% to 20% per year for the next five years. Benzoyl alc ide is an intermediate in the process of producing benzoic aci by oxidation of toluene with chlr   c. High prices for chlorine ι making this process obsolete and production of benzoyl chloride bar on benzoic acid from oxidation of toluene is forecast to increa at about 9-10% annually. Consumption of butyl benzoate, a dye car ier, used in dyeing some polyester fibers and fabrics, is fore-cast to increase at least 5% per year for the next five years.

Benzoic acid used for alkyd resins and all other miscellaneous end uses will probably not increase at more than 3-4% per year according to trade comments. Overall consumption volume in these minor applications is small and changes will not significantly impact total consumption.

TABLE VIII-3

BENZOIC ACID CONSUMPTION BY END USE IN 1972

End Use	% of Total	Million Pound
Phenol	51	80
Sodium Benzoate	14	22
Plasticizers	14	21
Benzoyl Chloride	9	14
Butyl Benzoate	4	6
Alkyd Resins	2	3
Miscellaneous	3	5
Stocks	3	4
Total	100	155

SOURCE: Contractor's Estimates.

c. Substitute Products

By-and-large, there are no broad and general substitutes
for benzoic acid. In the case of phenol manufacture, there is an alternate
process based on cumene oxidation. The relative economics of both
processes depends on their raw materials cost (benzene and propylene
vs. toluene) and the market price for acetone, a coproduct of phenol
under the cumene process, and for benzoic acid. For the other end
uses - which are mostly chemical intermediates - there are some market
substitutes, although generally there are important property differences.
These substitutes include alternate food or cosmetic preservatives and
phthalate plasticizers which are the most widely used plasticizers.
Benzoate plasticizers are manufactured by one producer and are utilized
principally for their high solvency capability where large proportions
of fillers are mixed with the polymer. Their price/property balance
does not bring them in direct competition with the phthalate plasticizers
used in quantities of over 1 billion pounds per year in the United
States. Currently, substitute products do not seem to pose serious
market threats to benzoic acid products.

d. Captive Requirements

As shown in Tab. VIII-4, in 1972 about 90% of total
production was used captively in the manufacturing of chemical products.
Over 50% of total captive consumption is in the manufacturing of phenol
and the remainder in the manufacturing of benzoic acid derivatives.
Commercial sales of benzoic acid are probably understated. Only 14
million pounds are reported by the U.S. Tariff Commission as sold in
1972 but commercial sales might have been closer to 40 million pounds.
Apparently one producer, Monsanto, devotes most of its capacity of
10 million pounds to the manufacture of USP grade benzoic acid for
direct sale and based on phenol capacity Kalama Chemical seems to use
only 80 million pounds captively and the remainder of the production,
from its 120 million pound plant, is sold as industrial or technical
grade benzoic acid.

TABLE VIII-4

CAPTIVE VERSUS COMMERCIAL CONSUMPTION OF BENZOIC ACID

(million pounds)

Year	Apparent Consumption	Consumption		
		Captive	Merchant	% of [2] Captive
1963	15.3	8.3	7.0	54
1964	15.9	7.9	8.0	50
1965	16.2	7.7	8.5	48
1966	20.5	8.9	11.6	43
1967	22.3	12.1	10.2	54
1968	21.9	13.5	8.4	62
1969	23.9	10.1	13.8	42
1970[1]	—	—	—	—
1971	142.9	125.7	17.2	88
1972	155.5	141.2	14.3	91

Notes:

1. Data for 1970 was not published.

2. Percentage of captive consumption from 1963 to 1969 is understated

SOURCES: Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Cyclic Intermediates, U.S. Tariff Commission, Washington, D.C.

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2. Supply Characteristics

a. Manufacturing Routes

Most of the U.S. production capacity is based on the toluene oxidation process. This is a continuous process where toluene and air, with a mixture of recycled gas and toluene, are combined in a reactor in the presence of a catalyst. Reaction temperatures may range from 150°C to 500°C with corresponding pressure ranges of 1 to 10 atmospheres. Specific manufacturers operate at different conditions. Benzoic acid and toluene are continuously stripped off; the unreacted toluene is recycled and the crude benzoic acid is refined using distillation. Crystallation or a combination of the two operations could also be used. The process can also produce benzaldehyde in varying proportions as a coproduct. Benzaldehyde is removed from the product stream before the first oxidation step to benzoic acid.

An older route for the production of benzoic acid involves the chlorination of toluene to benzotrichloride. This is then hydrolized to benzoic acid. One producer is reported by the Directory of Chemical Producers of having at least a portion of its benzoic acid capacity by this process.

b. Producers

Published information indicates that there are five producers of benzoic acid with a total reported capacity of 208 million pounds (see Table VIII-5). The industry is heavily concentrated in one producer, Kalama Chemical, with a 120 million pounds per year plant, about 60% of total capacity. Kalama has announced plans for an expansion of its benzoic acid capacity to 400 million pounds per year. The second largest plant, Velsicol, had a fire and explosion in 1973 which reduced its actual capacity to about half the nominal given capacity. In September 1974,

TABLE VIII-5

BENZOIC ACID PRODUCERS

Producer	Location	Annual Capacity (MM lbs)	Raw Material
Kalama Chemical	Kalama, Washington	120	Toluene
Monsanto	St. Louis, Missouri	10	Toluene
Pfizer	Terre Haute, Indiana	6	Toluene
Tenneco	Garfield, New Jersey	12	Toluene
Velsicol	Chattanooga, Tennessee	60	Cl_2 & Toluene
Total		208	

SOURCES: Chemical Profile, October 1, 1973; Director of Chemical Producers, 1974 Edition

Velsicol announced the construction of a benzoic acid plant in Beaumont, Texas. The plant will have an initial capacity of 50 million pounds per year with potential for later expansion to 150-175 million pounds.

Some 70% of Kalama's production is used captively in the manufacturing of phenol. The remainder is used to produce industrial and technical grade benzoic acid for sale to other firms. Pfizer's production is entirely for captive use, Tenneco and Velsicol manufacture benzoic acid primarily for production of different chemical derivatives at the same location. Monsanto's plant may no longer be active in the sale of technical grade benzoic acid, the form of product reported by the U.S. Tariff Commission.

c. Manufacturing Economics

Manufacturing economics are provided in Table VIII-6. It is shown that raw material costs, energy and capital depreciation are the major elements of the manufacturing cost and account for 88% of the total factor cost in 1973. Variable costs are estimated to be about 84% of the total factory cost. The capital investment for a 56 million pound per year plant is estimated to be $3.1 million.

3. Prices

List and actual price trends are shown in Table VIII-7. As this table indicates, list prices have been rather stable about 20¢ per pound from 63 to 1973 while actual prices have been in a declining trend from a stable 17¢-18¢ per pound maintained from 1963 to 1970 to 14¢ per pou d in 1971-1972 and 11.6¢ per pound in 1973. In 1972, actual prices were 35% below list prices. There are a number of reasons behind the price declines. The most important were an oversupply situation created by the new phenol plants using the cumene oxidation process in the last decade, which freed considerable volumes of benzoic acid to the merchant market and the entry of Velsical into this market in 1968.

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TABLE VIII-6

ESTIMATED COST OF MANUFACTURING BENZOIC ACID

Production Economics (Summer, 1973)

Process Air Oxidation and Toluene

Location Mid-West **Capacity** 15 MM lb/yr[1] **Invest.** $1.3 MM (1970 Construction)

	Cost	
	$/Year	¢/lb Product
Toluene 0.87 lb @ 3.1¢	405,000	2.70
Catalyst, Chem., Supplies	4,500	0.03
Utilities	106,500	0.71
Direct Labor 4 men @ $5/hr	41,600	0.28
Maintenance, Labor & Materials	62,400	0.42
Labor & Plant Overhead	41,600	0.28
Depreciation 9%/yr	117,000	0.78
Taxes & Ins. 1-1/2%/yr	19,500	0.13
Factory Cost	798,100	5.33

1. Investment in a plant with 56 million pounds per year capacity is estimated at $3.1 million.

TABLE VIII-7

ACTUAL VERSUS LIST PRICES FOR BENZOIC ACID

(cents per pound)

Year	Actual	List Price[1]
1963	18.0	20.0
1964	17.0	20.0
1965	18.0	20.0
1966	18.0	20.0
1967	17.0	19.5
1968	18.0	19.5
1969	17.0	19.5
1970[2]	—	21.5
1971	14.0	21.5
1972	14.0	21.5
1973	11.6	19.5
1974	N.A.	31.5

Notes:

N.A. — not available

1. Barrels, drums, carlots and truckloads, freight allowed

2. Data for 1970 not reported — 1974 list price 31.5¢/lb

SOURCES: Chemical Marketing Reporter

Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tariff Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Cyclic Intermediates, U.S. Tariff Commission, Washington, D.C.

List prices in July 1974 were posted at 31.5¢ per pound or
61% higher than their 1973 value. The reasons behind the increase are
higher raw material costs, which have quadrupled from late 1972 to
mid-1974 and a tight supply/demand situation. The increase in toluene
price would account for an increase in costs of about 5¢ per pound or only
about 40% of the list price change. Much of the price rise, therefore,
was probably the pricing opportunity brought about by the tightness of
supply.

4. Supply/Demand Balance

Since reported production data are believed understated, it is
difficult to establish the industry capacity utilization. We estimate
that in 1972 the industry was probably at about 85% of capacity utili-
zation. With Velsicol's capacity reduced to half, the industry must
have worked close to its nominal capacity in 1973. Future capacity utiliza-
tion will depend on Kalama's ability to market its phenol production
from the new facility planned for late 1976 and on Velsicol's plans to
increase capacity by virtue of a new plant.

C. ECONOMIC IMPACT

1. Treatment Costs

The costs required to achieve BPT and BAT guideline specifica-
tions as presented in the guideline document for a free standing plant
with a 164,000 pounds per day production capacity are 2.9¢ and 3.1¢ per
pound respectively. Substantially lower costs are realized by those
producers manufacturing benzoic acid in a medium plant complex with an
effluent volume of 3 million gallons per day: .04¢ and .16¢ per pound.
respectively. These are very probably at least partially offset by
the economies of scale of manufacture for the large free standing
producers. Even though the economies of scale in water treatment are
so significant, we estimate that 87% of the total industry capacity is

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located in free standing plants; therefore, pass through of the free standing plant effluent treatment costs as higher prices will be the only effluent treatment condition considered.

The major competing technology used for production of benzoic acid - chlorination of toluene - is not an important factor. Only one producer currently uses this technology and virtually all of its production is consumed captively. The guideline contractor has estimated that the treatment costs for this process will be much higher than for oxidation of toluene. In addition, chlorination of toluene has the disadvantage of consuming large quantities of expensive chlorine, all of which ends up as waste.

2. Price Impact

Actual prices for benzoic acid have declined from 17¢ per pound in 1970 to 12¢ per pound in 1973. Actual prices for 1974 are not available but list prices in mid-1974 were 31.5¢ per pound. Overcapacity in the industry and declining toluene prices lead to the price decline up to 1973. The 60% increase in list prices in 1974 reflects rising raw material costs and a tight supply/demand situation caused in part by the partial loss of the plant facilities of one of the producers.

The major question concerning this industry is whether enough of the current price increase can be maintained to offset the anticipated waste treatment costs. Currently, the industry is operating at close to nameplate capacity since a fire and explosion in 1973 reduced one major producer's capacity by one-half. However, another producer has announced a 400 million pounds per year plant expansion and a second producer has announced the replacement of the burned plant with an expansion of 50 million pounds per year should again provide ample industry capacity. Prices may once again be bid down as this new capacity comes on stream. However, since Kalama Chemical represents nearly 60% of the industry

production in essentially a free standing plant, full treatment cost pass through as higher prices will result.

The matrix in general suggests that full cost pass through will be possible. BAT treatment costs for a free standing plant represent a 27% price increase. Considering the high captive usage, the low foreign competition, the moderate price elasticity and the highly concentrated nature of the competition, all suggest full treatment cost pass through which will maintain the profitability typical of this industry.

This conclusion is predicated on the assumption that Kalama will, in the future, be able to continue to compete with other producers of phenol by the existing alternate routes. We assume these producers will also have to bear relatively high effluent treatment costs. If Kalama cannot compete, then benzoic acid production will have to be sold from existing and planned capacity, the industry will be in serious overcapacity and cost pass through may not be possible.

3. Plant Shutdown Decision

Since the treatment costs will be passed through in full, it is not likely that effluent treatment according to the guideline specifications will cause any plant shutdowns. The large capital investment required for free standing plants will be the only deterrent, but Kalama will no doubt make these to protect its dominant position and to continue to participate as a dominant factor in this industry. The secondary producers, who can achieve lower treatment costs per unit of production due to their location in plant complexes, will enjoy relatively higher profits and will be required to invest substantially lower capital in waste treatment facilities since they typically produce benzoic acid in locations which are part of medium-sized complexes.

4. Foreign Competition

Foreign trade in benzoic has been and is likely to continue to be negligible. High import duties of 1.7¢ per pound and 12.5% ad valorem are higher than projected waste treatment costs. Therefore, domestic producers would not choose to produce overseas and import into the U.S. based solely on treatment costs. No impact on the U.S. Balance of Trade is expected in this industry.

IX. ISOPROPYL ALCOHOL FROM PROPYLENE

A. SUMMARY

The U.S. Tariff Commission reports the production of 1.84 billion pounds per year for 1973 with an average growth rate of 2% per year from 1963 to 1973. Imports are negligible and exports during that period represented from 2% to 5% of total production. Based on production and export volume, apparent consumption increased from 1.4 billion pounds in 1963 to 1.77 billion pounds in 1972. Consumption reached a plateau in 1969 and then declined as a result of market oversupply for acetone, the major end use of isopropyl alcohol. Trends in consumption growth depend largely on the future of the acetone manufacturing industry using the isopropyl alcohol process. On the basis of the industry comment and published sources, we estimate overall growth at 3.5% per year for the next five years.

In 1972, about 40% of total isopropyl alcohol production was used in the manufacturing of acetone. For this end use, isopropyl alcohol competes with cumene oxidation as an alternate process in acetone manufacture. The cumene oxidation process yields phenol and acetone and its manufacturing economics for acetone are probably more attractive than with the isopropyl alcohol process. About 35% of total production is used as a solvent for a variety of applications and for this end use isopropyl alcohol often competes with ethanol on a price-performance basis. The remaining 25% of total production is used in the manufacturing of chemical derivatives in the drugs and cosmetic manufacture and the export market. About 50% of total isopropyl alcohol production is used captively, primarily in the manufacturing of acetone.

Isopropyl alcohol is manufactured from propylene which is absorbed in concentrated sulfuric acid and the resulting isopropyl ether of sulfuric acid is then hydrolyzed. It is produced by four companies in

six plants with a total nameplate capacity of 2.45 billion pounds in 1973. The industry was working at about 75% of capacity in 1973 and an estimated 90% in the first half of 1974. During 1970-1972, capacity utilization was more in the order of 70%-75% as a result of acetone oversupply.

Actual prices have remained stable at 6¢ per pound from 1963 to 1973 in spite of increases in posted prices which changed from 6.9¢ per pound in 1963 to 7.35¢ per pound in 1972 for anhydrous grade, tank delivered. In August 1974, prices were listed at 9¢ per pound.

The costs required to achieve BPT and BAT guideline specifications for the major producers in this industry are small; only $.03-$.05 per pound respectively for the smaller producers and $.03-$.04 per pound for the major producers. Competitive environmental factors will limit cost pass through to about 50% and as such will not adversely affect this industry. No plant shutdowns are expected and no major change in U.S. balance of trade in this industry is expected.

The summary of factors affecting these conclusions is given in Table IX-1 in our impact matrix.

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size and Growth

According to the U.S. Tariff Commission production of isopropyl alcohol increased from 1.5 billion pounds in 1963 to 1.8 billion pounds in 1973 which represents an average growth rate of 2% per year (see Table IX-2). Production volume, however, peaked at 9,950 million pounds in 1969 and has been declining since. This decline is directly correlated to a decrease in production volume of

TABLE IX-1

ISOPROPYLENE ALCOHOL FROM PROPYLENE

All Processes:

1972 Production (Million Pounds)	1800
1972 Unit Value (¢/Lb)	6
1972 Production Value ($MM)	108
Number of Plants (Current)	6

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.5% 0.7 – 0.9%
Substitute Products	High Occurrence		High (Solvents; Prod. from Cumene)
Capacity Utilization	Low		Low – 1972 & 1973
Captive Usage	Low		High: about 50%
Demand Growth	Low		Low: 3.5%/yr.
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		High
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Concentrated
Number of Producers	Many		3
Substitute Process	Many		None – direct; 1 for major use: acetone prod.

TABLE IX-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	1.9% 2.5 − 3.2%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	6.1 − 7.3% 8.0 − 10.1%
Integration	Low		High
Chemical Complex	Isolated Plant		Large complex
Other Environmental Problems (Including OSHA)	Multiple		Few
Emotional Commitment	Indifference		High
Ownership	Multi-Industry Companies		Multi-Industry

TABLE IX-2

PRODUCTION, FOREIGN TRADE[1] AND APPARENT
CONSUMPTION OF ISOPROPYL ALCOHOL
(million pounds)

Year	Production	Exports	Apparent[2] Consumption
1963	1,466	60	1,406
1964	1,504	31	1,473
1965	1,538	46	1,492
1966	1,714	36	1,678
1967	1,840	38	1,802
1968	1,890	54	1,836
1969	1,950	92	1,858
1970	1,919	81	1,838
1971	1,674	74	1,600
1972	1,790	91	1,699
1973	1,835	65	1,770

Note:

1. Imports are negligible
2. Apparent consumption = production less exports

SOURCES: Synthetic Organic Chemicals, Production and Sales, U.S. Tariff
Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Miscellaneous
Chemicals, U.S. Tariff Commission, Washington, D.C.

acetone produced from isopropyl alcohol, its major single end use.
Total acetone production has continued to increase.

Imports of isopropyl alcohol are negligible; the maximum
reported volume was 2.3 million pounds in 1967 which represented 1%
of total production for that year. Export of isopropyl alcohol in-
creased from 60 million pounds in 1963 to 91 million pounds in 1972.
On a year-to-year basis, export volumes have been uneven. During that
period of time, export volume represented from 2% to 5% of total pro-
duction.

Apparent consumption, estimated at 1.7 billion pounds for
1972, has grown at an average rate of 2% per year from 1963 to 1972.
Like production, consumption volume reached a plateau in 1969 and
declined afterwards as a result of lower demand for acetone manufacture.
The industry, at that time, was converting phenol production to the
cumene oxidation process which also yields acetone. Acetone is yielded
as a coproduct but volume of production is principally controlled by
the demand for phenol from cumene-based plants. Currently, phenol
capacity has been mostly switched to the cumene route and market demand
for coproduct acetone from this source has been absorbed. We expect
this transition to permit acetone producers using the isopropyl alcohol
process to work closer to existing capacity. Since 1971, this has increased
demand growth rate for isopropanol considerably above the 2% per year
rate experienced between 1963 to 1973. Further consumption growth rate
will depend on the market for acetone and the production of acetone
and phenol as coproducts of cumene oxidation.

b. Uses

The major use for isopropyl alcohol is in the manufacture
of acetone followed by its application as a solvent mainly for gums,
shellac and synthetic resins and in the manufacturing of other chemical
products, such as glycerine and isopropyl acetate (see Table IX-3).

TABLE IX-3

ISOPROPYL ALCOHOL CONSUMPTION BY END USE — 1972

End Use	% of Total	Million Pounds
Acetone	41	734
Other Chemical Uses	10	179
Coatings and Solvents	35	627
Drugs and Cosmetics	5	89
Miscellaneous Exports	9	161
Total	100	1,790

SOURCE: Chemical Marketing Reporter, April 15, 1973, pg. 1

Preliminary Report on U.S. Production and Sales of Miscellaneous Chemicals, U.S. Tariff Commission, Washington, D.C.

Isopropyl alcohol is also used widely as a rubbing alcohol.

As indicated in Table IX-4, consumption of isopropyl alcohol for acetone production reached a plateau in the late 1960's. In 1964, almost 60% of total isopropyl alcohol production was used in the manufacturing of acetone, whereas only about 40% was so used in 1972. Total acetone production in the United States increased from 1.05 billion pounds in 1964 to 1.74 billion pounds in 1972. Acetone is a coproduct of the production of phenol from cumene and has traditionally been disposed of as produced leaving the residual market to isopropanol derived acetone. About 1.9 billion pounds of phenol are produced and approximately 85% is via the oxidation of cumene yielding an estimated 920 million pounds of acetone. Phenol production is forecast to increase at 7.5%. Assuming 85% of this increase is via phenol (the current science), this will result in an increase in the supply of acetone from cumene at 7.5% per year to total 1,315 million pounds by 1977. Total demand for acetone is forecast to increase 6% per year to total 2,240 million pounds by 1977 or by 570 million pounds. This means demand for acetone via isopropyl will provide the balance or about 75 million pounds. Use of isopropyl for acetone pro- duction is, therefore, forecast to increase by about 10% in five years or at 2% per year.

Demand for isopropyl alcohol in other end uses is forecast to increase at 5% per year. Overall growth rate in demand, therefore, will be at about 3.5% per year over the next five years.

c. Substitute Products

There are no chemical substitutes for isopropyl alcohol in the manufacturing of acetone, other than the use of cumene, which produce phenol and acetone by oxidation of cumene and appears to offer attractive manufacturing economics. Acetone from isopropyl alcohol takes only the share of the market that cannot be supplied with cumene-based acetone.

TABLE IX-4

HISTORIC VOLUME OF ISOPROPYL ALCOHOL CONSUMPTION
BY END USE
(million pounds)

Year	Acetone	Other End Uses	Total Apparent Consumption
1963	825	581	1,406
1964	875	598	1,473
1965	859	633	1,492
1966	1,013	665	1,678
1967	911	890	1,801
1968	919	917	1,836
1969	1,001	857	1,858
1970	959[e]	879[e]	1,838
1971	786[e]	814[e]	1,600
1972	734[e]	965[e]	1,699

Note: [e]Estimates since 1970. Data on acetone production from isopropyl alcohol are no longer published by the U.S. Tariff Commission.

SOURCES: Synthetic Organic Chemicals, Production and Sales, U.S. Tariff Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Miscellaneous Chemicals, U.S. Tariff Commission, Washington, D.C.

As a solvent and in cosmetic uses, isopropyl alcohol competes with ethanol on a price-performance basis. Over the past several years, the two products have been quite close in price. Substantial price changes in either would probably lead to reformulation of some products and loss of market share by the more expensive product.

d. Captive Requirement

Isopropanol is used captively in the manufacturing of acetone and other chemical derivatives. As shown in Table IX-5, captive volume has declined from 924 million pounds in 1963 to 878 million pounds in 1972. Production of acetone from isopropanol peaked in 1966 and declined through 1972. As a percentage of total consumption, captive requirements decreased from 63% in 1963 to 49% in 1972, once again reflecting the market decline for acetone from isopropyl alcohol. About 90% of total captive consumption is for acetone manufacture.

2. Supply Characteristics

a. Manufacturing Routes

Isopropyl alcohol is made from a C_3 steam containing 40%-60% propylene that is isolated from refinery off-gasses. (Sometimes chemical grade, or even polymer grade propylene is also used.) Propylene feed-stock combined with hydrocarbons is absorbed in concentrated sulfuric acid to form a solution of diisopropyl sulfate and isopropyl acid sulfate. The reaction takes place at approximately 400 psig and 140°F. The sulfated hydrocarbon solution is converted to an acid solution of isopropyl alcohol, ether, and polymer by hydrolysis reactions with the addition of dilution water in the hydrolyzer-stripper. Hydrolyzed reaction products are steam-stripped from the acid and the vapors are condensed following neutralization with a caustic solution. Isopropyl alcohol is separated from isopropyl ether by distillation.

TABLE IX-5

CAPTIVE VS. COMMERCIAL CONSUMPTION OF ISOPROPYL ALCOHOL
(million pounds)

| Year | Production | Consumption | | |
		Captive	Merchant	% of Captive
1963	1,466	924	542	63
1964	1,504	965	539	64
1965	1,538	956	582	62
1966	1,714	1,019	695	59
1967	1,840	1,011	739	60
1968	1,890	1,096	795	58
1969	1,950	1,099	851	56
1970	1,919	1,058	861	55
1971	1,674	830	844	50
1972	1,790	878	912	49

SOURCES: Synthetic Organic Chemicals, Production and Sales, U.S. Tariff
Commission, Washington, D.C.

Preliminary Report on U.S. Production and Sales of Miscellaneous
Chemicals, U.S. Tariff Commission, Washington, D.C.

b. Producers

In 1973, there were four producers of isopropyl alcohol with six plants (see Table IX-6). Total nameplate capacity was reported at 2,450 million pounds. The two largest producers are Union Carbide and Shell, each with a total capacity of some 900 million pounds from two plants. Their combined capacity represents 70% of industry's total. Seventy-five percent of total capacity is concentrated in the Gulf Coast area, probably because of the heavy concentration of refineries in the area.

c. Manufacturing Economics

Estimated manufacturing costs for isopropyl alcohol production are provided in Table IX-7. It is clearly seen that raw material and energy costs are the major elements of the manufacturing cost accounting for 85% of the total factory cost in 1973. Variable costs are estimated to be about 90% of the total factory cost. The capital investment for a 470 million pound per year plant is estimated to be $8.75 million.

3. Prices

Isopropyl alcohol list prices have increased from 6.9¢ per pound for anhydrous grade, tank quantities, delivered, to 7.35¢ per pound in 1972. In August 1974, prices were posted at 9¢ per pound. List prices have increased by 30% in the last ten years. Actual prices have remained during that time at close to 6¢ per pound through 1973 (see Table IX-8). Future prices will probably remain higher than 6¢ per pound reflecting the higher values for propylene.

TABLE IX-6

ISOPROPYL ALCOHOL PRODUCERS — 1973

Producer	Location	Annual Capacity (Million Pounds)
Atlantic-Richfield	Channelview, Texas	50
Exxon	Baton Rouge, Louisiana	615
Shell	Deer Park, Texas	610
Shell	Dominguez, California	275
Union Carbide Corp.	Texas City, Texas	570
Union Carbide Corp.	Whiting, Indiana	330
Total		2,450

SOURCE: Directory of Chemical Producers, 1974 Edition

TABLE IX-7

ESTIMATED MANUFACTURING COSTS FOR ISOPROPYL ALCOHOL

Process Hydration of Propylene

Location Gulf Coast **Capacity** 200 MM lb/yr **Invest.** $5.0 MM[1] (1970 construction)

	Cost	
	$/Year	¢/lb Product
Propylene 0.80 lb @ 2.8¢/lb	4,480,000	2.24
Catalyst, Chem., Supplies	100,000	0.05
Utilities	2,680,000	1.34
Direct Labor 20 men @ $5.00/hr	213,000	0.11
Maintenance, Labor & Materials	240,000	0.12
Labor & Plant Overhead	213,000	0.10
Depreciation 9%/yr	450,000	0.23
Taxes & Ins. 1-1/2%/yr	75,000	0.04
Factory Cost	8,451,000	4.23

1. Estimated investment in a plant to produce 470 million pounds per year would total $8.75 million.

TABLE IX-8

ACTUAL VS. LIST PRICES FOR
ISOPROPYL ALCOHOL
(cents per pound)

Year	Actual	List Price[1]
1963	6	6.90
1964	6	6.90
1965	6	6.90
1966	6	7.20
1967	6	7.20
1968	6	7.20
1969	6	7.20
1970	6	7.35
1971	6	7.35
1972	6	7.35
1973	(5.8)	7.50[2]
1974	—	8.40[2]

Note: 1. Anhydrous, Tanks, Delivered
2. 49¢/gal. in 1973 and 55¢/gal. in 1974

SOURCE: Chemical Marketing Reporter

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4. Supply/Demand Balance

Capacity utilization has been significantly influenced by market demand for isopropyl alcohol-based acetone. In 1970, capacity utilization was in the order of 75% as a result of acetone oversupply. In the first half of 1974, with a rather tight acetone supply situation, the industry was probably working at about 90% of capacity. For the foreseeable future, the industry will probably experience a higher operating rate than the past five years as the impact of changing the production of phenol to cumene-based production has been absorbed by the industry and the demand for acetone continues to increase.

C. ECONOMIC IMPACT

1. Treatment Costs

The costs required to achieve BPT and BAT guideline specifications as presented in the guideline document for a free standing plant with a 1,370,000 pounds per day production capacity are only .07¢ and .10¢ per pound respectively. We estimate a small cost advantage benefits those plants which are part of a complex having effluent volumes of 3 million (.03¢ and .05¢ per pound) or 10 million (.03¢ and .04¢ per pound) gallons per day. We estimate existing plants are all associated with medium or large sized complexes.

Investment requirement for a free standing plant of the size specified totals $1.25 million to achieve BPT and $1.78 million to achieve BAT. This is estimated to decline to $0.53 million to achieve BPT (6.1% of fixed investment) and $0.70 million (8% of fixed investment) to achieve BAT in a 10 million gallons per day complex. A 3 million gallons per day complex is estimated to require investments of $0.64 million to achieve BPT guidelines and $0.88 million to achieve BAT guidelines.

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Virtually all isopropanol is produced by hydration of propylene. There are no other practical routes which would have substantially different waste water treatment costs.

No free standing isopropanol plants are found in the industry. About 25% of the industry capacity is located in medium complexes with 3 million gallons per day effluent volumes. The remaining 75% is part of large complexes. A high degree of vertical integration characterizes both size complexes. Since economies of scale for treatment costs appear not important in this industry, the plant size differences do not create significant differential treatment costs.

2. Price Impact

List prices for isopropanol have increased from 7.5¢ per pound in 1973 to 9.0¢ per pound by August 1974, reflecting the tight raw material supply affecting the entire petrochemical industry. As raw material supplies ease, these higher prices may be retained since currently this industry is estimated to be operating near capacity. However, demand for isopropanol shifts rapidly because demand for isopropanol-based acetone is erratic. Low-priced, cumene-based acetone - a byproduct of phenol production - is absorbed by the market first, leaving the residual acetone demand to the isopropanol-based producers. As new cumene-based phenol capacity comes on stream, more low-cost byproduct acetone will flood the market and the demand for isopropanol will decrease. The result of this is industry overcapacity and lower isopropanol prices. Low prices and low capacity utilization has been a more typical competitive environment characterizing the isopropanol industry.

The price matrix in general suggests that as a normal competitive environment is restored, at least half of the treatment costs will be absorbed into net income rather than be passed through to the consumer. It is likely that the treatment costs would appear in higher base prices, but would be discounted in the traditional heavy price cutting typical of this industry. The principal conditions constraining cost pass through are the high occurrence of substitute products and the low capacity utilization typical in this industry. It is significant that there are "substitute products" for isopropanol both as a raw material for acetone and as a solvent. Oxidation of cumene gives both acetone and phenol and as such cumene is a substitute "raw material" for isopropanol in the manufacture of acetone. However, phenol production is much larger than that of acetone making the disposal of phenol the principal concern of this manufacturing route. It is not surprising, therefore, that cumene oxidation is geared to phenol rather than acetone demand; nevertheless, this route provided 55% of all the acetone consumed in 1973. As a route to phenol, oxidation of cumene is a competitive process even without marketing the byproduct acetone. Therefore, the acetone from cumene need only be sold at a price above disposal cost and this economic fact keeps a tight lid on acetone and therefore isopropanol prices.

As a solvent, isopropanol competes with ethanol and to a lesser extent methanol. Since the cost of these alcohols has recently been virtually identical, the price changes for isopropanol depends on both the relative merit of each alcohol as an ingredient in the final product and the waste water treatment cost differential which results. It is not likely that these will be large, but uncertainty about them and the unwillingness to yield isopropanol market share to ethanol or methanol will constrain a full cost pass through. We expect that isopropanol producers will try and succeed with sharing treatment costs equally with their consumers.

Two principal factors which favor price pass through should be discounted heavily when interpreting the matrix: (1) the high captive usage, and (2) the low degree of foreign competition. The normally insulating quality of these conditions does not apply in this industry. First, acetone - the product for which isopropanol is captively consumed - is sold with relatively low margins in an extremely competitive environment. Therefore, high captive consumption of iso-propanol for acetone production does not imply the normal price in-sensitivity that usually exists. Secondly, although there is little foreign competition, the fluctuating demand for isopropanol-based acetone gives rise to the same kind of price pressures as periodic inflows of foreign produced isopropanol. Therefore, even without foreign com-petition, the potential for price constraint is strong and it is doubtful that the full treatment costs would be passed through. We therefore estimate that only 50% of the treatment costs will be passed through to customers. This will total 0.25% of 1973 price by 1977 and 0.35% by 1983.

3. Plant Shutdown Impact

It is doubtful that waste treatment costs will cause any iso-propanol plants to close down. Even though the treatment costs won't be passed on, both the costs and their impact on net income (1.9-3.2%) are small. The capital investment required, even for BAT treatment facilities, is not large, and in light of the high emotional commitment to isopropanol production due to the desire of petroleum companies to remain in petrochemicals, we conclude that the facilities will be installed and operations continued.

4. Foreign Competition

It is likely that foreign competition will remain insignificant. Import duties are currently 1.5¢ per pound compared with .04¢ and .05¢ per pound for estimated BAT treatment costs. Therefore, it is not likely current producers of acetone would look toward importing isopropanol rather than absorbing the additional treatment costs. Further, the U.S. domestic market for isopropanol is quite uncertain and will probably remain unattractive for foreign producers. We estimate no significant impact on the U.S. balance of trade in this industry.

X. METHYL CHLORIDE FROM METHANE

$$(CH_3Cl)$$
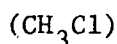
A. SUMMARY

Methyl chloride is produced in the United States primarily for use as an intermediate to silicone and tetramethyl lead. The 1973 value of methyl chloride production is $29 million. More than 50% of annual production is used captively.

Production of methyl chloride is dominated by four major organic chemical manufacturers, two of which are integrated forward into the manufacture of secondary products for which methyl chloride is an intermediate. The only major end use using methyl chloride directly was refrigeration, but this application is now largely lost to fluorinated hydrocarbons.

Growth of methyl chloride consumption has averaged 15.2% since 1963 but is currently growing at a much lower rate. Prices declined from 1963 through 1972 and rose slightly in 1973. List prices, and probably actual prices, increased modestly in 1974.

A summary of the factors used in the economic impact analysis is given in Table X-1. Producers of methyl chloride via thermal chlorination of methane will be able to pass through modest effluent treatment costs in the form of higher prices. We estimate BPT treatment costs at 0.9% of the 1973 sales price and BAT treatment costs at 1.3% of the 1973 sales price. The effluent treatment costs for the manufacturers of methyl chloride from methanol are higher than those for the thermal chlorination plants. Also the capital investment is significant. In our best judgment, over the long run, most producers utilizing methanol will switch to the use of methyl chloride from methane.

TABLE X-1

METHYL CHLORIDE FROM METHANE

All Processes:	
1972 Production (Million Pounds)	435
1972 Unit Value (¢/Lb)	5 (5.5¢ in 1973)
1972 Production Value ($MM)	22 (30 in 1973)
Number of Plants (Current)	13

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.7 – 0.9% 1.1 – 1.3%
Substitute Products	High Occurrence		Direct – Low Secondary – Low
Capacity Utilization	Low		Low – 71% in 1973
Captive Usage	Low		64% – High
Demand Growth	Low		Low – 4%
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		Unequal
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Fragmented
Number of Producers	Many		10
Substitute Process	Many		From methane and from methanol.

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TABLE X-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	2.4 – 10.2% 3.6 – 13.2%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	1.5 – 5.9% 1.9 – 7.7%
Integration	Low		High forward Low backward
Chemical Complex	Isolated Plant		Complex and isolated
Other Environmental Problems (Including OSHA)	Multiple		Air pollution and OSHA
Emotional Commitment	Indifference		Low
Ownership	Multi-Industry Companies		Multi-Industry

This could result in significant reduction in production of methyl chloride from methanol unless effluent treatment costs and investments by this alternate route are competitive with costs and investments associated with the thermal chlorination process.

B.   INDUSTRY BACKGROUND

1.   Market Characteristics

a.   Size

Large-scale U.S. production of methyl chloride began about 1920 chiefly to supply refrigerant requirements. However, since 1940, U.S. production of methyl chloride has grown from 3 million pounds per year to an estimated one-half billion pounds in 1974. Production in 1973 was 544.1 million pounds as shown in Table X-2. Since imports of methyl chloride are negligible and exports are not recorded separately, apparent consumption is taken equal to production.

b.   Growth

U.S. production of methyl chloride increased at an average annual rate of 15.2% between 1962 and 1972, however, since 1969 it has averaged only 4.0% growth per year. The slow rate of growth in recent years is due to uncertain demand from the tetramethyl lead end-use sector. However, a surplus of methyl chloride does not exist in the market and supplies were snug by mid-1974 due to limited availability of methanol. The future of the tetramethyl lead market plus the availability of methanol will affect future growth of methyl chloride most significantly and probably will limit it to moderate to static growth.

TABLE X-2

**PRODUCTION, FOREIGN TRADE AND APPARENT CONSUMPTION
OF METHYL CHLORIDE**
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	114.0	Not Reported Separately	Not Reported Separately	114.0
1964	134.0	Not Reported Separately	Not Reported Separately	134.0
1965	187.5	Not Reported Separately	Not Reported Separately	187.5
1966	236.9	Not Reported Separately	Not Reported Separately	236.9
1967	275.6	Not Reported Separately	Not Reported Separately	275.6
1968	305.2	Not Reported Separately	Not Reported Separately	305.2
1969	402.8	Not Reported Separately	Not Reported Separately	402.8
1970	422.7	Not Reported Separately	Not Reported Separately	422.7
1971	437.5	Not Reported Separately	Not Reported Separately	432.8
1972p	453.5	Not Reported Separately	Not Reported Separately	453.5
1973p	544.1	Not Reported Separately	Not Reported Separately	544.1

SOURCE: U.S. Department of Commerce

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c. Uses

The largest, and fastest growing, end-use area in 1972 was use as an intermediate for production of silicones. Silicone rubbers, fluids and polymers are forecast to grow at about 10% per year over the next five years. This area accounted for 43% of domestic consumption in 1972 as shown in Table X-3. However, use of methyl chloride as an intermediate in tetramethyl lead production is almost as large and future growth does not appear promising at present. In all probability the use of tetramethyl lead will decline as an increasing proportion of non-leaded gasoline is produced. The remaining consumption is shown in Table X-3, and only accounts for 19% of total. Its use as a refrigerant has been largely replaced by fluorocarbons.

d. Substitute Products

Methyl chloride is used synthetically as a source of the methyl group or radical. As such, it must compete with all other chemicals which also provide this group. The most common substitute chemicals are methanol, dimethyl sulfate, methyl bromide and methyl iodide. Methanol, for most practical purposes, is not a good methylating agent for most syntheses in which methyl chloride is used and, therefore, is not a real competitor.

Dimethyl sulfate, methyl bromide and iodide are all far superior methylating agents, however are really not competitive with methyl chloride for various reasons. Dimethyl sulfate is hard to handle, extremely toxic and not produced in quantities sufficient to replace much methyl chloride. Further, it is often too reactive to benefit controlled synthesis. Both methyl bromide and iodide are more reactive than methyl chloride but less than dimethyl sulfate. They can be substituted for methyl chloride in virtually all synthetic procedures; however, their primary disadvantage is cost. Whereas the cost of methanol is the same for each, iodine and bromine are far more expensive than chlorine.

TABLE X-3

CONSUMPTION OF METHYL CHLORIDE BY END USE

End Use	% of Total 1972
Silicone Intermediate	43
Tetramethyl Lead Intermediate	38
Butyl Rubber (catalyst solvent)	4
Miscellaneous[1]	15
Total	100

1. Mfg. methyl cellulose, quaternary ammonium compounds, ammonium salts, triptane (an antiknock fuel additive) methyl mercaptan (intermediate in jet fuel mfg.), and pesticides.

SOURCE: Chemical Economics Handbook

Further, if these are used as intermediates to supply the methyl groups, each pound contains fewer methyl groups than in a pound of methyl chloride and the heavy bromine or iodine is discarded and recycled. Therefore, manufacturing economics are doubly affected with substitution of either methyl bromide or methyl iodide for methyl chloride. We consider, therefore, the use of methyl chloride will be relatively price inelastic.

e. Captive Requirements

Since the two major end-use areas for methyl chloride are as chemical intermediates, it is not surprising that more than 50% of the 1972 production was used captively. Captive use has been above 50% in all but two of the last ten years as shown in Table X-4. Even with the high captive use, there are ten major producers of methyl chloride.

f. Other Market Requirements

Competition in the methyl chloride industry is on a price basis since most is consumed as an intermediate in other chemical production. For these uses, quality is standard and supply has been more than sufficient.

g. Foreign Competition

Foreign competition in methyl chloride has historically been insignificant and is likely to remain so at least for the next several years.

TABLE X-4

PRODUCTION SALES AND CAPTIVE USE
FOR METHYL CHLORIDE
(million pounds)

Year	Production	Sales	Captive Use[1]
1963	114.0	54.7	59.3
1964	134.0	67.2	66.8
1965	187.5	94.8	92.7
1966	236.9	104.2	132.7
1967	275.6	118.0	157.6
1968	305.2	139.2	166.0
1969	402.8	166.1	236.7
1970	422.7	176.0	246.7
1971	437.5	193.1	244.4
1972	453.5	208.0	245.5
1973p	544.1	227.3	316.8

1. Includes stock changes

p — preliminary

SOURCE: U.S. Department of Commerce

2. Supply Characteristics

a. Manufacturing Routes

There are two principal processes for industrial production
of methyl chloride: hydrochlorination of methanol and chlorination of
methane.

(1) Hydrochlorination of Methanol

This was the earliest industrial process used for
methyl chloride production but is now being replaced by methane chlorin-
ation. Methyl chloride from methanol, however, still accounts for over
50% of the 1974 methyl chloride capacity. The advantage of the hydro-
chlorination route is that methyl chloride is the sole product which
is not true for chlorination of methane. A second advantage can be
the capability of utilizing excess quantities of hydrogen chloride which
might be available. The chief disadvantage of this process is the cost
and availability of methanol and the large quantities of HCl required
if hydrogen chloride is not in excess supply in the local area. Typically
only those companies basic in methanol production will use this route.
The hydrogen chloride required is either manufactured on site or diverted
from a chlorination process such as methylene chloride, chloroform, or
carbon tetrachloride production.

(2) Chlorination of Methane

Methane can be chlorinated thermally, photochemically,
or catalytically; however, thermal chlorination is technically the most
important. The methane raw material for methyl chloride production may
be natural gas, coke oven gas, or petroleum refining gas since separation
of pure methyl chloride is essential to its production via methane
chlorination. Methyl chloride is not a single reaction product, but

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rather is a coproduct with methylene chloride, chloroform and carbon tetrachloride. Extensive modifications of this process exist and perhaps the most versatile is the McBee-Hass technique of controlled high temperature chlorination. The ratios of the chloromethanes in the product can be varied from nearly 100% methyl chloride to carbon tetrachloride exclusively. The primary disadvantage of this process is the generation of hydrogen chloride, but the gas is either oxidized to chlorine and recycled or scrubbed clean with water and sold on the open market as aqueous hydrochloric acid.

b. Producers

Currently ten producers have a capacity of 655 million pounds as shown in Table X-5; however, this capacity must be regarded as somewhat flexible since 36% of this capacity can be diverted to produce other chlorinated hydrocarbons. Dow and DuPont share half this market, but they both have large captive requirements for methyl chloride. These two, with Continental Oil and Ethyl Corporation, share 77% of the total market as shown in Table X-5.

c. Manufacturing Costs

Costs for the production of methyl chloride from methanol are provided in Table X-6. Costs for the production of chlorinated methanes are given in Table X-7. In Table X-8, these costs have been allocated among the various products produced by methane chlorination to provide a specific cost for the production of methyl chloride from methane.

TABLE X-5

METHYL CHLORIDE CAPACITIES

Producer	Location	Annual Capacity (MM lbs)	Raw Material
Allied Chemicals	Moundsville, West Virginia	25	Methanol
Continental Oil	Lake Charles, Louisiana	100	Methanol
Dow Corning	Carrollton, Kentucky	20	Methanol
Dow Corning	Midland, Michigan	15	Methanol
E.I. DuPont	Deepwater, New Jersey	30	Methanol
E.I. DuPont	Niagara Falls, New York	80	Methanol
Ethyl Corp.	Baton Rouge, Louisiana	75	Methanol
General Electric	Waterford, New York	20	Methanol
Union Carbide	Institute, West Virginia	50	Methanol
Dow	Freeport, Texas	70	Methane
Dow	Plaquemine, Louisiana	150	Methane
Stauffer	Louisville, Kentucky	15	Methane
Vulcan	Newark, New Jersey	2	Methane
Total		655	
Capacity based on Methanol		417	
% of Total		64%	

SOURCES: Chemical Profile, October 1, 1973; Directory of Chemical Producers, 1974 Edition.

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TABLE X-6

**ESTIMATED COST OF MANUFACTURING
METHYL CHLORIDE BY THE METHANOL PROCESS
Mid-1972**

Physical Investment:	$1.7MM
Capacity:	30MM lb/yr

	Quantity/100 lb	$/Unit	$/100 lb
Raw Materials			
Methanol	80	.014/lb	1.12
Muriatic Acid (32.5%)	260	.0062/lb	1.61
Utilities			0.70
Chemicals, Catalyst, Supplies			0.50
Direct Labor	6 men	$5/hour	0.31
Maintenance & Materials			0.78
Labor and Plant Overhead			0.31
Depreciation	9% of investment/year		0.51
Taxes and Insurance	1-1/2% of investment/year		0.08
Total Cost of Manufacture excluding cost of muriatic acid			4.31
Total Cost of Manufacture			5.92
Average Selling Price			5.14

TABLE X-7

ESTIMATED COST OF MANUFACTURING CHLORINATED METHANE
THERMAL CHLORINATION PROCESS
Mid-1972
(1970 Construction)

Physical Investment: $10.7 MM

Capacity: 130 MMlb/yr

Production is assumed to be:

39 MMlbs/yr Methyl Chloride   (30%)
52 MMlbs/yr Methylene Chloride (40%)
26 MMlbs/yr Chloroform   (20%)
13 MMlbs/yr Carbon Tetrachloride (10%)

Variable Costs	Quantity/100 lb	$/Unit	$/100 lb
Raw Materials			
Chlorine	170 lbs	0.02	3.40
Natural Gas	.504 MSCF	0.25	0.13
Utilities			
Power	30 kwh	0.008	0.24
Water	6 Mgal	0.03	0.18
Natural Gas	0.8 MMBtu	0.25	0.20
			4.15

Semi-Variable Costs			
Operating Labor	20 men	$5 00/hr	0.17
Maintenance	5% of Investment/yr		0.41
Labor & Plant Overhead	100% of Labor & Supervision		0.17
			0.75

Fixed Costs			
Depreciation	9% of Investment/yr		0.74
Taxes & Insurance	1-1/2% of Investment/yr		0.12
			0.86

Subtotal			5.76
Byproduct Credit — HC1 (100% basis) 86.9 lbs			(1.74)
Factory Cost			4.02

TABLE X-8

PRO RATED MANUFACTURING COSTS FOR CHLORINATED
METHANE COPRODUCTS FROM THERMAL CHLORINATION PROCESS

Mid-1972

Capacity: 130 MMlb/yr

	Methyl Chloride ($/100 lb)	Methylene Chloride ($/100 lb)	Chloroform ($/100 lb)	Carbon Tetrachloride ($/100 lb)
Variable Costs				
Raw Materials				
Chlorine	2.94	3.48	3.70	3.90
Natural Gas	0.13	0.13	0.13	0.13
Utilities				
Power	0.24	0.24	0.24	0.24
Water	0.18	0.18	0.18	0.18
Natural Gas	0.20	0.20	0.20	0.20
	3.69	4.23	4.45	4.65
Semi-Variable Costs				
Operating Labor	0.17	0.17	0.17	0.17
Maintenance	0.41	0.41	0.41	0.41
Labor & Plant Overhead	0.17	0.17	0.17	0.17
	0.78	0.78	0.78	0.78
Fixed Costs				
Depreciation	0.74	0.74	0.74	0.74
Taxes & Insurance	0.12	0.12	0.12	0.12
	0.86	0.86	0.86	0.86
Subtotal	5.33	5.87	6.09	6.29
Byproduct Credit — HCl	(1.50)	(1.78)	(1.90)	(2.00)
Total Cost of Manu-facturing	3.83	4.09	4.19	4.29
Average Selling Price — 1972	5.14	6.65	6.61	5.89

3. Prices

Prices historically have been depressed for methyl chloride. As shown in Table X-9, actual prices for methyl chloride have declined from 9¢ per pound in 1963 to 5¢ per pound in 1972. However, since 1968 actual prices have been relatively stable and probably increased in 1974, along with list prices, due to increasing raw material costs. List prices have usually been about 1¢ - 1 1/4¢ per pound above actual. The price decline between 1963 and 1968 is probably the result of rapid growth and expansion leading to economies of scale with new large volume capacity introduction and lower raw material prices. Since competition within the industry is primarily based on price, these conditions have favored price decreases.

4. Supply/Demand Balance

As shown in Table X-10, industry capacity has historically kept ahead of demand and in 1973 was about 110 million pounds ahead of estimated demand. However, the reported capacities for production by thermal chlorination must be considered highly flexible and can be easily diverted to production of other chlorinated hydrocarbons thereby utilizing otherwise unusuable capacity. Therefore, overcapacity should not cause price destabilization, but may limit potential price increases. Prices will be principally dependent on the price of methane, methanol and chlorine. All of these are directly related to energy costs and hence will most probably be significantly higher than they were before 1974.

TABLE X-9

ACTUAL VS. LIST PRICES – METHYL CHLORIDE

Year	Sales Quantity (MM lbs)	Sales Value ($ MM)	Unit Value (¢/lb)	List Price (¢/lb)
1963	54.7	4.7	9.0	10.00
1964	67.2	5.2	8.0	10.00
1965	94.8	6.4	7.0	10.00
1966	104.2	7.5	7.0	10.00
1967	118.0	8.0	7.0	10.00
1968	139.2	8.2	6.0	6.25
1969	166.1	8.7	5.0	6.25
1970	176.0	9.8	6.0	7.25
1971	193.1	11.2	6.0	7.25
1972	208.0	10.7	5.1	7.25
1973	227	12.6	5.5	7.25
1974	N.A.	N.A.	N.A.	8.50

SOURCES: U.S. Department of Commerce, Chemical Marketing Reporter

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TABLE X-10

INDUSTRY OPERATING CAPACITY — METHYL CHLORIDE
(million pounds)

Year	Capacity[1]	Production	% Capacity
1963	—	114.0	—
1964	—	134.0	—
1965	209	187.5	90
1966	—	236.9	—
1967	376	275.6	73
1968	—	305.2	—
1969	—	402.8	—
1970	436	422.7	97
1971	—	432.8	—
1972	501	444.5	89
1973	655	544.1	83

1. Capacities are flexible since some processes produce more than one product.

SOURCES: U.S. Department of Commerce, Chemical Marketing Reporter

C. ECONOMIC IMPACT

  1. Water Treatment Costs

    a. Thermal Chlorination

        The development document describes the costs association
with the treatment of effluent from a methane chlorination plant to
produce chloromethanes. The cost of the treatment described in the
development document, for a plant producing 356,000 pounds per day,
is $128,400 per year or 0.17¢ per pound of product to achieve BPT
effluent guidelines. The cost to achieve BAT in the free standing
plant described totaled 0.22¢ per pound of product.

        The guideline document does not attempt to assign effluent
control costs to the individual chlorinated methanes - methyl chloride,
methylene chloride, chloroform and carbon tetrachloride - but rather
specifies total control costs for the total product mix. For purposes
of our analysis, we have assumed the effluent control costs are equivalent
for the various chloromethane products produced.

        By our calculations, the cost to achieve BPT in a 3 million
gallons per day complex would decline to 0.05¢ per pound and 0.04¢ per
pound in a 10 million gallons per day complex.

        The cost to achieve BAT would decline to 0.07¢ per pound in
a 3 million gallons per day complex and 0.06¢ per pound in a 10 million
gallons per day complex.

  2. Price Impact

        Estimation of price impact is complicated by the fact that two
significantly different routes exist for the manufacture of methyl chloride:
methanol utilizing HCl and methane from thermal chlorination. It is our

judgment that a modest price pass through will be possible which will cover the effluent treatment costs of the thermal chlorination process. Although there are a fairly large number of producers, the producers compete on price, and the market share is fragmented in a low capacity utilization situation; there is on the other hand a high degree of captive usage, no foreign competition and little substitution possible as well as relatively low elasticity of demand. A complicating situation exists in that the producers of methyl chloride by thermal chlorination do not have fixed capacities for methyl chloride. Their capacities are fixed at any given time for the total production of the family of chlorinated methanes but they have the capability of switching production as demand indicates from one product to antoher; e.g., methyl chloride, methylene chloride, chloroform and carbon tetrachloride. The nominal capacity of those producers of methyl chloride from methane totals 36% of total given capacity with the residual 64% based on methanol.

There are four producers of methyl chloride by the thermal chlorination of methane: two in medium-sized complexes and two in large complexes. We expect that there would be no difficulty for these producers to pass through the relatively small costs for BPT treatment in medium-sized complexes. This would be equivalent to 1.3% of the 1973 sales price.

The longer range possibility forecast pass through is more difficult to judge. The increase in price by 0.17¢ per pound increases the advantage of the thermal chlorination producer in the production of methyl chloride. It also increases the attractiveness of methyl chloride as one of the products from methane chlorination. It is our best judgment that given the time available between the present and 1983, there will be a switch in capacity by the producers towards production from methane and prices will not increase further by virtue of effluent treatment costs. As shown in Table X-11, thermal chlorination in medium complexes to achieve BAT is estimated at .07¢ or only 1.3% of 1973 price.

TABLE X-11

COST OF EFFLUENT TREATMENT TO ACHIEVE
BPT AND BAT CONTROL LEVELS

	Thermal Concentration
BPT (¢/lb)	
Mfg. Cost (¢/lb)	3.83
Free Standing	.17
Medium-Sized Complex	.05
Large-Sized Complex	.04
Range (¢/lb)	3.87 — 4.00
BAT (¢/lb)	
Free Standing	.22
Medium-Sized Complex	.07
Large-Sized Complex	.06
Range (¢/lb)	3.89 — 4.05

SOURCE: Guideline Contractor and Economic Contractor Estimates.

We forecast a continuation of the 1.8% price increase for methyl chloride through 1983.

The comparison of manufacturing economics, as shown in Table X-11, indicates that those producers utilizing thermal chlorination already manufacture slightly more cheaply than those producers utilizing methanol, even including the estimate that there is no cost associated with the hydrochloric acid used in the process. In many instances, the methanol process is utilized to take advantage of available byproduct hydrochloric acid which might otherwise have no application within the chemical complex.

3. Plant Shutdown Decision

We expect no shutdown of thermal chlorination plants due to the BPT and BAT effluent guidelines. As previously indicated, we expect relatively modest effluent treatment costs, even in the long term, to be passed through in the form of higher prices for methyl chloride.

4. Foreign Competition

We foresee no significant effects of U.S. balance of trade by virtue of the effluent control guidelines which are proposed. The effect of these guidelines as described above will be to switch the industry towards the use of thermal chlorination as a method of achieving the required production of methyl chloride.

XI. METHYLENE CHLORIDE FROM METHANE
$$(CH_2Cl_2)$$
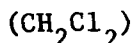
A. SUMMARY

Methylene chloride is produced in the United States primarily for use as a solvent. Its largest application is as a component in paint stripping composition. Current value of methylene chloride production is about $30 million. Less than 15% of annual production is used captively and about 20% is exported.

Production of methylene chloride is dominated by one major organic chemical manufacturer which has nearly 50% of the total market for methylene chloride. Three producers share 70% of the market.

Growth of methylene chloride consumption has averaged 13.4% over the past five and ten years and we estimate will be about 8% per year over the next five years. Prices have been both stable and high relative to other chlorinated hydrocarbons, but low relative to most organic chemicals.

A summary of factors affecting price increases and plant shutdowns is provided in Table XI-1. Effluent treatment costs required to meet both BPT and BAT guidelines are moderate and can probably be passed through in the form of higher prices. A 2.2% increase in the 1973 price will be required to cover the cost of meeting the BPT regulations, and 2.8% of the 1973 sales price will be the price increase required to comply with BAT guidelines for a free standing plant. We do not anticipate any plant shutdowns, and no effect on the U.S. balance of payments is foreseen as a result of the water treatment guidelines.

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TABLE XI-1

METHYLENE CHLORIDE FROM METHANE

All Processes:			
1972 Production (Million Pounds)			471
1972 Unit Value (¢/Lb)			7
1972 Production Value ($MM)			30
Number of Plants (Current)			8

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.5 – 2.2% 0.8 – 2.8%
Substitute Products	High Occurrence		Direct — Moderate Secondary — Moderate
Capacity Utilization	Low		High — 97% 1973
Captive Usage	Low		Low
Demand Growth	Low		High: 8%
Foreign Competition	High		Moderate — 10% Competition
Abatement Cost Differences	Unequal		Unequal
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Moderate
Number of Producers	Many		6
Substitute Process	Many		1: from methyl chloride (methanol derived)

TABLE XI-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	1.1 – 4.6% 1.6 – 5.9%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	1.5 – 5.9% 1.9 – 7.7%
Integration	Low		Low
Chemical Complex	Isolated Plant		Isolated & Complex
Other Environmental Problems (Including OSHA)	Multiple		Air pollution & OSHA
Emotional Commitment	Indifference		Low
Ownership	Multi-Industry Companies		Multi-Industry

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B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size

Methylene chloride became an industrial chemical of importance during World War II and since 1944 production has grown from 8.3 million pounds per year to over one-half billion pounds in 1974. U.S. production in 1973 was about 521 million pounds and imports were an additional 42.3 million pounds, as shown in Table XI-2. Exports for 1973 were 114.2 million pounds and during 1972 were 103.7 million pounds. Apparent consumption, shown in Table XI-2, is taken as production plus imports less exports.

b. Growth

U.S. production of methylene chloride has grown at an average annual rate of 13.4% between 1963 and 1973. This average rate slowed during the last five years when growth of methyl chloride production declined 11.3%. However, exports seem to have accounted for a large measure of this growth. Anticipated future growth for methylene chloride consumption is forecast at an average of 8% per year.

c. Uses

Methylene chloride is used for its physical rather than for its chemical properties. Methylene chloride is a solvent. Virtually no methylene chloride is used as a chemical intermediate. The most important application is as a paint remover component and this end use accounted for 32% of all domestic consumption in 1972, as shown in Table XI-3. This application has been primarily responsible for the rapid growth in consumption of this product. Methylene chloride is superior to other chlorinated solvents as a paint stripper. Its efficiency, low cost, and

TABLE XI-2

PRODUCTION, FOREIGN TRADE AND APPARENT CONSUMPTION
OF METHYLENE CHLORIDE
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	148.0	—	—[1]	148.0
1964	179.6	19.2	—	198.8
1965	210.8	12.3	—	223.1
1966	267.2	11.1	—	278.3
1967	262.3	10.2	—	272.5
1968	302.6	19.3	—	321.9
1969	366.0	7.8	—	373.8
1970	402.2	9.5	85.5	326.2
1971	401.2	7.8	86.9	322.1
1972	471.3	11.1	103.7	378.7
1973p	520.2	42.3	114.2	448.8

P — Preliminary

1. Not reported separately before 1970.

SOURCES: U.S. Department of Commerce, U.S. Tariff Commission.

TABLE XI-3

CONSUMPTION OF METHYLENE CHLORIDE BY END USE

End Use	% of Total 1972
Paint Remover	32
Aerosol Vapor Pressure Depressant	20
Solvent Degreasing	10
Plastics Processing	10
Miscellaneous[1]	28
TOTAL	100

1. Includes exports and applications of pharmaceutical solvents; extraction solvent for some naturally occurring food substances, photographic film and synthetic fiber solvent, fire extinguisher component.

SOURCE: Chemical Economics Handbook.

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extremely low toxicity ensure its preeminence in this area. We expect growth in consumption in this use to slow as the opportunities for replacement of other solvents have declined.

Other areas of importance are use as aerosol vapor pressure depressants and in various solvent applications, as listed in Table XI-2.

d. Substitute Products

Methylene chloride is basically a solvent. Apart from its use as a vapor depressant and fire extinguisher ingredient, it functions as a solvent in all applications. As such, it competes with a large variety of other solvents. However, because of its low cost, powerful solvent action, stability under recovery conditions, low toxicity, and ready availability, it has few real competitors. The primary substitute solvents are BTX aromatics and the other chlorinated methanes and light hydrocarbons. Methylene chloride is higher priced than most competing solvents. Its unique properties, however, make demand for the product relatively inelastic to price competition from other solvents in the established end uses for methylene chloride. Prices for all competitive solvents will be significantly affected by the increase in petroleum and energy costs.

e. Captive Requirements

Since methylene chloride is used for its physical properties rather than as a chemical intermediate, it is not surprising that captive usage is less than 10%. Captive use has only been above 15% in one year since 1963, as shown in Table XI-4. Most users are essentially formulators and purchase rather than produce internally their requirements.

TABLE XI-4

PRODUCTION, SALES AND CAPTIVE USE FOR METHYLENE CHLORIDE
(million pounds)

Year	Production	Sales	Captive Use[1]
1963	148.0	133.2	15.8
1964	179.6	156.7	22.9
1965	210.8	194.5	16.3
1966	267.2	225.8	41.4
1967	262.3	226.9	35.4
1968	302.6	288.1	14.5
1969	366.0	338.1	27.9
1970	402.2	358.2	44.0
1971	401.2	366.0	35.2
1972	471.3	443.3	28.0
1973	520.2	473.9	46.3

1. Includes stock changes.

SOURCE: U.S. Department of Commerce.

f. Other Market Requirements

Competition in the methylene chloride industry is primarily on a price basis for use in paint stripping applications, but premium prices are received from many special applications, e.g., as a food processing solvent. Quantities supplied have historically been adequate and prices have been relatively stable since 1963.

g. Foreign Competition

Exports have typically been well ahead of imports and have been growing rapidly in recent years. As raw materials become scarce, some greater quantities may be imported, but it is likely that U.S. produced methylene chloride will be less expensive than foreign produced since production utilizes chlorine which is produced in an energy intensive process. While chlorine production costs are rising domestically, they are rising less than in the many industrialized foreign countries heavily dependent on imported oil as a source of energy.

2. Supply Characteristics

a. Manufacturing Routes

(1) Chlorination of Methane

Chlorination of methane is the most important route to methylene chloride. However, a single product cannot be produced via this process. Therefore, it is merely a coproduct along with all other possible chlorinated hydrocarbons. Purification techniques, however, have been refined to produce ultra-pure methylene chloride.

A disadvantage of this process is that it produces large quantities of hydrogen chloride which either are scrubbed with water, concentrated and sold as aqueous hydrogen chloride or are oxidized to chlorine and recycled.

(2) Hydrochlorination of Methanol

This process relies on chlorination of methyl chloride rather than methane. The principal advantage here is that hydrogen chloride generated in the chlorination step is recycled through the methanol-methyl chloride cycle, eliminating the need to further process the hydrogen chloride evolved. This process should be most attractive to those producers basic in methanol production as it offers a captive market to the methanol producer.

b. Producers

Currently six producers have a capacity of 532 million pounds; however, as for all chlorinated methanes, this capacity must be considered flexible and can be varied between the chlorinated methanes as market conditions demand. Dow is the leading supplier of methylene chloride with 45% of the current market share. The three largest producers, Dow, Diamond Shamrock, and Stauffer, share 70% of the market, as shown in Table XI-5.

c. Manufacturing Costs

Costs for the production of the chlorinated methane products are in the section on methyl chloride from methane. Methylene chloride costs are in the same section and are estimated based on the allocation of manufacturing costs among the various products produced by methane chlorination.

3. Prices

Prices historically have been stable for methylene chloride and typically have been the highest priced of all the chlorinated methanes. Prices were stable but discounted from list from 1963 to 1967, as shown in Table XI-6, but then gently slid from 9¢ per pound to 7¢ per pound

TABLE XI-5

METHYLENE CHLORIDE

Producer	Location	Annual Capacity (MM lbs)	Raw Material
Allied Chemical	Moundsville, West Virginia	50	Methane
Diamond Shamrock	Belle, West Virginia	72	Methane
Dow	Freeport, Texas	150	Methane
Dow	Plaquemine, Louisiana	90	Methane
Stauffer	Louisville, Kentucky	60	Methane
Vulcan	Wichita, Kansas	30	Methane
Vulcan	Newark, New Jersey	40	Methanol
DuPont	Niagara Falls, New York	40	Methanol
Total		532	
Capacity based on methane		452	
% of total		85%	
Capacity based on methanol		80	
% of total		15%	

SOURCES: Chemical Profile, April 1, 1974; Directory of Chemical Producers, 1974 Edition.

TABLE XI-6

ACTUAL VS. LIST PRICES — METHYLENE CHLORIDE

Year	Sales		Unit Value (¢/lb)	List Price (¢/lb)
	Quantity (MM lbs)	Value ($ MM)		
1963	133.2	12.3	9.0	12.00
1964	156.7	14.0	9.0	10.50
1965	194.5	17.2	9.0	10.50
1966	225.8	12.5	10.0	12.50
1967	226.9	20.0	9.0	12.50
1968	288.1	22.5	8.0	11.75
1969	338.1	25.9	8.0	11.75
1970	358.2	28.8	8.0	12.50
1971	366.0	26.7	7.3	10.25
1972	443.3	29.5	6.6	10.25
1973	473.9	37.3	7.8	10.00
1974	N.A.	N.A.	N.A.	12.50

SOURCES: U.S. Department of Commerce, Chemical Marketing Reporter.

by 1971. Actual prices increased in 1973 and list prices have subsequently increased and very probably there has been an additional increase in actual prices reflecting increased costs of chlorine and methane. The demand for and its value as an excellent solvent has probably contributed to this price pattern. Industry capacity utilization had not been tight prior to 1973, as shown in Table XI-7. However, in 1973 capacity became a restrictive factor and nominal supply may be limited by availability of easily convertible facilities, the availability of chlorine, and demand for other chlorinated methanes.

4. Supply/Demand Balance

Industry capacity has historically kept pace with demand, as shown in Table XI-7. However, it is currently being stretched by demand. Du Pont and others have new large chlorinated hydrocarbon facilities scheduled to come on-stream in 1974 to produce for captive consumption. If prices for methylene chloride rise, additional supplies can be expected from these.

C. ECONOMIC IMPACT

1. Treatment Costs

The development document supplies the treatment costs for plants producing chloromethanes by the thermochlorination process for a plant with the capacity of 358,000 pounds per day of product. The document specifies that a free standing plant of the size would incur a cost of .17¢ per pound to achieve BPT and .22¢ per pound of product to achieve BAT guidelines. The plant would require an investment of $0.68 million to achieve BPT guidelines and an additional $.19 million to achieve BAT guidelines.

The cost to achieve BPT in a 3 million gallon per day effluent complex is estimated at .05¢ per pound and .04¢ per pound in a 10 million

TABLE XI-7

INDUSTRY OPERATING CAPACITY -- METHYLENE CHLORIDE
(million pounds)

Year	Capacity[1]	Production	% of Capacity
1963	—	148.0	—
1964	—	179.6	—
1965	250	210.8	84
1966	—	267.2	—
1967	335	262.3	78
1968	—	302.6	—
1969	—	366.0	—
1970	—	402.2	—
1971	490	401.2	82
1972	—	471.3	—
1973	532	520.7	98

1. Capacities are flexible since some processes produce more than one product.

SOURCES: Chemical Marketing Reporter, U.S. Department of Commerce.

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gallons per day complex. The cost to achieve BAT would be .07¢ per pound in a 3 million gallon per day complex and .06¢ per pound in a 10 million gallons per day complex. For purposes of our analysis, we have assumed the effluent control costs are equivalent for the various chloromethanes produced.

2. Price Impact

Since there are few real competitive products in terms of price or product performance, the treatment costs are low in relation to the selling price, capacity utilization is high, and demand growth is high, water treatment costs will probably be passed on as price increases. These factors are of greater importance and tend to outweigh the other price increase constraints such as low captive use, moderate foreign competition and the moderately fragmented market share distribution. The expected price increases as a result of water treatment costs, even for a free standing producer, will be small since the BPT treatment costs are only 2.2% of the average 1973 selling price for a free standing plant and 0.5% for a plant in a 10 million gallons per day complex. We have predicted full cost pass through based on costs for a free standing plant principally because of expected tight capacity utilization and relatively low manufacturing margins.

The differential in treatment costs may possibly prevent the producer with a free standing plant from fully recovering the treatment costs, although we believe this unlikely. Since the BPT treatment costs represent such a small percentage of the selling price, the apparent **sizable** differential of treatment costs is mitigated. In any case, it is not expected that prices will be raised by 2.2% of 1973 selling price due to water treatment costs for BPT and by an additional 0.8% due to BAT treatment costs.

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3. Plant Shutdown Impact

Since the industry should be able to pass on the treatment costs through price increases, it is not expected that there will be any plant shutdowns on the basis of the water treatment costs provided us. Also, the relatively low level of AT treatment costs in relation to industry profitability, the positive cash flow, and the magnitude of the investment in treatment facilities compared to the net fixed investment support this conclusion. The free standing plants are at a modest economic disadvantage because of the economies of scale of the treatment costs, but as we expect cost pass through on the basis of a free standing plant, no closures of free standing plants are indicated.

Several of the methylene chloride producers are integrated with chlorine production facilities, although overall, the industry integration is low. Chlorine production facilities are also faced with water treatment costs where marginal plants may be subject to shutdown. As a result, if any of the methylene chloride producers are integrated with a marginal chlorine facility, the methylene chloride facility could be subject to shutdown except if competitive alternative raw material supplies are available.

4. Balance of Payments

No effect is foreseen for the balance of payments.

XII. CHLOROFORM FROM METHANE CHLORINATION
$(CHCl_3)$
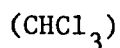
A. SUMMARY

Chloroform is produced in the United States primarily for use as an intermediate in fluorocarbon gas and resin production. Its largest application is in the manufacture of fluorocarbon refrigerants and propellant gas which consumes over half of the annual production. Current value of chloroform production is $14 million. Less than 25% of annual production is used captively.

Production of chloroform is dominated by one major organic chemical manufacturer which has nearly 50% of the total market for chloroform. Three major producers share 80% of the total market.

Growth of chloroform consumption has averaged 9.2% over the past ten years with a 6.8% average annual rate over the past five years. We estimate future demand will increase at 5% per year unless fluoro-carbon use based on chloroform is restricted due to environmental considerations. Prices have been stable but substantially discounted from list.

A summary of factors affecting price increases and plant shutdowns is provided in Table XII-1. Effluent treatment costs required to meet both BPT and BAT guidelines are moderate even for a free standing plant and can probably be passed through in the form of higher prices. A 2.6% increase in the 1973 price will be required to cover the cost of meeting the BPT regulations, and 3.3% will be the price increase required to comply with BAT guidelines. We do not anticipate any plant shutdowns, and no effect on the U.S. balance of payments are foreseen as a result of the water treatment guidelines.

TABLE XII-1

CHLOROFORM FROM METHANE

All Processes:	
1972 Production (Million Pounds)	235
1973 Unit Value (¢/Lb)	6.6
1972 Production Value ($MM)	16
Number of Plants (Current)	8

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.6 – 2.6% 0.9 – 3.3%
Substitute Products	High Occurrence		Direct – Low Secondary – Low
Capacity Utilization	Low		88% – 1973
Captive Usage	Low		About 20%
Demand Growth	Low		5% – Low
Foreign Competition	High		Est. Low
Abatement Cost Differences	Unequal		Unequal
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Mod. Conc: 2 with 2/3 total
Number of Producers	Many		6
Substitute Process	Many		None

TABLE XII-1 (Continued)

PLANT SHUTDOWN DECISION		Treatment Level	
Factor	Condition for Shutdown		
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	1.6 – 6.8% 2.4 – 8.8%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	1.5 – 5.9% 1.9 – 7.7%
Integration	Low		Low
Chemical Complex	Isolated Plant		Isolated & Complex
Other Environmental Problems (Including OSHA)	Multiple		Air pollution & OSHA
Emotional Commitment	Indifference		None
Ownership	Multi-Industry Companies		Multi-Industry

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size

The chloroform market is today the smallest of the four chlorinated methane markets but was one of the first organic chemicals produced on a large scale in the United States. Prior to World War II, chloroform was used mainly as an anesthetic and in pharmaceutical preparations which required only 2-3 million pounds per year. However, use as an intermediate for the production of fluorocarbon gasses (fluorocarbon 22) and fluoroplastics has increased the market size from 3 million pounds in 1940 to about 265 million pounds in 1974. Production in 1973 was officially recorded as 253 million pounds as shown in Table XII-2. Imports are probably negligible and exports are not recorded separately. We have assumed apparent consumption, as shown in Table XII-2 to equal production.

b. Growth

U.S. production of chloroform has grown at an average annual rate of 9.2% between 1963 and 1973. Growth over the last five years has been only 6.8% per year and at an even lower rate since 1970. Ultimately the demand for chloroform depends on the demand for refrigerating equipment and for fluorocarbon plastics. We forecast demand will grow at an average rate of 5% per year over the next five years with the largest proportional increase from the increased production of fluorocarbon polymers. Demand could, however, be dramatically reduced should the Environmental Protection Agency restrict the use of fluorocarbon 22, manufactured from chloroform and used as the working fluid in refrigeration equipment.

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TABLE XII-2

PRODUCTION FOREIGN TRADE, & APPARENT CONSUMPTION OF CHLOROFORM
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	105.2	Not Reported Separately	Not Reported Separately	105.2
1964	119.2	Not Reported Separately	Not Reported Separately	119.2
1965	152.5	Not Reported Separately	Not Reported Separately	152.5
1966	179.0	Not Reported Separately	Not Reported Separately	179.0
1967	190.0	Not Reported Separately	Not Reported Separately	190.0
1968	180.8	Not Reported Separately	Not Reported Separately	180.8
1969	216.2	Not Reported Separately	Not Reported Separately	216.2
1970	239.9	Not Reported Separately	Not Reported Separately	239.9
1971	230.8	Not Reported Separately	Not Reported Separately	230.8
1972	234.7	Not Reported Separately	Not Reported Separately	234.7
1973p	252.8	Not Reported Separately	Not Reported Separately	252.8

P — Preliminary

SOURCE: U.S. Department of Commerce

c. Uses

Consumption by end use is shown in Table XII-3. Virtually all chloroform is consumed as a chemical intermediate. In 1972, 60% was consumed as an intermediate in the manufacturing of fluorocarbon refrigerants and propellants with chlorodifluoromethane being the most important product. These fluorocarbons are the working fluids in air conditioning and industrial refrigeration systems. The second area of importance consuming 19% of 1972 production is as an intermediate in the production of polyethylene tetrafluoride or Teflon[R]. Other areas account for 21% with medical and pharmaceutical end uses accounting for less than 10% and declining. We estimate fluorocarbon refrigerants based on chloroform will grow at approximately 4% per year, fluorocarbon resins at 8%-10% per year, while miscellaneous uses will decline at about 2% per year over the next five years.

d. Substitute Products

As an intermediate for fluorocarbon gasses and plastics, chloroform has no practical substitute products. These products themselves cannot easily be substituted, although fluorocarbon plastics can be replaced in some cases by other high performance polymers. However in medical and pharmaceutical applications, many substitute products are available and are currently replacing chloroform in these end uses.

e. Captive Requirements

Even though chloroform is used as a chemical intermediate, captive use is less than 25%. Captive use has only been above 25% in two years since 1963 as shown in Table XII-4.

TABLE XII-3

CONSUMPTION OF CHLOROFORM BY END USE

End Use	% of Total — 1972
Fluorocarbon Refrigerants & Propellants	60
Fluorocarbon Resins	19
Miscellaneous[1]	21
Total	100

1. Includes use of chloroform as extraction and general solvent, and as an intermediate in preparation of dyes, drugs and pesticides.

SOURCE: Chemical Economics Handbook

TABLE XII-4

PRODUCTION, SALES & CAPTIVE USE FOR CHLOROFORM
(million pounds)

Year	Production	Sales	Captive Use[1]
1963	105.2	77.3	27.9
1964	119.2	98.1	21.1
1965	152.5	143.6	35.4
1966	179.0	143.6	35.4
1967	190.9	135.8	55.1
1968	180.8	139.9	40.9
1969	216.2	172.2	44.0
1970	239.9	174.9	65.0
1971	230.8	183.2	47.6
1972	234.7	202.8	31.9
1973 p	252.8	243.8	9.0

P — Preliminary

1. Includes stock changes.

SOURCE: U.S. Department of Commerce

f. Other Market Requirements

Competition in the chloroform industry is on a price basis
since most is a commodity product consumed as an intermediate in other
chemical production. For these uses, quality is standard and supply
has been more than sufficient.

g. Foreign Competition

Imports of chloroform have been negligible and exports are
not reported separately. Most exports are for the production of fluoro-
carbon refrigerant gasses abroad. With supplies close to capacity in
the United States, it is not likely that exports will grow faster than
production unless a significant price and/or cost differential develops.
Foreign trade nevertheless is not too attractive since shipping costs
for these very heavy, low-priced chemicals are a relatively high pro-
tion of value.

2. Supply Characteristics

a. Manufacturing Routes

(1) Chlorination of Methane

Virtually all chloroform is produced via chlorination
of methane. As mentioned in other reports, a single product is not
produced in this process but rather a mixture of all possible chlorinated
methanes.

The primary problem with this manufacturing process is
the large quantity of hydrogen chloride evolved which is either scrubbed
with water, concentrated and sold as aqueous hydrochloric acid or is
oxidized to chlorine and recycled.

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b. Producers

Currently, six producers have a capacity of 308 million pounds as shown in Table XII-5; however, as for all chlorinated methanes, this capacity must be considered flexible and can be expanded or otherwise utilized as market conditions demand. Dow is the leading supplier of chloroform with 42% of the current market. Dow, Stauffer and Vulcan together share 80% of the market.

c. Manufacturing Costs

Costs for the production of the chlorinated methane products are in the section on methyl chloride from methane. Chloroform costs are in the same section and are estimated based on the allocation of manufacturing costs among the various products manufactured by methane chlorination.

3. Prices

List prices historically have been relatively stable for chloroform, but large quantity contracts have typically sold at large discounts from list as shown in Table XII-6. Actual prices slowly slid from 9¢ per pound in 1963 to about 6¢ per pound by 1971 as production more than doubled. Prices then increased in 1972 and 1973 to 6.6¢ per pound. In 1974 actual prices have probably risen reflecting higher raw material costs and tighter supplies. As with other chlorinated methane derivatives, actual prices will very probably remain higher because of higher raw material costs but manufacturing profit margins may not correspondingly increase over the long term.

TABLE XII-5

CHLOROFORM

Producer	Location	Annual Capacity (MM lbs)	Raw Material
Allied Chemical	Moundsville, West Virginia	30	Methane, Cl_2
Diamond Shamrock	Belle, West Virginia	18	Methane, Cl_2
Dow	Freeport, Texas	100	Methane, Cl_2
Dow	Plaquemine, Louisiana	30	Methane, Cl_2
DuPont	Niagara Falls, New York	15	Methane, Cl_2
Stauffer	Louisville, Kentucky	75	Methane, Cl_2
Vulcan	Newark, N.J.	10	Methane, Cl_2
Vulcan	Wichita, Kansas	30	Methane, Cl_2
Total		308	
Capacity from Methane, Cl_2		308	
% of Total		100%	

SOURCE: Chemical Profile, April 1, 1974.

TABLE XII-6

ACTUAL VS. LIST PRICES — CHLOROFORM

Year	Sales Quantity (MM lbs)	Sales Value ($ MM)	Unit Value (¢/lb)	List Price (¢/lb)
1963	77.3	7.0	9.0	17.0
1964	98.1	8.2	8.0	17.0
1965	123.3	9.9	8.0	17.0
1966	143.6	10.8	8.0	17.0
1967	135.8	10.1	7.0	17.0
1968	139.9	9.8	7.0	17.0
1969	172.2	10.8	6.0	17.5
1970	174.9	10.7	6.2	17.5
1971	183.2	11.4	6.2	17.5
1972	202.8	13.4	6.6	17.5
1973	243.8	N.A.	6.6	17.5
1974	N.A.	N.A.	N.A.	17.0

SOURCES: U.S. Department of Commerce, Chemical Marketing Reporter.

4. Supply/Demand Balance

Industry capacity has historically kept pace with demand as
shown in Table XII-7. However, raw material supply, especially of
chlorine, caused tight supplies in the first half of 1974. The tight
supply situation may be eased by expected drops in construction
activities which may result in lowered sales of industrial air con-
ditioning and refrigeration system and, indirectly, chloroform and
other fluorocarbon intermediates.

C. ECONOMIC IMPACT

1. Treatment Costs

The treatment costs for the production of chloroform are
assumed to be identical to the costs provided for methyl chloride in
the section dealing with methyl chloride. The costs for BPT range
from .04¢ per pound in a 10 million gallon per day complex to .17¢ per
pound in a free standing complex. BAT costs range from .06¢ per
pound to .22¢ per pound for a large complex (10 million gallons per
day effluent) and a free standing complex respectively.

Investment requirements range from 1.5% to 5.9% of existing
fixed investment to achieve BPT guidelines. Achievement of BAT guide-
lines will require investment of between 1.9% and 7.7% depending if the
plant is free standing or in a large effluent treatment complex.

2. Price Impact

Water treatment costs for free standing plants will be passed
on as price increases because there are no real substitute products,
capacity utilization is high, and foreign competition is low. Also,
since before tax treatment costs are small relative to the selling
price, the chloroform producers should be able to recover both BPT and

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TABLE XII-7

INDUSTRY OPERATING CAPACITY – CHLOROFORM
(million pounds)

Year	Capacity[1]	Production	% Capacity
1963	—	105.2	—
1964	136	119.2	88
1965	—	152.5	—
1966	—	179.0	—
1967	228	190.9	84
1968	234	180.8	77
1969	—	216.2	—
1970	285	239.9	84
1971	—	230.8	—
1972	—	234.7	—
1973	285	253.0	88
1974	308	—	—

1. Capacities are flexible since some processes produce more than one product.

SOURCES: Chemical Marketing Reporter, U.S. Department of Commerce.

BAT water treatment costs through small price increases of 2.6% of 1973 price by 1977 and 3.3% of 1973 price by 1983. These increases should not jeopardize the competitive position for chloroform. Also, these factors mitigate the impact of other price increase constraints such as low captive usage, low demand growth and price as the basis for competition. The impact of unequal abatement costs for free standing plants and plants in a large chemical complex is also minimized because the treatment costs represent such a small percentage of the selling price.

3. Plant Shutdown Impact

The plant shutdown impact is interrelated with the treatment costs and price impact on the other chloromethane coproducts. However, we believe that the industry should be able to pass on treatment costs through price increases for chloroform. Since treatment costs for methylene chloride, chloroform and carbon tetrachloride can be passed on as price increases, the contractor does not expect that there will be any plant shutdown as a result of the water treatment costs. Also, this conclusion is supported by such factors as the relatively low after tax treatment cost relative to net income, the positive cash flow, and the magnitude of investment in treatment facilities relative to the fixed investment. Free standing plants with higher treatment costs relative to plants located in large chemical complexes should be able to fully recover costs through price increases.

As with the production of methylene chloride, chloroform production is often integrated with chlorine production facilities. The plant shutdown decision, as discussed previously, will most probably be dependent on the decision to install effluent controls for the chlorine facility unless alternative raw material supplies are available. Also, air pollution and OSHA requirements may place additional burdens on chloroform producers which would influence the plant shutdown decision.

4. Balance of Payments

No effect is expected on balance of payments.

A. SUMMARY

Carbon tetrachloride is produced in the United States principally
as an intermediate used in the manufacture of fluorocarbon 11 and 12.
Current value of carbon tetrachloride production is about $60 million.
Less than 15% is consumed captively; however, a recent large capacity
methane chlorination plant introduced by DuPont may change this sub-
stantially.

Production of carbon tetrachloride is dominated by four major
organic chemical manufacturers who share 95% of the total market.

Growth of carbon tetrachloride consumption has averaged 7.3% over
the past ten years. Prices have been stable and low during this time
period. We estimate future growth at an average rate of 6% per year
over the next five years.

A summary of factors affecting price increases and plant shutdowns
is provided in Table XIII-1. Effluent treatment costs required to
meet both BPT and BAT guidelines are moderate and can probably be
passed through in the form of higher prices. A 2.8% increase in the 1973
price will be required to cover the cost of meeting the BPT regulations
and 3.7% will be the price increase required to comply with BAT guide-
lines. We do not anticipate any plant shutdowns, and no effect on the
U.S. balance of payments is foreseen as a result of the water treatment
guidelines.

TABLE XIII-1

CARBON TETRACHLORIDE FROM METHANE

All Processes:	
1972 Production (Million Pounds)	997
1972 Unit Value (¢/Lb)	6
1972 Production Value ($MM)	60
Number of Plants (Current)	11

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	0.6 – 2.8% 1.0 – 3.7%
Substitute Products	High Occurrence		Direct – Low Secondary – Low
Capacity Utilization	Low		1972 – high 1973 – low including all capacities
Captive Usage	Low		Low (about 15%)
Demand Growth	Low		6%/year
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		Unequal
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Conc. – 2 Producers hold 60%
Number of Producers	Many		6
Substitute Process	Many		1: from CS_2

TABLE XIII-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	2.3 – 9.9% 3.5 – 12.9%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	1.5 – 5.9% 1.9 – 7.7%
Integration	Low		Low
Chemical Complex	Isolated Plant		Isolated & Complex
Other Environmental Problems (Including OSHA)	Multiple		Air pollution and OSHA
Emotional Commitment	Indifference		None
Ownership	Multi-Industry Companies		Multi-Industry

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B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size

The market for carbon tetrachloride is the largest of all the chlorinated methanes. Prior to World War II, large quantities were consumed by the dry cleaning trade, but carbon tetrachloride steadily lost ground to perchloroethylene in this application. However, during and immediately after World War II, production of fluorocarbon gasses based on carbon tetrachloride began and today this is carbon tetrachloride's most important use. This change in chloride production from 100.8 million pounds in 1940 to over 1,049 million pounds in 1973 is shown in Table XIII-2. Production in 1977 is estimated to reach 1,350 million pounds. Apparent consumption is assumed to be domestic production plus imports.

b. Growth

U.S. production of carbon tetrachloride has grown at an average annual rate of 7.3% over the past decade and 6.8% over the past five years. However, market growth since 1970 has been much lower. Future growth is anticipated to continue at about 6% per year through 1977 but this depends on demand for fluorocarbons continuing to increase at about 6% per year.

c. Uses

Virtually all carbon tetrachloride is consumed as an intermediate in fluorocarbon production. About 80% of the total 1972 production was consumed in the domestic production of fluorocarbon 11 and 12 manufacture as shown in Table XIII-3. Although exact data on exports is not available, a large portion of the other end-use area is attributable to exports for foreign fluorocarbon 11 and 12 production.

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TABLE XIII-2

PRODUCTION, FOREIGN TRADE AND APPARENT CONSUMPTION OF CARBON TETRACHLORIDE
(million pounds)

Year	Production	Imports	Exports	Apparent Consumption
1963	519.2	2.5	Not Reported Separately	521.7
1964	535.9	7.9	Not Reported Separately	543.8
1965	593.6	10.0	Not Reported Separately	603.6
1966	648.0	10.7	Not Reported Separately	658.7
1967	713.6	5.0	Not Reported Separately	718.6
1968	763.4	4.2	Not Reported Separately	767.6
1969	882.7	0.2	Not Reported Separately	882.7
1970	1,011.2	0.1	Not Reported Separately	1,011.3
1971	1,009.2	NEG	Not Reported Separately	1,009.2
1972	996.7	11.8	Not Reported Separately	1,008.5
1973	1,049.0	7.5	Not Reported Separately	1,056.5

SOURCE: U.S. Department of Commerce.

TABLE XIII-3

CONSUMPTION OF CARBON TETRACHLORIDE BY END USE

End Use	% of Total — 1971
Fluorocarbon 11	28
Fluorocarbon 12	52
Other[1]	20
Total	100

1. Includes: exports and uses as solvents, grain fumigant, pesticide intermediate, gasoline additive, and fire extinguisher intermediate. Industries indicate that fastest growing use in other category is export to countries producing fluorocarbons. Although exports data are not available, it probably accounts for a large percentage of the other usage.

SOURCE: Chemical Economics Handbook.

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Other areas of importance include use as a spot dry cleaning solvent, grain fumigant, industrial degreasing solvent, and as a component in fire extinguishers for chemical, oil and electrical fires.

d. Substitute Products

There are few substitute products for carbon tetrachloride since it is a critical chemical intermediate in fluorocarbon synthesis. However, the fluorocarbon products do compete among themselves for certain end uses. All fluorocarbons of interest use some form of halogenated methane or light hydrocarbon as a starting material, so relative costs tend not to change. Therefore, selection of a fluorocarbon gas or liquid usually relies more on physical and chemical properties than price. The most common uses of the fluorocarbon gasses 11 and 12 are as a refrigerant, insulation in conjunction with urethane foam and as an aerosol propellant. There are few acceptable competitive materials for these end uses; e.g., methyl chloride and fluorocarbons, which have dominated these end uses and probably will continue to dominate the market. Propane and vinyl chloride monomer which have competed for the aerosol market pose significant consumer hazards. We estimate the demand for fluorocarbon 11 and 12 will increase at an average rate of 6% per year over the next five years.

e. Captive Requirements

Even though most carbon tetrachloride is consumed as a chemical intermediate, captive use has typically been less than 20%. Only in 1971 did captive requirements reach 20% and in 1972 fell precipitously to around 6% as shown in Table XII-4. However, DuPont plans a large expansion of its fluorocarbon capacity in Corpus Christi, Texas, and this will increase captive usage substantially. Few other producing companies appear integrated forward into fluorocarbon production.

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TABLE XIII-4

PRODUCTION, SALES AND CAPTIVE USE FOR
CARBON TETRACHLORIDE
(million pounds)

Year	Production	Sales	Captive Use[1]
1963	519.2	421.1	98.1
1964	535.9	464.5	71.4
1965	593.6	509.4	84.2
1966	648.0	615.4	32.6
1967	713.6	605.6	108.0
1968	763.4	647.8	115.6
1969	882.7	785.9	96.8
1970	1,011.2	841.2	170.0
1971	1,009.2	797.0	212.2
1972	996.7	930.2	66.5
1973	1,047.3	989.4	57.9

1. Includes stock changes

SOURCE: U.S. Department of Commerce

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f. Other Market Requirements

The margin on carbon tetrachloride is quite narrow and
pricing is largely on a negotiated basis. Since most nonpharmaceutical
applications require the same quality materials, and since the users
are a few large fluorocarbon producers, competition is strictly on a
price and product availability basis.

g. Foreign Competition

Imports have ranged between near negligible levels to about
10 million pounds. Imports and exports have not been a major factor
in this industry. However, the export activity which does exist,
largely depends on foreign fluorocarbon production and probably
accounts for a substantial amount of the "other" end-use category.

2. Supply Characteristics

a. Manufacturing Routes

There are two major manufacturing routes used today with
chlorination of carbon disulfide being the oldest and currently least
attractive and chlorination of hydrocarbons being the newest and most
attractive.

(1) Chlorination of Carbon Disulfide

The principal advantages of this process are that it
forms no byproducts or coproducts, other than reusable sulfur, and
the separation and purification of the carbon tetrachloride is easier.
However, the plants for this conversion are complex and the lead lined
reactors are expensive.

(2) Chlorination of Hydrocarbons

Reaction of chlorine gas and methane produces carbon tetrachloride as one of four possible products. The percent composition of carbon tetrachloride can be varied by changing reaction conditions and when optimized for carbon tetrachloride production, perchloroethylene is the principal coproduct.

When ethylene is substituted for methane in this process, perchloroethylene becomes the main product and carbon tetrachloride becomes one of a group of coproducts, including hexachlorobutadiene, hexachloroethane and hexachlorobenzene.

b. Producers

Currently, six producers have a capacity of 1,578 million pounds as shown in Table XIII-5, however, this capacity must be considered flexible. Only the CS_2 route is limited to carbon tetrachloride production. Four major producers dominate the market, sharing 95% of the market between them. Of these, DuPont and Stauffer Chemical are the largest and share nearly 60% of the total market.

c. Manufacturing Costs

Costs for the production of the chlorinated methane products are in the section covering methyl chloride from methane. Carbon tetrachloride costs are also in the section on methyl chloride and are estimated based on the allocation of manufacturing costs among the various products' production by methane chlorination.

TABLE XIII-5

CARBON TETRACHLORIDE

Producer	Location	Annual Capacity (MM Lbs)	Raw Material
Allied Chemical	Moundsville, West Virginia	8	Methane-Cl_2
Dow Chemical	Freeport, Texas	130	Methane-Cl_2
	Pittsburg, California	45	Co-Product
	Plaquemine, Louisiana	100	Co-Product
Stauffer	Louisville, Kentucky	70	Methane-Cl_2 & Co-Product
Vulcan	Geismar, Louisiana	35	Methane-Cl_2 & Co-Product
	Wichita, Kansas	40	Methane-Cl_2 & Co-Product
FMC — Allied	South Charleston, West Virginia	300	CS_2 and Methane-Cl_2
Du Pont	Corpus Christi, Texas	500	Methane-Cl_2 Co-Product with Perchloroethylene
Stauffer	Lemoyne, Alabama	200	CS_2
	Niagara Falls, New York	150	CS_2
	Total	1,578	
	Capacity base on hydrocarbon Chlorination	1,148	
	Percent of Total	73%	

SOURCES: Chemical Profile, January 1, 1973; Directory of Chemical Producers, 1974 Edition.

3. Prices

Prices historically have been stable but low for carbon tetrachloride. Most carbon tetrachloride is sold in large quantities to large fluorocarbon producers in long-term contracts. The prices are negotiated and are discounted from list as shown in Table XIII-6. Actual prices probably increased in 1974 due to the rising cost of raw materials. Prices will in all probability remain higher but manufacturing profit margins will probably not significantly change over the next five years.

4. Supply/Demand Balance

Capacity utilization during the early to mid-1960's has been normal for chlorination hydrocarbons but became tight during the late 1960's as shown in Table XIII-7. DuPont's Corpus Christi facility lowered capacity utilization to less than 70%. However, DuPont plans to utilize this capacity in several stages, thus helping to ease dislocations in the marketplace.

In spite of the large capacity excess, chlorine and availability may restrict supply which, coupled with an increase in demand for fluorocarbons, may make supplies relatively tight for the next one or two years.

C. ECONOMIC IMPACT

1. Treatment Costs

The treatment costs for the production of carbon tetrachloride are assumed to be identical to the costs provided for the other chloromethane products. The costs for BPT range from .17¢ per pound in a free standing complex to .04¢ per pound in a 10 million gallons per day effluent treatment complex. BAT costs range from .22¢ per pound to .06¢

TABLE XIII-6

ACTUAL VS. LIST PRICE — CARBON TETRACHLORIDE

Year	Sales Quantity (MM Lb)	Sales Value ($MM)	Unit Value (¢/lb)	List Price (¢/lb)
1963	421.1	32.3	8.0	10.75
1964	464.5	33.7	7.0	10.75
1965	509.4	37.5	7.0	10.75
1966	615.4	42.2	7.0	10.75
1967	605.6	37.3	6.0	10.75
1968	647.8	37.0	5.7	10.75
1969	785.9	42.7	5.4	11.25
1970	841.2	44.1	5.2	11.25
1971	797.0	43.7	5.5	11.25
1972	930.2	54.8	5.9	11.25
1973	989.4	59.5	6.0	11.125
1974	N.A.	N.A.	N.A.	12.00

SOURCE: U.S. Department of Commerce

TABLE XIII-7

INDUSTRY OPERATING CAPACITY
(million pounds)

Year	Capacity[1]	Production	% Capacity
1963	—	519.2	—
1964	—	535.9	—
1965	—	593.6	—
1966	—	648.0	—
1967	—	713.6	—
1968	—	763.4	—
1969	918	882.7	96
1970	1,078	1,011.2	94
1971	1,078	1,009.2	94
1972	1,078	996.7	92
1973	1,578	1,049.0	66

1. Capacities are flexibl since some processes
   produce more than one product.

SOURCES: Chemical Economics Handbook,
U.S. Department of Commerce.

per pound for a free standing complex and a large complex (10 million gallons per day effluent) respectively.

Investment required ranges an estimated 1.5% to 5.9% of existing fixed investment to achieve BPT. It ranges between 1.9% and 7.7% to achieve BAT guidelines depending on whether the plant is in free standing condition or in a large effluent treatment complex.

2. Price Impact

Before tax BAT treatment costs represent only 3.7% of the 1973 selling price for a free standing plant and 1.0% for a plant in a large chemical complex. We forecast price pass through based on the costs of a free standing producer. Although capacity utilization is low, demand growth is low, and the basis for competition is price, these factors are outweighed by the fact that there are no real substitution products, market share is heavily concentrated between two producers and foreign competition is low. The capacity utilization figure may be deceptive because of the flexibility producers have in shifting production to other products which are more profitable, although this flexibility is limited by the demand for other chloromethane products. Also, a new plant by DuPont did not begin production until mid-1973 so that the industry capacity and capacity utilization are overstated. Free standing plants may be unable to fully recover treatment costs because of the unequal abatement costs relative to plants located in large chemical complexes although we believe this unlikely since the before tax treatment costs represent such a small percentage of the selling price it mitigates the apparent differential in abatement costs.

3. Plant Shutdown Impact

As indicated previously, the plant shutdown decision is inter-related with the water treatment cost impact on the other chloromethane coproducts. Since producers of methylene chloride, chloroform and carbon

tetrachloride by thermal chlorination can pass on treatment costs as small price increases, it is not expected that carbon tetrachloride producers will shut down. Also, the level of after tax treatment costs relative to profitability indicate that cost increases could, if necessary, be absorbed to some degree by the industry. This favorably affects producers with free standing plants which would be faced with higher treatment costs relative to producers with plants in large chemical complexes, and therefore, may not be able to fully recover through price increases. In addition, the positive cash flow and the relatively low level of treatment costs in relation to the fixed investment, support the conclusions that there will be no plant shutdowns.

On the other hand, if the chloromethane plant producing carbon tetrachloride is integrated with a marginal chlorine production facility, the decision to shut down the plant may well be dependent on the decision to install facilities for control of the effluent from the chlorine facility. Also, as previously indicated, the shutdown decision may be affected by any pollution and OSHA requirements which are beyond the scope of this study.

4. Balance of Payments

No impact on the balance of payments is foreseen.

XIV. CALCIUM STEARATE BY NEUTRALIZATION
AND PRECIPITATION

A. SUMMARY

In 1972, production of calcium stearate was 42.8 million pounds, a figure which capped a period of average annual growth of 15% per year. Calcium stearate finds a variety of uses, but the single largest use (50% of total consumption) is as a stabilizer and internal lubricant in plastic compounding, particularly for PVC. Other major uses include paper coating, general surface coatings, and numerous other applications.

Calcium stearate is produced by two processes - precipitation and fusion. Precipitation is used to produce a dry, pure powder final product which is used in plastics and other applications. Fusion manufacture is less expensive and yields a 50% water dispersion of calcium stearate of lower quality. Dispersion product is mostly used in paper applications. There are currently eleven producers operating fourteen plants.

Supply of calcium stearate is currently tight, but not restricted. Capacity utilization is presently estimated in excess of 90%, but new capacity is expected to be brought on line within a year or two. Prices at mid-1974 were at historical highs due to raw material price increases and the present tight supply situation.

The costs to achieve BPT and BAT guideline specifications in a free standing plant are 1.4¢ and 1.9¢ per pound respectively. The lack of substitute products and the extreme price inelasticity will favor complete treatment cost pass-through. No adverse impact is expected in this industry and we expect no impact on the U.S. balance of trade.

The impact matrix summarizing the economic factors is given in Table XIV-1.

TABLE XIV-1

PRECIPITATED CALCIUM STEARATE

All Processes:

1972 Production (Million Pounds)	38
1973 Unit Value (¢/Lb)	48
1972 Production Value ($MM)	13
Number of Plants (Current)	13

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	1.8 – 3.8% 3.2 – 5.1%
Substitute Products	High Occurrence		Low
Capacity Utilization	Low		High
Captive Usage	Low		Low – 8%
Demand Growth	Low		8%/yr
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price & Service
Market Share Distribution	Fragmented		Fragmented
Number of Producers	Many		11
Substitute Process	Many		None for precipitated. Also process for fused product – lower grade.

TABLE XIV-1 (Continued)

PLANT SHUTDOWN DECISION				
Factor	Condition for Shutdown	Treatment Level		
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	16.7% 22.3%	
Cash Flow (Including Treatment Costs)	Negative		Positive	
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	116% 158%	
Integration	Low		Low	
Chemical Complex	Isolated Plant		Isolated Plant	
Other Environmental Problems (Including OSHA)	Multiple		Few	
Emotional Commitment	Indifference		Moderate	
Ownership	Multi-Industry Companies		Multi-Industry	

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size and Growth

In 1972, production of calcium stearate was 42.8 million pounds. This amount was a record high for the industry and marked a strong comeback from the period 1967-1970, when production and apparent consumption remained nearly level. Table XIV-2 summarizes recent production history for calcium stearate and shows that from a small base of only 10.8 million pounds in 1963, calcium stearate consumption grew at an average annual rate of 15% per year. The rapid growth rate can be largely attributed to calcium stearate's increasing usage in plastics, particularly PVC. From approximately 35% of total consumption in 1963, use in plastics had increased to about 50% of total consumption by 1972. Exports and imports of calcium stearate are probably negligible and are not reported separately from other stearates in U.S. Tariff Commission data.

b. Uses

The primary end use for calcium stearate is in plastics. Table XIV-3 gives a breakdown of end uses. In plastics applications, stearate is used as an internal lubricant to improve the processing

TABLE XIV-2

PRODUCTION, FOREIGN TRADE, AND APPARENT CONSUMPTION
FOR CALCIUM STEARATE
(million pounds)

Year	Production	Exports[1]	Imports[1]	Apparent Consumption
1963	10.8	—	—	10.8
1964	11.0	—	—	11.0
1965	12.7	—	—	12.7
1966	19.0	—	—	19.0
1967	20.8	—	—	20.8
1968	16.4	—	—	16.4
1969	26.9	—	—	26.9
1970	23.3	—	—	23.3
1971	26.9	—	—	26.9
1972	37.8	—	—	37.8
1973	42.8	—	—	42.8

Note: 1. Exports/Imports not reported separately, believed negligible.

SOURCE: U.S. Tariff Commission

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TABLE XIV-3

CALCIUM STEARATE END USE PATTERN

	% of Total Consumption
Plastics	50
Paper	22
Food, Drug, & Cosmetics	8
Paint & Varnish	4
Other	16

SOURCE: Contractor's Estimates

characteristics of the plastic resin, particularly in extrusion and in-
jection molding operations. Calcium stearate also serves as a mold re-
lease agent and as a stabilizer in plastics and rubber processing. PVC
is the major resin in which calcium stearate is used, and it has enjoyed
significant growth in the 1970's in pipes and other rigid extrusions.
The most potentially severe obstacle to continued growth in this application
is the future growth in demand and availability for PVC resin.
We estimate tight supply of PVC resins due to OSHA requirements over
the next two years and long-term growth at 5-6% per year. Calcium
stearate in plastics is forecast to grow at 7% per year.

Another major use is in the manufacture of coated paper and
paperboard. Here, calcium stearate is used to promote smooth, uniform
coatings and to reduce friction in blade coating operations. Forecast
growth in this application is at 5% per year. Other major uses are in
food, drug and cosmetics applications, where calcium stearate is commonly
used as a moisture barrier coating and in pharmaceutical pill and tablet
manufacture as a mold release agent. Calcium stearate also finds numerous
other uses in coatings, greases, metal lubrication, and in other areas.
All other uses are forecast to grow at 5% per year to provide an
overall growth in demand at 6% per year over the next five years.

c. Substitute Products

Calcium stearate generally is not prone to substitution by
other products. What potential threat of substitution it does encounter
comes mostly from other stearates, especially zinc stearate. The primary
reason for few substitute products lies in the fact that calcium stearate
frequently plays a dual role in its use - that of a stabilizer as well
as an internal lubricant. These properties are especially important in
plastics, where calcium stearate performs not only as a lubricant, but
also as an anti-degradation agent for the polymer system. This dual role
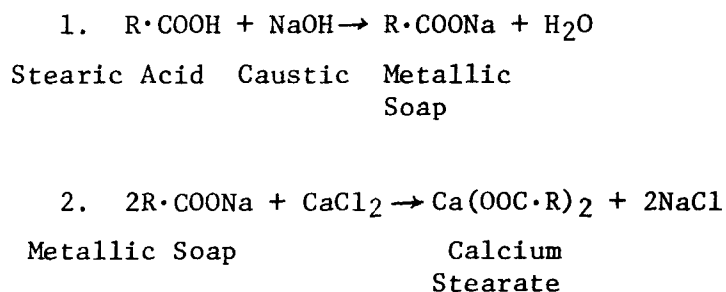is not easily duplicated by any single substitute product.

Table XIV-4 summarizes production, sales and captive requirement data. No specific data is available regarding annual changes in stock levels, so that the last column in Table XIV-4 is actually a mixture of captive consumption and stock changes. Stock changes, however, are probably insignificant from year to year. In any case, captive consumption has not accounted for more than 8.2% of total industry production. Industry contacts confirmed that captive consumption is quite low.

2. Supply Characteristics

a. Manufacturing Routes

Production of calcium stearate is carried out by two basic processes, depending on the final product form desired. The precipitation process produces a fine, pure powder form of calcium stearate which is easily dried for recovery. This process utilizes a two-step reaction sequence to produce first, a metallic soap, then the desired stearate salt, as shown:

1. $R \cdot COOH + NaOH \rightarrow R \cdot COONa + H_2O$

     Stearic Acid Caustic Metallic
                           Soap

2. $2R \cdot COONa + CaCl_2 \rightarrow Ca(OOC \cdot R)_2 + 2NaCl$

     Metallic Soap   Calcium
                                Stearate

The product from this process is very pure and is typically used in dry applications such as plastics.

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TABLE XIV-4

PRODUCTION, SALES, AND CAPTIVE USE OF CALCIUM STEARATE
(million pounds)

Year	Production	Sales	Inventory Change and Captive Consumption
1963	10.8	10.7	.15
1964	11.0	10.4	.62
1965	12.7	12.3	.35
1966	19.0	19.3	(.95)
1967	20.8	19.4	1.40
1968	16.4	15.1	1.30
1969	26.9	24.7	2.20
1970	23.3	23.0	.34
1971	26.9	24.9	1.90
1972	37.8	38.0	(.23)
1973	42.8	43.0	(.03)

SOURCE: U.S. Tariff Commission

The alternate production method is the fusion process which gives a product that is less pure and slightly off-color, relative to the precipitation process product, unless extremely high purity raw materials are utilized. The process proceeds according to the following reaction:

$$2R \cdot COOH + Ca(OH)_2 \rightarrow Ca(OOC \cdot R)_2 + 2H_2O$$

Stearic   Calcium
Acid   Stearate
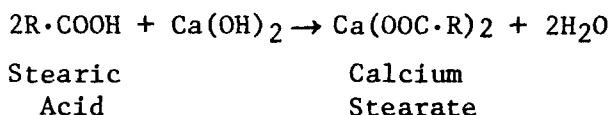
Industry sources indicate that, while product purity is lower, this process is less expensive than precipitation and is used to produce a 50% water dispersion form of calcium stearate which is sold into paper and coating applications. Most producers, but not all, have both processes and offer calcium stearate both in the powder and dispersion form.

b. Producers

Table XIV-5 summarizes calcium stearate production and their plant locations. Individual plant capacities are not available, although given the total size of the market, a typical plant is probably not very large - averaging on the order of 3-4 million pounds per year. Most calcium stearate manufacturers also manufacture other metallic stearates in the same equipment.

Manufacturers are generally not integrated either forward or backward to any significant degree. Most producers buy stearic acid from separate fatty acid producers. The only end-use areas in which calcium stearate producers do not participate are smaller, less important applications such as resins and coatings.

TABLE XIV-5

CALCIUM STEARATE PRODUCERS AND PLANT LOCATIONS

Producer	Location	Annual Capacity (MM lbs)
American Cyanamid Co.	Woodbridge, New Jersey	N.A.
Dart Industries	Cleveland, Ohio	N.A.
Diamond Shamrock	Cedartown, Georgia	N.A.
Diamond Shamrock	Richmond, California	N.A.
Ferro Corp.	Baton Rouge, Louisiana	N.A.
Mallinckrodt Chem.	St. Louis, Missouri	N.A.
The Norac Co., Inc.	Lodi, New Jersey	N.A.
Original Bradford Soap Works	West Warwick, Rhode Island	N.A.
Tenneco, Inc.	Piscataway, New Jersey	N.A.
Joseph Turner & Co.	Ridgefield, New Jersey	N.A.
Smith Chem. & Color Co., Inc.	Jamaica, New York	N.A.
Witco Chemical Clearing, Inc.	Los Angeles, California	N.A.
Witco Chemical Clearing, Inc.	Perth Amboy, New Jersey	N.A.

SOURCE: Directory of Chemical Producers, 1974 Edition

c. Raw Materials

The most important raw material for calcium stearate pro-
duction is stearic acid. Both precipitation and fusion producers must
buy this fatty acid from outside sources. Industry contacts report
that supplies of stearic acid went through a period of rapidly escalating
prices and tight supply in early 1974, but that the situation stabilized
by mid-1974. Supplies in mid-1974 were tight but available, and prices
leveled at about double what they were a year previous. Other raw
materials for calcium stearate production were readily available.

d. Manufacturing Economics

Manufacturing economics for the production of calcium stearate
are presented in Table XIV-6, based on neutralization and precipitation of
stearic acid. Published prices for stearic acid were used in determining
raw material costs, which biases the production economics unfavorably
for the integrated producers. The capital investment in a plant with
27 million pounds per year capacity is estimated at $1.4 million.

3. Prices

Table XIV-7 summarizes recent price history for calcium stearate.
During the period, list prices were relatively stable but realized
prices have varied significantly. As in many other industries, the
realized price variability largely reflects supply/demand situations
prevailing at any one time. Calcium stearate prices show a leveling
and actual decline during the period 1965-1970 which corresponds to the
period when sales growth was slowed somewhat from earlier levels. In-
dustry sources report that prices in the 1970's have continued to advance.
Due to increased stearic acid costs and the current tight supply situation,
actual average prices in mid-1974 were probably over 60¢ per pound.

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TABLE XIV-6

ESTIMATED MANUFACTURING COSTS FOR
PRECIPITATED CALCIUM STEARATE

Production Economics (Summer, 1973)

Product Calcium Stearate (By analogy to aluminum sulfate)

Process Lime phos. stearic acid

Capacity 2 MM lb/yr Invest. $275,000[1] (1970 construction)

	Costs ¢/lb Product
Stearic Acid 0.98 lb @ 19¢	18.6
Caustic Soda .14 lb @ 2.5¢	0.35
Calcium Chloride 0.20 lb @ 2.4¢	0.48
Catalyst, Chem. & Supplies	0.01
Utilities	0.25
Direct Labor 6 men @ $5.00/hr	3.12
Maintenance	1.25
Labor & Plant Overhead	3.12
Depreciation 9%/yr	1.24
Taxes & Ins. 1-1/2%/yr	0.21
Factory Cost	28.63

1. Investment in a plant with 27 million pounds per year capacity is estimated at $1.4 million.

TABLE XIV-7

ACTUAL VS. LIST PRICE HISTORY FOR CALCIUM STEARATE

Year	Sales (MM lbs)	List Price (¢/lb)	Actual Price (¢/lb)
1963	10.7	39.0	28
1964	10.4	39.0	28
1965	12.3	39.0	34
1966	19.3	39.0	27
1967	19.4	39.0	26
1968	15.1	39.0	31
1969	24.7	39.0	32
1970	23.0	42.0	35
1971	24.3	45.0	37
1972	38.0	45.0	33
1973	42.8	48.0	37
1974 June		57.0 - 61.0	N.A.

SOURCES: U.S. Tariff Commission, Chemical Marketing Reporter

4. Supply/Demand Balance

Due to the lack of industry capacity data, it is not possible to ascertain capacity utilization to any detail. Industry contacts report that capacity utilization for the industry has been high and increasing in the past two years. One source estimated current capacity utilization in excess of 90%. Several capacity expansion projects are currently underway and the present tight supply situation for calcium stearate is expected to ease somewhat as new facilities become operative over the next several years. In the relatively near term the industry may experience another cycle of excess capacity with reduced producers profit margins. This overcapacity situation, we believe, will result primarily from a slowdown in the rate of growth of demand resulting from a slowdown in the demand for polyvinyl chloride resins which utilize calcium stearate.

C. ECONOMIC IMPACT

1. Treatment Costs

The costs required to achieve BPT and BAT guideline specifications as presented in the guideline document for a free standing plant with an 80,000 pounds per day production capacity is 1.4 and 1.9¢ per pound respectively. Substantially lower costs (0.8 and 1.2¢ per pound) are possible for those plants which are part of a complex with waste effluent volumes of 3 million gallons per day. We estimate that most producers in this industry produce calcium stearate in a free standing plant with effluent volumes less than 3 million gallons per day.

The guideline document specifies a plant providing 80,000 pounds per day or 27 million pounds per year, operating 345 days per year. As this is such a large proportion of total annual U.S. production, we

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assume that the plant described is a multi-purpose facility producing a number of relative products, but that the costs described for treatment are applicable for the plant when producing calcium stearate.

2. Price Impact

Actual price behavior for calcium stearate has been erratic since 1963. Although actual processes have typically been less than list, discounts have varied depending on supply and costs of raw materials. Historically, prices have shown a pattern of passing through higher raw material costs. List prices in mid-1974 were 57-61¢ per pound or 14¢ per pound higher than 1972. As costs have risen, prices have similarly risen to cover increased costs. This is probably principally due to the relatively low price sensitivity shown by users of calcium stearate. Its principal use is as a lubricant and stabilizer and as such is used in very small quantities. Therefore, relatively large price increases in calcium stearate do not substantially affect the total manufacturing cost for those products which require calcium stearate. This condition should continue in the future.

Other factors which will contribute to full treatment cost pass through are the low occurrence of subsitute products, the high capacity utilization and the moderate to high projected demand growth as indicated in the matrix. We expect that these factors will continue to act in favor of a pass through of effluent treatment costs as higher prices for calcium stearate and that prices will increase by about 3% of 1973 prices to meet BPT guidelines and 4% to meet BAT guidelines.

3. Plant Shutdown Decision

Since, as we expect, there will be no significant impact on net income, we do not forecast any plant shutdowns by virtue of reduced income. The major problem facing these producers is the high capital investment

required to install treatment facilities. This is somewhat misleading, however, since the treatment system is probably appropriate for treating wastes from the manufacture of other stearates as well. Capital investment for a free standing plant treatment facility is $1,620,000 to meet BPT guidelines and $2,490,000 to meet BAT specifications. These costs are 116% and 158% of present net fixed investment for typical free standing plants. Since current import duties are only 0.7¢ per pound and 5% ad valorem, import duties are less than projected treatment costs for free standing plants. It would, therefore, appear within reason for calcium stearate producers to relocate overseas and ship the finished product back into the United States. Normally, since most producers are not highly integrated, there would be little commitment to remaining a domestic producer. However, the major supply of stearic acid appears to be the United States and producers might have to buy domestic stearic acid for export then import the finished product. The double shipping costs might well push the total costs significantly above the projected treatment costs.

4. Foreign Competition

Imports of calcium stearate have been negligible. Unless domestic producers relocate overseas, imports will continue as a minor force in this industry. However, the high price increases anticipated for calcium stearate versus the low import duties will make imports of calcium stearate more important. However, the relatively low consumption per customer and the need for regular, small quantity shipments of known quality materials will favor domestic producers rather than imports. We expect little impact on the U.S. balance of trade due to the requirements of meeting the proposed effluent guidelines.

XV. HYDRAZINE BY PARTIAL OXIDATION OF AMMONIA

A. SUMMARY

Limited data on hydrazine are available in published literature.
As a result, most information was obtained by industry contacts,
although because of the proprietary nature of much of the information
requested, limited data were available. In 1973, consumption of
hydrazine (N_2H_4) was estimated to be 9-10 million pounds. Major uses
are for rocket fuel, pesticides production, as a plastics blowing
agent, pharmaceutical manufacture, and as an oxygen scavenger in
utility boilers. Hydrazine is currently being substituted by monomethyl
hydrazine as a rocket fuel.

Hydrazine is produced by the reaction of sodium hydroxide, chlorine,
and ammonia. There are three domestic producers as well as additional
producers in Japan and Europe. Capacity utilization is currently high
and hydrazine is in tight supply. Captive consumption is significant,
primarily for pesticide and pharmaceutical production, and as a plastics
blowing agent.

The costs referred to achieve BPT and BAT guideline specifications as
presented in the guideline document for a free standing plant are 9.5¢
and 11.2¢ per pound respectively. Although these appear relatively large,
the high captive consumption and the tight supply and demand balance will
permit full treatment cost pass through with no adverse effect on the
industry or U.S. balance of trade.

The impact matrix relative to hydrazine is provided in Table XV-1.

TABLE XV-1

HYDRAZINE BY PARTIAL OXIDATION OF AMMONIA

All Processes:		
1972 Production (Million Pounds)	10	
1973 Unit Value (¢/Lb)	150	
1972 Production Value ($MM)	10	
Number of Plants (Current)	3	

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	6.3% 7.5%
Substitute Products	High Occurrence		Direct — High (Rocket Fuel) Secondary — Moderate (Agchem)
Capacity Utilization	Low		High
Captive Usage	Low		Moderate
Demand Growth	Low		8%
Foreign Competition	High		Low
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price and Technology
Market Share Distribution	Fragmented		Concentrated
Number of Producers	Many		3
Substitute Process	Many		None

TABLE XV-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	27.9% 56.2%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	18.5% 19.1%
Integration	Low		High
Chemical Complex	Isolated Plant		Isolated Plant
Other Environmental Problems (Including OSHA)	Multiple		Few
Emotional Commitment	Indifference		High
Ownership	Multi-Industry Companies		Multi-Industry companies

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size and Growth

Consumption of hydrazine is not available in the published
literature, however, we estimate 1973 consumption of hydrazine (N_2H_4)
at 9-10 million pounds, which is primarily accounted for by domestic
production. Growth in consumption has probably been at less than 10%
per year and we forecast future demand to increase at 8% per year over
the next five years due to increasing uses in agricultural chemicals
and as blowing agents.

b. Uses

Our estimate of the demand for hydrazine by end use is
given in Table XV-2. Hydrazine as a propellant finds its principal appli-
cation as rocket fuel. The literature suggests, however, that the
material finds other marketing applications where breakdown of the
molecule provides gases to power other mechanisms providing underwater
propulsion, underwater buoyancy and pressuring of rocket fuels. Growth
in demand is extremely hard to predict because of the confidential or
secret nature of applications of this type. We estimate use in these
applications to increase at 5% per year although this may be extremely
conservative.

We believe the second largest use for hydrazine is in the
production of agricultural chemicals, chiefly maleic hydrazide, where
hydrazine-derived products find application as plant growth regulators.
It is reportedly used to prevent spreading of harvested root crops,
to delay blossoming of fruit trees, prevent the growth of suckers on
tobacco plants and control the growth of plants. Another hydrazine

TABLE XV-2

**ESTIMATED END USE BREAKDOWN FOR
HYDRAZINE 1973**

Propellants	50%
Agricultural Chemicals	25
Blowing Agents	15
Other	10
	100%

Source: Kirk Othmer Encyclopedia of Chemical
Technology and Contractor Estimates.

derivative is used as a defoliant for cotton to facilitate harvesting.
We estimate demand growth as agricultural chemicals at 12% per year.

Hydrazine finds use in the manufacture of blowing
agents used to produce foamed plastics. These compounds decompose under
processing conditions to generate the cellular structure desired in the
production of some types of polymeric foams. We estimate demand growth
in this area at 9% per year over the next five years.

Other uses for hydrazine or its derivatives include applica-
tion in the preparation of medicinals, the production of spandex fibers,
and for boiler water treatment. We have forecast these and other end
uses to increase at 10% per year over the next five years.

Two producers are planning significant expansions of
capacity. Information on their plans for hydrazine applications are
proprietary. We suspect that they foresee demand developing in military
applications or agricultural chemicals at a more rapid rate than we have
forecast. Our forecast, therefore, should be considered conservative
in view of these plans and our inability to obtain more definitive
information from the producers.

c. Substitute Products

Information on the substitution of hydrazine as a rocket
fuel is generally classified; however, monomethyl hydrazine is currently
being used to replace hydrazine. Monomethyl hydrazine can be produced
with the same production equipment utilized to produce hydrazine.
Substitutes for hydrazine in agricultural chemicals are not available.
In general terms, we expect that hydrazine demand is relatively inelastic
in its commercial applications as well as its uses for military and space
applications. The product makes possible the production of unique or
almost unique end products in its major applications. In many of these
applications, hydrazine is a modest component of the cost of the final
product of use.

d. Captive Requirements

A significant portion, perhaps one-third, of hydrazine production is consumed captively. All three producers engage in the production of agricultural chemicals and other derivatives of hydrazine. In fact, Uniroyal's production is 100% captive consumption.

2. Supply Characteristics

a. Manufacturing Routes

Hydrazine is manufactured only by the Raschig process. Sodium hydroxide and chlorine are mixed in a reactor system to produce sodium hypochloride. Aqueous ammonia is added to produce chloramine, which when reacted with anhydrous ammonia, produces hydrazine hydrate. After ammonia removal, evaporation and fractionation, a commercial grade of hydrazine hydrate is formed. Anhydrous hydrazine is produced by extractive distillation of hydrazine hydrate.

b. Producers

There are currently three producers of hydrazine of which Olin is the largest. Table XV -3 summarizes producers and plant locations. Hydrazine is currently in tight supply. Olin has plans for expansion of their operations and, also, Mobay has announced plans for a major new plant with 22 million pounds of maximum capacity.

All three producers are integrated into the production of hydrazine-based products.

c. Manufacturing Economics

Estimated manufacturing economics for hydrazine are given in Table XV-4.

TABLE XV-3

HYDRAZINE PRODUCERS AND LOCATIONS

Producer	Location
Fairmount Chemical Co., Inc.	Newark, New Jersey
Olin Corporation Agricultural Chemical Division	Lake Charles, Louisiana
Uniroyal, Inc. Uniroyal Chemical Division	Geismar, Louisiana

SOURCE: Chemical Marketing Reporter

TABLE XV-4

MANUFACTURING COST ESTIMATE FOR HYDRAZINE

Production Economics (Summer 1973)

Product Hydrazine (as anhydrous)

Process Partial Oxidation of NH_3 (Raschig)

Location Gulf Coast Capacity 2.0 MM lb/yr. Invest. $3.4 MM[1] (1970 construction)

	Cost	
	$/Year	¢/lb Product
Ammonia 2.41 lb @ 2.0¢/lb.	96,400	4.82
Chlorine 5.04 lb @ 3.8¢/lb	383,000	19.15
Caustic Soda 6.22 lb @ 3.8¢/lb	472,800	23.64
Inhibitor 0.31 lb @ 20¢/lb	124,000	6.20
Catalyst, Chem., Supplies	30,000	1.50
Utilities	278,000	13.90
Direct Labor 16 men @ $5.00/hr	166,400	8.32
Maintenance, Labor & Materials	250,000	12.50
Labor & Plant Overhead	166,400	8.32
Depreciation 9%/yr	306,000	15.30
Taxes & Ins. 1-1/2%/yr	51,000	2.55
Factory Cost	2,324,000	116.20

1. Utilizing .65 factor results in capital cost of $3.3 million for a plant of 5,500 pounds per day capacity.

C. ECONOMIC IMPACT

1. Treatment Costs

The costs required to achieve BPT and BAT guideline specifications as presented in the guideline document for a free standing plant with a 5,500 pound per day production capacity are 9.5¢ and 11.2¢ per pound respectively. All hydrazine is produced in essentially free standing plants and all use the Raschig manufacturing process.

2. Price Impact

Prices (list) since 1972 have doubled reflecting a tight supply and demand balance for hydrazine and general price increases for the ammonia and chlorine raw materials. Mid-1973 price is estimated to have been $1.50 per pound.

The matrix data suggest that a full cost pass through would be possible in this industry. Much of the hydrazine produced is used captively in the production of relatively high value-added products. Its major use is as a propellant purchased by the U.S. Government. In this application propellant cost is not only a small part of total costs of the devices but also is sold to relatively price insensitive applications concerned with national security. The prices of these products would be affected little on a percentage basis by full pass through of treatment costs. Therefore, the consumers of these hydrazine derived products, including agricultural chemicals, would not likely reduce their consumption if the treatment costs were added to this product cost as long as alternate sources and substitute products are not readily available.

The tight supply and demand balance also supports a full cost pass through. There are currently only three producers manufacturing hydrazine and a significant portion is consumed captively. It is not likely that new entrants or plant expansions competing for the now-captive market would drive supply very far ahead of demand. The large capital outlay required for production of hydrazine and its derivative products also acts to keep supply and demand in balance. We do not expect significant overcapacity in this industry in the near future and the resulting snug supply and demand balance will support full treatment cost pass through. Therefore, we expect that prices for hydrazine will decline but remain high enough to recover added BAT treatment costs as additional capacity comes on stream during the next five years.

3. Plant Shutdown Decisions

It is not likely that in the face of tight hydrazine supplies and projected full treatment cost recovery that any plants would be shut down. The only negative feature for hydrazine producers is the capital investment; BPT and BAT treatment facilities for a free standing plant would require a $610,000 and $818,000 capital investment respectively. The BAT investment represents 24.8% of the current 3.3 million investment in net plant and equipment. However, this should not be a deterrent since much of the hydrazine is used captively requiring this investment to support the production of products derived from hydrazine.

4. Foreign Trade

Data on imports or exports of hydrazine are not available from the published sources of the U.S. Bureau of Census. However, even though the import duty of 5% ad valorem is less than the treatment costs, shipping and storage of hydrazine should favor domestic production rather than importing. Hydrazine used as rocket fuel will continue to be produced domestically. Therefore, we expect no effect on the U.S. balance of trade in this industry.

XVI. MALEIC ANHYDRIDE BY OXIDATION OF BENZENE

A. SUMMARY

In 1973, production of maleic anhydride was 279 million pounds, having risen at an average annual rate of 12% per year since 1963. Major uses are in unsaturated polyester resins (44% of production), fumaric acid production (13%), agricultural chemicals (10%) and numerous other uses. Maleic anhydride is subject to competition in the production of unsaturated polyester resins through substitution by fumaric acid, and a major basis for competition is price.

Maleic anhydride is produced in the United States by the oxidation of benzene. There are seven domestic producers and numerous producers outside the United States in Japan and Western Europe. Capacity utilization has been moderate, although in the 1969-1971 period, maleic anhydride was in tight supply as a result of poor yield from catalysts used. Captive consumption is significant, having been as high as 30% of production in recent years, and all but one manufacturer are integrated into the production of maleic anhydride derivatives.

A summary of factors used for the economic impact analysis is given in Table XVI-1. In our judgment effluent treatment costs required to meet BPT guidelines will be passed through in the form of increased prices. This will amount to approximately 11% of the 1973 price. No incremental capital or operating costs will be needed to meet BAT standards. While the imposition of effluent guidelines will undoubtedly make foreign producers more competitive, it is difficult to quantify the direct effect of the guidelines on the U.S. balance of payments position.

TABLE XVI-1

MALEIC ANHYDRIDE BY OXIDATION OF BENZENE

All Processes:	274
1972 Production (Million Pounds)	13 (1973 at 15¢)
1972 Unit Value (¢/Lb)	36
1972 Production Value ($MM)	8
Number of Plants (Current)	

PRICE INCREASE CONSTRAINTS			
Factor	Condition for Constraint	Treatment Level	
Ratio of BT Treatment Cost to Selling Price (%)	High	B.P.T. B.A.T.	10.7% 10.7%
Substitute Products	High Occurrence		Direct — Low Secondary — Low
Capacity Utilization	Low		82% in 1973
Captive Usage	Low		30%
Demand Growth	Low		9%/yr.
Foreign Competition	High		Low: (to date)
Abatement Cost Differences	Unequal		—
Price Elasticity of Demand	High		Low
Basis for Competition	Price		Price
Market Share Distribution	Fragmented		Fragmented
Number of Producers	Many		7
Substitute Process	Many		None in United States. Butene Oxidation: Japan, Europe

TABLE XVI-1 (Continued)

PLANT SHUTDOWN DECISION			
Factor	Condition for Shutdown	Treatment Level	
Ratio of AT Treatment Cost to AT Net Income (%)	High	B.P.T. B.A.T.	23.5% 23.5%
Cash Flow (Including Treatment Costs)	Negative		Positive
Ratio of Investment in Treatment Facilities to Net Fixed Investment (%)	High	B.P.T. B.A.T.	15.1% 15.1%
Integration	Low		High
Chemical Complex	Isolated Plant		Isolated Plant 30% Complex 70%
Other Environmental Problems (Including OSHA)	Multiple		Few
Emotional Commitment	Indifference		Moderate — High
Ownership	Multi-Industry Companies		Multi-Industry

B. INDUSTRY BACKGROUND

1. Market Characteristics

a. Size and Growth

In 1973, apparent consumption of maleic anhydride was 279 million pounds, which is primarily accounted for by domestic production. Table XVI-2 summarizes historical production and apparent consumption. for the 1963-1973 period. Production has grown at an annual compound rate of 12.4% per year since 1963. Major growth in production (16% per year compound rate) took place in the 1963-1968 period while from 1968-1973 production only increased at a 9% annual rate. The growth rate is expected to continue at a level between 9% and 10% for the foreseeable future.

Imports and exports are not reported by the Tariff Commission; however, they are probably small. Only limited quantities of benzene-based maleic anhydride have been imported in the past because of the high duty rate. Domestic producers face a possible influx of C_4 based maleic anhydride produced in briquette form since it is classified under a tariff schedule which reduces the duty 80% and enables it to be more competitively priced with domestic production.

b. Uses

Table XVI-3 details an estimated end-use pattern for maleic anhydride. The largest single use is for the production of unsaturated polyester resins used in reinforced plastic applications. Consumption of maleic anhydride for production of unsaturated polyester resins increased at an average annual growth rate of 9% from 1965 to 1971, and is forecast to increase at a 12%-15% rate in the foreseeable future. Breakthroughs in the use of unsaturated polyester resins in sheet molding compounds by the automobile manufacturers could result in considerable

TABLE XVI-2

PRODUCTION, IMPORT, AND APPARENT CONSUMPTION
OF MALEIC ANHYDRIDE
(million pounds)

Year	Production	Imports and Exports	Apparent Consumption
1963	86.6	Negligible	86.6
1964	118.1	Negligible	118.1
1965	128.2	Negligible	128.2
1966	168.6	Negligible	168.6
1967	168.2	Negligible	168.2
1968	181.7	Negligible	181.7
1969	200.7	Negligible	200.7
1970	215.1	Negligible	215.1
1971	228.7	Negligible	228.7
1972	274.4	Negligible	274.4
1973 P	281.8	Negligible	281.8

P — Preliminary

Note: Assumes constant inventory levels

SOURCE: U.S. Tariff Commissions

TABLE XVI-3

MALEIC ANHYDRIDE CONSUMPTION BY END USE
(million pounds)

End Use	1965	1968	1971	% of Total (1971 Consumption)
Unsaturated Polyester Resins	60	90	100	43.7
Fumaric Acid	18	21	30	13.1
Agricultural Chemical	15	20	25	10.9
Alkyd Resins	6	7	6	2.6
Miscellaneous Uses	29	44	68	29.7

SOURCE: Chemical Economics Handbook Estimates

increases in maleic anhydride consumption. A breakthrough is not expected in the immediate future.

Other major uses of maleic anhydride are for the production of fumaric acid and agricultural chemicals. Uses for fumaric acid are as a food acidulant, in the production of fortified paper-size resins, and in unsaturated polyester resins. Use of maleic anhydride for the production of fumaric acid is expected to level off while use in agricultural chemicals is expected to grow at about a 10% per year rate.

Minor uses for maleic anhydride are for lubricating additives, reactive plasticizers, copolymers, maleic acid, and chlorendic anhydride. The largest growth for maleic anhydride usage will occur in the pro- duction of chlorendic polyester resins. However, this is a small market and 1975 use is estimated to be only 12 million pounds.

c.   Substitute Products

Maleic anhydride can be substituted by fumaric acid in its largest use, the production of unsaturated polyester resins. During 1970 when maleic anhydride was in short supply, fumaric acid was used as a replacement. However, as maleic anhydride became available in 1971, unsaturated polyester manufacturers switched back to using it because of its cost advantage. Since the manufacture of fumaric acid is primarily from maleic anhydride (only one producer manufactures fumaric acid by another process), maleic anhydride will maintain its cost advantage over fumaric acid unless alternative routes for the production of fumaric acid are more widely utilized. Maleic anhydride cannot be easily substituted by phthalic anhydride, the principal dibasic acid used in polyester resins,as maleic acid is unsaturated and can be crosslinked in a fashion that phthalic anhydride cannot.

Fumaric acid competes with a variety of food acidulants as described under the Citric Acid section of this report. It is also nonsubstitutable for the manufacture of maleic hydrazide plant growth regulators as described under the section on Hydrazine. We consider that maleic anhydride has a relatively low elasticity of demand relative to price.

d. Captive Requirements

Captive consumption of maleic anhydride is shown in Table XVI-4.

e. Other Market Characteristics

The United States is the largest consumer of maleic anhydride, accounting for 48% of world consumption in 1972. However, substantial manufacturing capacity exists outside the United States, especially in Western Europe and Japan. Dumping of maleic anhydride in the United States as a result of worldwide excess capacity was prevented because of the high duty rate on the chemical produced from benzene (1.7¢ per pound plus 12.5% ad valorem).

2. Supply Characteristics

a. Manufacturing Routes

Maleic anhydride is exclusively produced in the United States by the oxidation of benzene. Benzene is converted to maleic anhydride by catalytic oxidation in the vapor phase. The reaction is carried out in a fixed-bed reactor utilizing a catalyst composed of 70% by weight vanadium pentoxide and 25%-30% molybdenum oxide. After reaction, the off-gas is condensed, dehydrated, and fractionated to produce pure maleic anhydride.

TABLE XVI-4

CAPTIVE CONSUMPTION OF MALEIC ANHYDRIDE
(million pounds)

Year	Production	Sales	Captive Consumption
1963	86.6	57.1	29.5
1964	118.1	67.8	50.3
1965	128.2	94.4	33.8
1966	168.6	118.9	49.7
1967	168.2	114.1	54.1
1968	181.7	131.3	50.4
1969	200.7	120.7	80.0
1970	215.1	151.0	64.1
1971	228.7	151.7	77.0
1972	274.4	190.6	83.8
1973	281.8	213.9	N.A.

Notes: "Sales" are assumed to be merchant sales. Inventory levels assumed constant.

SOURCE: U.S. Tariff Commission

b. Producers

There are currently seven domestic producers of maleic anhydride and Monsanto is the largest with 31% of total industry capacity. Reichhold is the only producer which operates more than one plant. Table XVI-5 summarizes producers and plant data. Reichhold's plant in Morris, Illinois has been experiencing start-up problems, and therefore, reportedly is currently not capable of operating at capacity. Plant capacity was tight during 1969-1971 due to poor yields from the catalysts used rather than insufficient nameplate capacity. As demand has increased, maleic anhydride was again in tight supply in 1973. Petro-Tex Chemical has planned a plant expansion for maleic anhydride, however, because of the uncertainty of feedstock supplies, expansion has been delayed.

All seven producers have some captive use for the production of maleic anhydride-based products, usually unsaturated polyester resins and fumaric acid. Allied Chemical and Reichhold produce maleic anhydride exclusively for captive use and Petro-Tex Chemical is the only company which exclusively produces for the merchant market. As a result, there is a significant degree of forward integration from maleic anhydride manufacture.

c. Raw Materials

Maleic anhydride's basic raw material is benzene, a basic petrochemical. Benzene was in tight supply in early 1974, and as a result, manufacturers of maleic anhydride are prevented from operating at capacity in spite of the high demand for the product. Benzene became more readily available in late 1974. We do not expect benzene availability to be a continuing restraint in maleic anhydride capacity utilization.

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TABLE XVI-5

MALEIC ANHYDRIDE PRODUCERS, LOCATION AND CAPACITY

Producer	Location	Capacity (MM lbs)
Allied Chemical	Moundsville, West Virginia	20
Koppers Company	Bridgeville, Pennsylvania	34
Monsanto	St. Louis, Missouri	105
Petro-Tex Chemical	Houston, Texas	50
Reichhold Chemicals	Elizabeth, New Jersey	30
Reichhold Chemicals	Morris, Illinois	40*
Tenneco Chemical	Fords, New Jersey	22
United States Steel	Neville Island, Pennsylvania	40
Total		341

*Start-up capacity, maximum capacity 60 million pounds per year.

SOURCE: Chemical Marketing Reporter

d. Manufacturing Economics

Estimated manufacturing economics for maleic anhydride are described in Table XVI-6.

3. Prices

Price history is shown in Table XVI-7 and reveals a fairly stable actual price history except in recent years. This is a result of fairly constant capacity utilization throughout the 1960's. The 1968-1970 period shows an increasing price trend because of the yield problems from existing capacity rather than inadequate capacity. Prices dropped in 1972 probably because nominal capacity became actually available and rose in 1973 both because of rising benzene prices and the beginning of a supply restraint due to unavailability of benzene. Benzene prices will remain relatively higher because of higher petroleum costs. Prices for maleic anhydride will consequently be higher but probably down from the levels experienced during mid-1974.

4. Supply/Demand Balance

The industry has been in a relatively good capacity situation with the exception of the 1969-1971 period. Table XVI-8 outlines the history of production versus capacity. The 1969-1971 period of tight supply is not reflected in these figures because the supply difficulties were a result of poor yield from catalysts rather than lack of nameplate capacity. The product was in tight supply because of the benzene shortage. By 1975, benzene availability was no longer a constraint and hence capacity was again available.

TABLE XVI-6

ESTIMATED COST OF MANUFACTURING
MALEIC ANHYDRIDE FROM BENZENE

Production Economics (Summer, 1973)

Process Scientific Design — Fixed Bed

Location Gulf Coast Capacity 50 MM lbs/yr Invest. $5.5 MM (1970 Construction)

	Cost	
	$/Year	¢/lb Product
Benzene 0.17 gal @ $0.27/gal	2,295,000	4.59
Catalysts, Chemicals and Supplies	190,000	.38
Utilities	495,000	.99
Direct Labor 13 men @ $5.00 hr	142,000	.28
Maintenance Materials and Labor	264,000	.53
Labor and Plant Overhead	142,000	.28
Depreciation 9%/yr	495,000	.99
Taxes and Ins. 1-1/2%/yr	83,000	.17
Factory Cost	4,106,000	8.21

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TABLE XVI-7

PUBLISHED VS. ACTUAL PRICES
PER MALEIC ANHYDRIDE
(cents per pound)

Year	Published Prices	Actual Prices
1963	14.0	13
1964	14.5	12
1965	13.0	12
1966	14.0	13
1967	15.5	13
1968	15.5	12
1969	14.0	15
1970	17.0	16
1971	17.0	15
1972	13.0	13
1973	17.0	15
1974 (June)	16.0-26.0	N.A.

SOURCES: Chemical Marketing Reporter, U.S. Tariff Commission

TABLE XVI-8

MALEIC ANHYDRIDE PRODUCTION VS. CAPACITY

(million pounds)

Year	Capacity*	Production	% Utilization
1965	164	128.2	78
1966	189	168.6	89
1967	189	168.2	89
1968	209	181.7	87
1969	237	200.7	85
1970	259	215.1	83
1971	281	228.7	81
1972	321	274.4	85
1973	341	278.8	82

*Nameplate capacity

SOURCES: U.S. Tariff Commission, Chemical Marketing Reporter

C. ECONOMIC IMPACT

1. Treatment Costs

The cost to achieve BPT and BAT guideline specifications as presented in the guideline document is for a free standing plant with 137,000 pounds per day of production capacity. Unlike most of the other products treated by the guideline document, maleic anhydride effluent was handled by incineration rather than biological techniques. This cost is given at 1.60¢ per pound to meet BPT guidelines and involves no additional cost or investment to meet BAT guidelines.

As the incineration technique is used there are no economies of scale as a consequence of commonly treating effluent from a chemical complex. Economies of scale, because of differences in plant size and consequent amount of effluent incinerated, would be modest. The major cost involved in incineration would be the energy requirement which is a direct function of the amount of material treated. The size plant specified in the guideline document is about an average size plant for the industry.

2. Price Impact

The latest available annual average price paid for maleic anhydride was for the year 1973. The actual average price was 15¢ per pound. List prices increased from 17¢ per pound in 1973 to a range of 16¢-26¢ per pound by mid-1974 and subsequently to 38¢ per pound by May of 1975. The recent rapid increase in price, since 1973, is due to both relatively high demand compared to supply and because of the higher cost for benzene, the raw material used in the United States for maleic anhydride production.

Maleic anhydride is produced outside the United States by the oxidation of normal butene as well as the oxidation of benzene. The

duty rate applicable to benzene manufactured maleic anhydride totals
1.7¢ per pound plus 12.5% ad valorem. The duty applicable to maleic
anhydride produced from butene is 6% ad valorem.

Most probably one of the reasons that maleic anhydride has been
restricted from U.S. markets through 1973 has been the high rate of
duty associated with the benzene produced product. Production of maleic
anhydride from butene is a relatively new technology. The lower rate
of duty now applicable to butene derived products no longer acts as the
severe barrier to importation.

The impact matrix suggests the probability of cost pass through
for the producers of maleic anhydride. There are few substitute products
and also, we expect,   the price elasticity of demand is low. Maleic
anhydride is used in relatively modest quantities, about 10% of final
product weight, in its major end use, for production of unsaturated
polyester resins. It is also the primary way that fumaric acid can be
manufactured and is a vital component of specific agricultural chemicals.
Capacity utilization has been over 80% since 1966 and probably even
higher than the data suggests both because of occasional restraints
in raw material supply such as the capability to procure benzene in late
1973 and early 1974 and because of manufacturing problems. The demand
growth is high and to date foreign competition has been low primarily
because of the high rate of duty. The major factor mitigating against
cost pass through of treatment costs is the relatively high proportion
of this cost compared to sales price. We do not know what the actual price
for maleic anhydride is at the present time, however, and this price
has no doubt been changing rapidly, as reflected in list prices. At
present, the price is probably significantly above the 1973 average
price but below the list price. As a consequence, the ratio of treat-
ment cost to selling price is somewhat lower than the 10.7% indicated by
the impact matrix.

It is our best judgment that producers of maleic anhydride will pass through the treatment cost as a price increase. The price increase will in the future, therefore, total 1.60¢ per pound or 10.7% of the 1973 price.

3. Plant Shutdown

We expect no shutdowns of domestic plants for the production of maleic anhydride by virtue of the BPT and BAT guideline specifications. As cost pass through will occur, there should be no impact on profitability. Investment to achieve both BPT and BAT through incineration is relatively modest compared to total plant investment and, we expect, by itself would not inhibit producers from continuing to manufacture maleic anhydride via the oxidation of benzene.

4. Balance of Trade

The effect on future balance of trade is difficult to estimate because of the combination of two significant changes which are taking place simultaneously: the addition of a cost penalty of approximately 1.6¢ per pound for the U.S. producer, and reduction in the rate of duty on maleic anhydride produced from butene. Both of these effects will act to make foreign producers more competitive in U.S. markets.

Demand is forecast to increase at 9% per year. By 1975, demand should reach the limits of nominal domestic capacity. This will require that either domestic producers expand or foreign imports will assume an increasing portion of demand. We estimate that both events will occur simultaneously; that is, domestic producers will expand either by the conventional route or oxidation of butenes and that foreign producers will increase shipments into the United States. We estimate that by 1977, 10% of domestically acquired maleic anhydride will be imported or a total of 40 million pounds valued at $6 million in 1973 dollars and prices. By 1983 imports will have continued to increase to reach 15% of total domestic demand or approximately 100 million pounds valued at $18 million in 1973 dollars and prices.

XVII. PRESCREENING ANALYSIS

The first step in our analysis of Phase II of the organic chemicals industry was to prescreen the list of products on which costs were available in the guideline document in order to eliminate those which, on the basis of preliminary judgments, appeared not to present serious problems of economic impact or were of minor commercial significance.

The economic contractor's approach was to rely on the guideline contractor's estimates of costs for best available technology in a free standing plant condition as a proportion of total selling price as one major consideration. This presents the highest cost case possible for any given product-process combination.

We also eliminated some products on the basis of the commercial significance to the organic chemicals industry. Finally, the economic contractor tried to take into account the probability of manufacturers of the products being able to pass through effluent treatment costs as price increases. Our judgments were also conditioned on whether we estimated the profitability of the process under consideration to be in the high, medium or low range in profitability relative to the total U.S. chemical industry.

In a number of specific instances, as indicated below, the products were not prescreened by the economic contractor but rather by the Environmental Protection Agency. In most of these cases, data on effluent treatment cost were not available or were significantly changed during the course of the study. It is the economic contractor's understanding that those products prescreened by the Environmental Protection Agency were analyzed using the same approach as the economic contractor.

1. Benzene Toluene, and Xylene - Reforming and Extraction

The initial guideline document indicated BAT treatment costs of approximately 0.6% of 1972 selling prices. By 1974, selling prices of

these products had risen, due to increasing prices of crude oil and shortages of aromatic products, to the point that effluent treatment costs represented approximately 0.3% of the selling price.

Due to changes in the guideline document in the course of the study, BAT treatment costs were increased to approximately 2% of the 1972 selling price and about 1% of the 1974 selling price.

Although products were originally judged on the first set of guideline costs, the economic contractor continued to include these products in the prescreening analysis due to the still relatively low treatment costs as a proportion of total current selling price and judgments that the industry traditionally has operated in the median range of profitability of the chemical industry.

a. Benzene

Approximately 1.5 billion gallons of benzene were produced in the United States in 1973. Total U.S. capacity for benzene production and isolation was around 1.8 billion gallons held by approximately 68 producers. About half the total benzene produced and isolated went into the manufacture of styrene. An additional third of the production of phenol and cyclohexane was used for nylon production. The remainder, approximately 15%, was used in a variety of other chemical intermediate products.

b. Toluene

Approximately 880 million gallons of toluene were produced in the United States in 1972 by about 45 producers. All but about 2% of this was petroleum-derived. The product is used not only for conversion to benzene but also has extensive application as a solvent in the manufacture of toluene diisocyanate and a large variety of other intermediate chemical products.

c. Xylene

During 1972, 736 million gallons of mixed xylenes were produced in the United States by about 50 producers. Virtually all of the mixed xylenes isolated came from petroleum. Production of xylenes increased 60% in the two-year period between 1970 and 1972. The large increase in production over the past several years seems to have been principally due to the increasing demand for para-xylene as a starting raw material for the production of dimethyl terephthalate and terephthalic acid which in turn is used in the production of polyester fiber and film. Another major isomer, ortho-xylene, is used in phthalic anhydride production, while meta-xylene has a modest requirement in the production of isophthalic acid.

2. Chlorobenzene - Chlorination of Benzene

At the time of the economic contractor's prescreening analysis, no data were available from the guidelines contractor as to the costs associated with effluent treatment. The economic contractor, therefore, did not include this end product in the prescreen list. The product was included by the Environmental Protection Agency. BAT treatment cost estimated by the EPA totaled 3.8% of the 1971 selling price and probably about half this amount for the average 1974 selling price.

3. Citronellol and Geraniol - Processing of Citronellol Oil

Citronellol is one of a group of turpene-based fragrances. It is produced in conjunction with geraniol. In the process under considera-tion, natural geraniol is isolated by the distillation of natural citronellol oil and citronellol produced from the hydrogenation of geraniol. These materials are consumed in limited quantities in the United States. No definition of consumption or growth of demand is readily available in the prescreening process. The products are, however, essential to the buyers in the sense that they constitute a necessary

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part of specific fragrance formulations. We estimate returns on the sale of both citronellol and geraniol at a high range of the possibility of the U.S. chemical industry.

The product was excluded from further consideration principally on two bases: its modest significance in the U.S. organic chemicals industry and the fact that estimated BAT treatment costs are between 3% and 4% of selling price. It also seems likely that in this case cost pass through would be possible due to the relatively small proportions of these materials used in the finished products and their essential nature in the qualities of the finished product.

4.   Cumene - Benzene and Propylene

Cumene was not included in the prescreen analysis. It was pre-screened by the Environmental Protection Agency, presumably on the basis of the extremely low effluent treatment cost as a proportion of total selling price. This cost was estimated by the Environmental Protection Agency at .03% of the 1971 selling price.

5.   Diphenylamine - Deammonation of Aniline

Diphenylamine was not included in the prescreening analysis by the economic contractor. It was included by the Environmental Protection Agency presumably on the basis of the relatively low estimated BAT treatment cost as a percentage of the selling price. These costs, as estimated by the Environmental Protection Agency, are less than 2% of the 1971 selling price.

6.   Ethyl Acetate - Esterification of Ethanol and Acetic Acid

No costs for the treatment of effluent resulting from the production of ethyl acetate were available in the original guideline document. The product was, therefore, not prescreened by the guideline contractor.

The development of costs in a later revision of the guideline document indicated relatively low effluent treatment cost as a proportion of total selling price. The Environmental Protection Agency estimated these at 1.4% of the 1971 selling price.

7. Hexamethylenediamine - Ammonolysis of 1,6-Hexanediol

There are four producers of hexamethylenediamine in the United States. Total production in 1973 was 918 million pounds. As virtually all hexamethylenediamine produced is consumed by the manufacturers in the production of nylon 66 fiber and polymer, a quoted price is not generally available. In 1972, however, external sales were approximately 8 million pounds as reported by the U.S. Tariff Commission at a unit value of 36¢ per pound.

These producers of hexamethylenediamine utilize the hydrogenation of adiponitrile. One producer, accounting for about 5% of total production, utilizes the ammonolysis of 1,6-hexanediol. The product was eliminated in the prescreening analysis by the economic contractor, both on the basis of the relatively small commercial significance and on the basis that, as in the case with more conventional routes to hexamethylenediamine through adiponitrile, effluent treatment costs would be passed through. BAT effluent treatment costs are estimated at about 1.5% of selling price.

8. Ionone and Methyl Ionone - Condensation and Cyclization of Citral

Ionone and methyl ionone were not considered in the prescreening process as the initial guideline document indicated no waste treatment cost associated with the production of these materials. The revised guideline document indicates BAT treatment costs at about 7% of total 1971 selling price as estimated by the Environmental Protection Agency.

According to the guideline document, ionones and methyl ionones are used in perfumes and flavors. The beta ionone isomer is also an intermediate in the manufacture of vitamin A. Presumably these were included

by the Environmental Protection Agency on the basis of potential cost pass through of treatment costs due to the essential nature of the materials in the manufacture of the products utilizing them and the lack of substitution possible.

9. Methyl Salicylate - Esterification of Salicylic Acid with Methanol

Production of methyl salicylate totaled 6.8 million pounds in 1973. Methyl salicylate is used in perfumes and pharmaceuticals and as a solvent for cellulose derivatives, polishes, inks and insecticides. Growth in consumption is estimated to have been at an average rate of 5% per year between 1963 and 1973. Methyl salicylate was eliminated from detailed analysis by the prescreening process on the basis of BAT treatment costs of approximately 1% of sales value and the modest total commercial value of the product.

The profitability of the product was judged to be in the medium to low range of the chemical industry.

10. Ortho-Nitroaniline - Ammonolysis of O-Nitrochlorobenzene

In 1972 there was one producer of this chemical. Production and sales volume were therefore not reported by the U.S. Tariff Commission in order not to disclose confidential manufacturer's information. Ortho-nitroaniline is used as a dye intermediate, in the synthesis of photo-graphic antifogging agents and as a chemical intermediate.

The product was eliminated in the prescreening analysis because of assumed modest commercial significance and the lack of available data on which to make judgments relative to economic impact. BAT treatment costs are estimated by the Environmental Protection Agency at 6.5% of 1972 list price.

11. Para-Aminophenol - Catalytic Reduction of Nitrobenzene

There is only one producer of para-aminophenol reported in 1972 and thus production and sales figures are not available from the U.S. Tariff Commission. Para-aminophenol is available in technical and photographic grades and is used as a specialty chemical in dyeing agents, as a photographic developer, in pharmaceutical applications and as an antioxidant in oil additives. BAT effluent abatement cost is estimated at 2.5% of list price. The product was eliminated in prescreening from detailed analysis both because of the specialty nature and limited information available in order to make impact judgments and the relatively low effluent abatement cost as a percentage of the selling price.

12. Para-Nitroaniline - Ammonolysis of P-Nitrochlorobenzene

In 1969 there were three producers of para-nitroaniline, two of them holding 2-3 million pounds per year capacity and the third with about 10 million pounds per year capacity. By 1972 only two producers remained and capacity availability was reported at 13 million pounds per year. Capacities are flexible since the equipment can be used to make other intermediates and is probably close to 10 million pounds per year, though it is not reported by the U.S. Tariff Commission. Para-nitroaniline is used as a rubber antioxidant, a gasoline additive, an intermediate in dye and pigment manufacture, pharmaceutical and veterinary use and in agricultural chemicals.

Effluent abatement costs to achieve BAT standards are equivalent to 4.3% of the 1972 list price.

Para-nitroaniline was prescreened from detailed study because of the modest commercial significance of the products of the organic chemicals industry and the relatively modest cost, 4.3% of 1972 list price, required to achieve BAT standards.

13. Para-Xylene - Fractional Crystallization

Para-xylene is used in the manufacture of dimethylterephthalate and terephthalic acid used as intermediates in the production of polyester fiber and film. In 1973 total capacity of around 2.4 billion pounds was held by ten producers all of whom were involved in petroleum refining. Capacity in 1973 was virtually fully utilized.

The original guideline document specified pollution abatement cost to achieve BAT at .2% of selling price. The product was excluded based on this modest abatement cost. The revised guideline document increased abatement cost to 1.1% of 1972 prices. The ex act para-xylene manufacturing profitability is in the median range of the chemical industry based on 1972 and 1973 price. The product was prescreened out from detailed study principally on the basis of the relatively low pollution abatement cost requirement.

14. Phthalic Anhydride

The original guideline document specified BAT treatment cost at 1.1% of 1972 price. The product was excluded from detailed consideration on the basis of this modest cost. BAT treatment costs were increased in the revised guideline document to .21¢ a pound from a previous level of .075¢ per pound. This increased to 2.9% the cost relative to the 1972 selling price. This increase in price is substantially ameliorated, however, by the increase in prices for phthalic anhydride between 1972 and 1974. In 1974 phthalic anhydride was quoted at a list price of 20.75¢ per pound. At this price the BAT effluent treatment cost is equivalent to 1.0% of selling price.

Phthalic anhydride has been commercially produced in the United States both by the oxidation of ortho-xylene and the oxidation of naphthalene. In 1973 the great majority of the product produced was derived from ortho-xylene. The product is used principally in the manufacture of plasticizers, alkyd resins and polyester resins.

Capacity for the production of phthalic anhydride is approximately
1 billion pounds per year held by nine different producers. Consumption
in 1973 was approaching 1 billion pounds per year. Growth in consumption
over the past decade has been around 5% per year. In recent years,
phthalic anhydride has been significantly in excess capacity relative to
demand. Demand appeared to be coming back into balance in the latter
half of 1973. On the basis of 1973 prices, producers are estimated to be
obtaining returns on sales in the intermediate range in the U.S. chemical
industry.

15. Plasticizers – Condensation of Phthalic Anhydride

The guideline document does not specify any particular plasticizer,
but phthalic anhydride esters in total sold at an average price in 1973
of 14¢ per pound. On the basis of the costs in the revised guideline
document, BAT costs constitute 2.1% of 1973 average selling price.
Phthalate plasticizers increased markedly in price and approximately
doubled in price since 1963 and BAT abatement costs are currently probably
close to about 1% of 1974 sales prices.

Production of phthalic anhydride esters, the great majority of
which are used as plasticizers, totaled approximately 1.2 billion pounds
in 1973. Consumption is forecast to grow at about 5% per year in the next
five years. About 85% of total plasticizers consumed are used in polyvinyl
chloride plastics and other markets are relatively small, including
cellulose ester plastics, synthetic elastomers, vinyl resins other than
polyvinyl chloride and other polymers. There are an estimated 25 com-
panies producing plasticizers, most of whom produce more than one type
at the same facility.

The category of phthalic anhydride based plasticizers was prescreened
on the basis of the relatively low pollution abatement cost required to
meet BAT effluent standards.

16. Tannic Acid - Extraction

The revised guideline document provides a BAT effluent cost of .89¢
per pound for tannic acid. It is equivalent to 2.1% of 1972 sales price.
There are only two producers of tannic acid in the United States and
production is not reported. No readily available public information was
found for the production or consumption of tannic acid.

In general terms, the application of vegetable tannins has been
replaced by synthetic organic materials. The remaining small markets are
probably relatively secure from further competition. This product was
prescreened from detailed studies by virtue of the relatively low
effluent abatement costs compared as a proportion of sales price and
because of the modest significance of tannic acid in the U.S. synthetic
organic chemicals industry.