United States
Environmental Protection
Agency

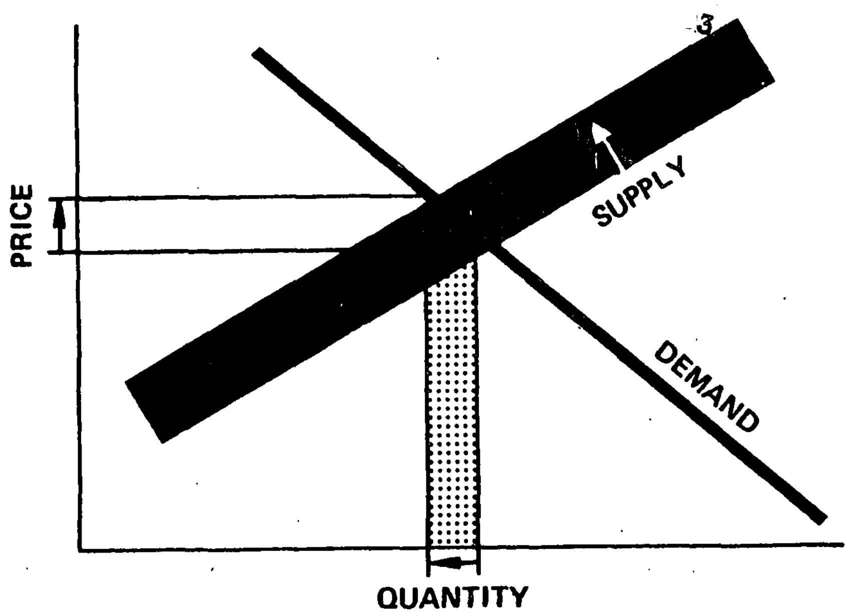
Office of Water Regulations
and Standards
Washington DC 20460

EPA-440/2-82-012
October 1982

Water

EPA

Economic Impact Analysis of Proposed Effluent Standards and Limitations for the Battery Manufacturing Industry



ECONOMIC IMPACT ANALYSIS
OF PROPOSED
EFFLUENT STANDARDS AND LIMITATIONS
FOR THE BATTERY MANUFACTURING INDUSTRY

Submitted to:

Environmental Protection Agency
Office of Analysis and Evaluation
401 M Street, Southwest
Washington, D.C. 20460

Submitted by:

JRB Associates
8400 Westpark Drive
McLean, Virginia 22102

October 25, 1982

PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impacts which could result from the application of effluent standards and limitations issued under Sections 301, 304, 306, 307, 308, and 501 of the Clean Water Act to the battery manufacturing industry.

The study supplements the technical study (EPA Development Document) supporting the issuance of these regulations. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports certain standards and limitations based upon an analysis of the feasibility of these standards in accordance with the requirements of the Clean Water Act. Presented in the Development Document are the investment and operating costs associated with various control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the application of various control methods and technologies. This study investigates the effects in terms of product price increases, effects upon employment and the continued viability of affected plants, effects upon foreign trade, and other competitive effects.

The study has been prepared with the supervision and review of the Office of Water Regulations and Standards of EPA. This report was submitted in accordance with Contract No. 68-01-6348, Work Assignment 14, by JRB Associates and was completed in October 1982.

This report is being released and circulated at approximately the same time as publication of a notice of proposed rulemaking in the Federal Register. 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 final rulemaking proceedings.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

S. SUMMARY

SUMMARY

PURPOSE

This report identifies and analyzes the economic impacts of water pollution control regulations on the battery manufacturing industry. These regulations include effluent limitations and standards based on BPT (Best Practical Control Technology currently available), BATEA (Best Available Technology Economically Achievable), PSES (Pretreatment Standards Existing Sources), NSPS (New Source Performance Standards), and PSNS (Pretreatment Standards New Sources), which are being proposed under authority of Sections 301, 304, 306, 307, 308, and 501 of the Federal Water Pollution Control Act, as Amended (the Clean Water Act). The primary economic impact variables of interest include price changes, plant closures, substitution effects, changes in employment, shifts in the balance of foreign trade, changes in industry profitability, structure, and competition, and impacts on small business.

INDUSTRY COVERAGE

Batteries store electrical energy through the use of one or more electrochemical cells in which chemical energy is converted to electrical current. A typical battery cell consists of two dissimilar materials (called cathodes and anodes) immersed in an electrolyte (a substance which in solution is capable of conducting an electric current). When the metal electrodes are connected to an electric circuit, current flows.

There are at least two dozen battery types, as defined by their basic electrolyte couple type, and many variations of each, depending on battery structure, variations in chemistry, and production methods. Sixteen of these battery types represent at least 98 percent of the volume of shipments of batteries in the U. S. For purposes of this study, the battery industry consists of establishments that manufacture these 16 types of batteries. A list of these appears in Table S-1. The remaining battery types were omitted from detailed analysis in this study because they are either no longer in production, are of little commercial significance, or are experimental (e.g., nickel-zinc and fuel cells).

There are a number of ways in which battery types may be classified for study and different portions of the study use different classification schemes depending upon data availability and analytical requirements. The companion technical study categorized the industry according to the basic anode material used and, to some extent, according to whether the electrolyte was acid or alkaline. The basic groupings are: Cadmium, Calcium, Lead, Leclanche, Zinc, Lithium, and Magnesium. This categorization seems appropriate since the primary purpose of the study was an evaluation of production processes and their effluents.

While the anode classification scheme may be appropriate from a technical viewpoint, it is expected that economic and financial impacts of the regulations will vary with the type of product, end use, and industry organization. This is because the determinants of demand, availability of substitutes, and pricing latitude will vary with these factors. For this reason, battery type as described by their cathode-anode pair is the primary segmentation scheme used in the economic study, wherever the data allowed. Table S-1 shows the relationship between the technical and economic industry classification schemes.

STUDY APPROACH

The basic approach used to assess the economic impacts likely to occur as a result of the costs of each regulatory alternative was to develop a model of the operational characteristics of the industry and to use the model to compare industry conditions before and after compliance with the proposed regulations. Side analyses were used to assess linkages of industry conditions to other effects such as employment, community and foreign trade impacts. For the lead-acid, zinc and cadmium battery industry segments there were five alternative

TABLE S-1. RELATIONSHIP OF TECHNICAL INDUSTRY SUBCATEGORIES TO ECONOMIC INDUSTRY SEGMENTS

Battery Product Groups	Technical Subcategory
Lead Acid	Lead
Carbon Zinc and Related Types	Leclanche
Alkaline Manganese Carbon Zinc-Air Mercury Ruben Nickel Zinc Mercury Cadmium Zinc	Zinc Anode, Alkaline Electrolyte
Nickel Cadmium Mercury Cadmium Silver Oxide Cadmium	Cadmium Anode
Magnesium Carbon Magnesium Reserve Thermal	Magnesium Anode
Lithium	Lithium Anode
Calcium	Calcium

regulatory options considered in the economic study; each option represents increasing levels of compliance costs and, generally, pollution abatement. For the other industry segments four regulatory options were considered. Specifically, the study proceeded in the following steps:

Step 1 Description of Industry Characteristics

The first step in the analysis is to develop a description of the basic industry characteristics. The characteristics of interest are those that would enable estimation of key parameters which describe the initial impacts of the regulation. These include the determinants of demand (e.g., demand elasticities), market structure, the degree of intra-industry competition, and financial performance. These basic characteristics are described in Chapters 3, 4 and 5 of the report.

The sources for this information are many. They include government reports, proprietary market research studies, text books, trade association data, The trade press, discussions with various trade association representatives and individuals associated with the industry, visits to a number of battery manufacturing plants and an industry survey and plant-by-plant compliance cost estimates conducted by EPA's Effluent Guidelines Division. From the first step, several observations were made which influenced the remainder of the analysis. These are:

- generally low demand elasticity for the total industry, due primarily to a lack of substitutes for batteries
- somewhat higher demand elasticities (although still generally inelastic) for individual battery product groups, due to the ability to substitute one battery type for another
- low estimated compliance costs for most plants
- a wide variation in estimated unit compliance costs among plants
- a lack of plant-level data on a number of key variables, such as profitability.

These observations indicated the need for an analytical methodology that would account for variations in conditions among plants and firms within the industry.

Step 2 Industry Supply and Demand Analysis

The second step in the analysis is a determination of expected changes in market prices and industry production levels for each battery product group and for each regulatory option. If prices can be successfully raised without significantly reducing product demand and companies are able to maintain their current financial status, the potential for plant closings will be minimal. If prices cannot be raised to fully recover compliance costs, because of significant intra-industry competition, for example, the firms may attempt to maintain their financial status by closing higher cost/less efficient plants.

The price/output model assumes a full-cost pricing strategy. Full-cost pricing appears to characterize the long-term behavior of battery firms in normal years in which price is assumed to cover average total cost. In this context, average total cost equals average variable cost plus average fixed cost plus a target rate of return of investment.

Using the pricing strategy outlined above and externally developed elasticity estimates, the model was used to calculate a range of expected output changes. (Output changes result from application of the estimated price changes and elasticity estimates.)

Step 3 Analysis of Cost of Compliance

Investment and annual compliance costs for 239 production facilities were estimated by EPA's Effluent Guidelines Division. For three technical subcategories (lead, zinc and cadmium) there are five sets of costs, corresponding to increasing levels of pollution control. For the remaining subcategories four options were considered. For purposes of this report, the regulatory options are labeled "Alternative 1, Alternative 2, etc." A description of the control and treatment technologies and the rationale behind these compliance cost estimates appear in Chapter 6.

Step 4 Screening Analysis

The screening analysis uses several basic parameters to separate out those plants with obviously small impacts from those with potentially significant impacts. The primary variables are the ratio of total compliance cost to revenue and degree of gross profit margin reduction. Those plants with unit compliance costs significantly greater than industry unit price increases were analyzed to assess the significance of the estimated profit reduction. In general, if return on sales (ROS) fall by less than one percent, these plants are not considered candidates for closure. Plants with greater reductions in profits were subjected to a more detailed financial analysis to determine if they are likely plant closures.

Step 5 Plant Level Financial Analysis

There are two basic financial characteristics which are examined: profitability and capital requirements. Both characteristics are examined through standard financial analysis techniques. That is, profitability is measured by both return on investment (net assets) analysis and discounted cash flow approaches. Capital requirements of the regulation are evaluated in terms of the amount of the initial capital investment in relation to normal new plant and equipment expenditures and in relation to fixed assets. The use of these approaches was hampered by a lack of plant-specific data on a number of input variables such as value of shipments, profit margins, asset values and cash flow. However, using a number of industry-wide parameters obtained from various published sources and company-wide data from corporate annual reports, a range of plausible values was developed for each of the key parameters (e.g. return on investment). Then, the majority of the analysis was conducted using the most conservative end of the range of each parameters (e.g., lowest ROI). Consequently, the resulting estimates are considered "worst-case" scenarios of likely impacts.

Step 6 Assessment of Plant Level Impacts

The sixth step involved the assessment of the degree of impacts on individual plants. These assessments were made by evaluating the above financial variables in conjunction with non-financial factors and non-quantifiable factors such as substitutability of products, plant and firm integration, the existence of specialty markets and expected market growth rates.

Step 7 Assessment of Other Impacts

Once the assessment of plant closure and price and quantity changes are made, other variables which flow from these were analyzed. The primary variables considered include employment, industry structure, the special case of small entities, and imports and exports. These impacts are assessed through the use of industry-wide and firm-wide ratios calculated from public data sources, (e.g., value of shipments per employee) and associated trends.

Step 8 Estimation of Social Costs

Social costs measure the value of goods and services lost by society because of the regulatory action. These costs generally include the use of resources needed to comply with a regulation, the use of resources to implement or enforce a regulation, plus the value of the output that is forgone because of the regulation. A reasonable estimate of these costs is provided by the present value of direct compliance costs, which generally account for most of the social costs.

Step 9 Small Business Analysis

The Regulatory Flexibility Act (RFA) requires Federal regulatory agencies to consider small entities throughout the regulatory process. This analysis addresses these objectives by identifying and evaluating the economic impacts that are likely to result from the promulgation of BPT, BCT, BATEA, NSPS, PSES and PSNS regulations on small business in the battery manufacturing industry. Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis which is described above and in the remainder of this report. The specific conditions of small firms are evaluated against the background of general conditions in battery markets.

Step 10 Estimation of New Source Impacts

Newly constructed facilities and facilities that are substantially modified are required to meet the New Source Performance Standards (NSPS) and/or the Pretreatment Standards for New Soruces (PSNS).

The costs of the selected new source standard are defined as those that are incremental over those for existing standards. These costs are estimated for the period 1980 to 1990 under the assumption that all of the increases in capacity during that period will be subject to new source standards. The assessment of economic impacts on new sources is based upon the above cost estimates and by analogy to the impact conclusions for similar existing sources described above. The primary variables covered are identical to those for existing plants plus the potential of the regulation for fostering barriers to entry or causing intra-industry shifts in competitiveness.

Limitations

In performing these analyses a number of assumptions, empirical estimates, and judgements were made. These factors are discussed in detail in various appropriate sections of the report. The major limitations arise from a lack of extensive time series data on industry characteristics and plant and firm-level data on product mix, value of shipments, financial performance, employment, and cyclical behavior. All assumptions and judgements were made in a very conservative manner. That is, if there is any bias in the analysis, it is to overestimate the economic impacts of the proposed regulatory options.

OVERVIEW OF INDUSTRY CHARACTERISTICS

The 1977 domestic production of both primary and secondary batteries amounted to 2.6 billion dollars.[1] Seventy-five percent of this amount represented storage batteries used in a multitude of products and applications.

The storage battery market is dominated by the lead-acid and nickel-cadmium type. The lead-acid battery accounts for 90 to 95 percent of storage batteries. About 82 to 86 percent of lead-acid batteries are used for Starting, Lighting and Ignition (SLI) applications, primarily for the automobile market. The other 14 to 18 percent goes to the industrial and consumer market. Nickel-cadmium batteries are used in a wide variety of consumer and industrial products. There are two basic types of nickel-cadmium batteries -- vented and sealed. Vented nickel-cadmium batteries are large heavy products used primarily for aircraft engines. Sealed nickel-cadmium batteries are smaller and portable. They are used to power a variety of products such as calculators, portable tools, toys and emergency lights.

Most primary batteries are used in consumer products such as flashlights, toys, games, watches, calculators, hearing aids, and electronic equipment. Sales of primary batteries for use in consumer products generally represent 70 to 75 percent of total primary battery shipments.

In general, there is little or no ability to substitute other products for batteries in most applications. However, some switching from one battery type to another is possible. The amount of switching possible varies among the 16 battery types studied. Thus, a separate treatment of each battery type was included in the study. In this separate treatment, it was found that there is little substitution potential among "wet cell" batteries (e.g., the automobile lead acid battery) and significant substitution potential among "dry cell" battery types (e.g., flashlight or calculator batteries). Because of this substitution potential, some dry cell batteries will experience greater reduction in demand due to price increases which may be necessitated by the regulation, than others.

---

[1] 1977 Census of Manufacturers

According to the 1977 Census of Manufacturers, there were 175 firms and 276 establishments in the industry. The firms are heterogeneous, consisting of large diversified firms, large firms that specialize in battery manufacturing and small independent one-plant firms. The majority of establishments are owned by small, private companies that deal primarily in one particular aspect of the battery market. The production of primary batteries is highly concentrated and that of storage batteries is less concentrated, but still considerable.

The EPA data base used in the economic impact analysis identified 258 battery "production facilities". A production facility, in this context, is defined differently than that of "establishment" used by the Census. A production facility is a specific battery product line as defined by cathode-anode pair. The number of production facilities identified by EPA and the number of establishments reported by the Census differ (a) because the definition of production facility differs from that of establishment used in the Census, (b) because the EPA data base was assembled for a different time period than that of the Census, and (c) because a number of firms listed in directories as manufacturers did not perform a significant amount of battery manufacturing activities (e.g. distributors). The primary data base upon which the plant by plant impact analysis is based is the 258 production facilities identified by EPA (referred to as "plants" in this report).

The financial characteristics of specific battery operations were difficult to determine because of the lack of detailed plant-level data. However, it is estimated that the industry is generally financially sound and growing at a rate slightly above that of the real GNP over the long run.

FINDINGS

The key findings reported are investment and annual costs, economic impacts, social costs and the impacts on small entities.

Compliance Cost

Table S-2 shows the estimated investment and total annual compliance cost in 1977 dollars by technical subcategory for each regulatory alternative. Descriptions of the technical characteristics of these options appear in Chapter 6 and in the Development Document. The costliest control option (Alternative 5) would add $9.5 million to the annual costs of battery manufacturing. This represents 0.37 percent of the value of shipments of batteries ($2.6 billion). Associated investment costs would be $32.9 million, representing 5 percent of fixed assets. The estimated compliance costs for most other treatment options are significantly lower, as shown in the Table. Table S-3 shows the compliance costs in 1982 dollars.

Industry Impacts

The economic impacts expected to result from these compliance costs are generally mild. The primary variables of interest are summarized in Table S-4. The mild economic impacts result from the fact that compliance costs as a percent of revenues are generally small and the demand for battery products is not very sensitive to changes in relative prices.

The lead-acid and nickel-cadmium product groups are projected to experience the greatest impacts. In the lead-acid sector, there is a high potential for two plant closures under the Alternative 5 option (out of 165 plants identified for which data was available). In addition, there will be some profit reduction for many small lead-acid battery plants. Specifically, out of the 165 lead acid plants for which data was available, 152 will experience reduction in return on sales of less than 1 percent, eight will experience profit reductions of 1-2 percent, four plants each will experience reductions of 2-4 percent, and one plant will experience reductions of 4 percent. However, except for the aforementioned two closures, these changes in gross profit margin are not enough to cause, by themselves, other plant shutdowns. Moreover, the lead-acid compliance costs, together with other Federal regulations (OSHA lead standard, air pollution, solid waste), will reinforce the current trend in the industry toward closings of small plants and increased industry concentration. In fact, at least 20 small lead-acid plants will probably cease

TABLE S-2. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS EXISTING SOURCES 1978 DOLLARS

SUBCATEGORY	ALTERNATIVE 1 CAPITAL COST $	ALTERNATIVE 1 ANNUAL COST $	ALTERNATIVE 2 CAPITAL COST $	ALTERNATIVE 2 ANNUAL COST $	ALTERNATIVE 3 CAPITAL COST $	ALTERNATIVE 3 ANNUAL COST $	ALTERNATIVE 4 CAPITAL COST $	ALTERNATIVE 4 ANNUAL COST $	ALTERNATIVE 5 CAPITAL COST $	ALTERNATIVE 5 ANNUAL COST $
Cadmium										
Direct Dischargers	60472.	23065.	122762.	37576.	146732.	48575.	181070.	65933.	624290.	133643.
Indirect Dischargers	330090.	75625.	318290.	109185.	416245.	140330.	622480.	183368.	1501581.	490754.
Subcategory Total	390562.	98690.	441052.	146761.	562977.	188905.	803550.	249301.	2125871.	624397.
Calcium										
Direct Dischargers	---	---	---	---	---	---	---	---		
Indirect Dischargers	4412.	3322.	4412.	3322.	4412.	3322.				
Subcategory Total	4412.	3322.	4412.	3322.	4412.	3322.				
Lead										
Direct Dischargers	551172.	255227.	1847257.	545971.	2251816.	670331.	2251816.	670331.	3560616.	1009569.
Indirect Dischargers	6935562.	2293924.	17773189.	4306833.	20237086.	5119444.	20237086.	5119444.	26565175.	7542289.
Subcategory Total	7486734.	2549151.	19620446.	4852804.	22488902.	5789775.	22488902.	5789775.	30125791.	8551858.
Leclanche										
Direct Dischargers	---	---	---	---	---	---	---	---		
Indirect Dischargers	45241.	28226.								
Subcategory Total	45241.	28226.								
Lithium										
Direct Dischargers	0.	494.	---	---	---	---	---	---		
Indirect Dischargers	0.	6080.								
Subcategory Total	0.	6574.								
Magnesium										
Direct Dischargers	20908.	8134.	0.	14230.	0.	14230.	0.	14230.		
Indirect Dischargers	28272.	14571.	37371.	20236.	37371.	20236.	73784.	27846.		
Subcategory Total	49180.	22705.	37371.	34466.	37371.	34466.	73784.	42076.		
Zinc										
Direct Dischargers	50294.	18219.	90013.	23918.	102156.	38187.	102156.	38187.	109028.	55191.
Indirect Dischargers	258474.	88243.	346662.	100197.	405624.	159308.	405624.	159308.	547387.	252265.
Subcategory Total	308768.	106462.	436675.	124115.	507780.	197495.	507780.	197495.	656415.	307456.
TOTAL										
Direct Dischargers	682846.	305139.	2060032.	621695.	2500704.	771323.	2535042.	788681.	4293934.	1198403.
Indirect Dischargers	7602051.	2509991.	18479924.	4539773.	21100738.	5442640.	21338974.	5489966.	28614143.	8285308.
Subcategory Total	8284897.	2815130.	20539956.	5161468.	23601442.	6213963.	23874016.	6278647.	32908077.	9483711.

TABLE S-3. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS EXISTING SOURCES 1982 DOLLARS

	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3		ALTERNATIVE 4		ALTERNATIVE 5	
SUBCATEGORY	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $
Cadmium										
Direct Dischargers	81637.	31138.	165729.	50728.	198088.	65576.	244445.	89010.	842792.	180418.
Indirect Dischargers	445622.	102094.	429691.	147400.	561931.	189446.	840348.	247546.	2027134.	662518.
Subcategory Total	527259.	133232.	595420.	198128.	760019.	255022.	1084793.	336556.	2869926.	842936.
Calcium										
Direct Dischargers	---	---	---	---	---	---	---	---	---	---
Indirect Dischargers	5956.	4485.	5956.	4485.	5956.	4485.	---	---	---	---
Subcategory Total	5956.	4485.	5956.	4485.	5956.	4485.	---	---	---	---
Leclanche										
Direct Dischargers	---	---	---	---	---	---	---	---	---	---
Indirect Dischargers	61075.	38105.	---	---	---	---	---	---	---	---
Subcategory Total	61075.	38105.	---	---	---	---	---	---	---	---
Lithium										
Direct Dischargers	0.	667.	---	---	---	---	---	---	---	---
Indirect Dischargers	0.	8208.	---	---	---	---	---	---	---	---
Subcategory Total	0.	8875.	---	---	---	---	---	---	---	---
Magnesium										
Direct Dischargers	28226.	10981.	0.	19211.	0.	19211.	0.	19211.		
Indirect Dischargers	38167.	19671.	50451.	27318.	50451.	27318.	99608.	37592.	---	---
Subcategory Total	66393.	30652.	50451.	46529.	50451.	46529.	99608.	56803.	---	---
Zinc										
Direct Dischargers	67897.	24596.	121518.	32289.	137911.	51552.	137911.	51552.	147188.	74508.
Indirect Dischargers	348940.	119128.	467994.	135266.	547592.	215066.	547592.	215066.	738972.	340558.
Subcategory Total	416837.	143724.	589512.	167555.	685503.	266618.	685503.	266618.	886160.	415066.
Lead										
Direct Dischargers	744082.	344556.	2493797.	737061.	3039952.	904947.	3039952.	904947.	4806832.	1362918.
Indirect Dischargers	9363009.	3096797.	23993805.	5814224.	27320066.	6911249.	27320066.	6911249.	35862986.	10182090.
Subcategory Total	10107091.	3441353.	26487602.	6551285.	30360018.	7816196.	30360018.	7816196.	40669818.	11545008.
TOTAL										
Direct Dischargers	921842.	411938.	2781044.	839288.	3375951.	1041286.	3422308.	1064720.	5796812.	1617844.
Indirect Dischargers	10262769.	3388488.	24947897.	6128694.	28485996.	7347564.	28807614.	7411453.	38629092.	11185166.
Subcategory Total	11184611.	3800426.	27728941.	6967982.	31861747.	8388850.	32229922.	8476173.	44425904.	12803010.

TABLE S-4A. CADMIUM ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Measure	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Investment Compliance Cost (Millions of 1978 $)	0.39	0.44	0.56	0.80	2.13
Annual Compliance Cost (Millions of 1978 $)	0.99	0.15	0.19	0.25	0.62
Annual Compliance Cost/ Subcategory Revenues (%)	0.04	0.06	0.08	0.11	0.27
Annual Compliance Cost/ Revenue (%) (for plants incurring costs)a/	0.08	0.11	0.14	0.19	0.48
Price Change (%)	0.03	0.04	0.05	0.07	0.12
Production Change (%)	0.02	0.03	0.04	0.06	0.10
Average Industry Change in Return on Sales (%)	b	b	b	b	b
Foreign Trade Change	0	0	0	0	0
Industry Structure	0	0	0	0	+
Plant Closures	0	0	0	0	2
Employment at Closed Plants	0	0	0	0	220-380

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $230 million
- number of plants = 11
- baseline plant closures = 0
- employment at cadmium plus lead plus other storage batteries = 26 thousand.

a 8 plants incur costs

b negligible, less than .05 percent

\+ increase in industry concentration

TABLE S-4B. CALCIUM ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Measure	Alternative 1	Alternative 2	Alternative 3
Investment Compliance Cost (Millions of 1978 $)	0.004	0.004	0.004
Annual Compliance Cost (Millions of 1978 $)	0.003	0.003	0.003
Annual Compliance Cost/ Subcategory Revenues (%)	0.03	0.03	0.03
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)a/	0.03	0.03	0.03
Price Change (%)	0.03	0.03	0.03
Production Change (%)	0.02	0.02	0.02
Average Industry Change in Return on Sales (%)	b	b	b
Foreign Trade Change	0	0	0
Industry Structure	0	0	0
Plant Closures	0	0	0

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $12 million
- number of plants = 3
- baseline plant closures = 0
- employment for all primary batteries equals 11 thousand.

a Two plants will incur costs

b Negligible - less than half a percent

TABLE S-4C. LEAD ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Measure	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Investment Compliance Cost (Millions of 1978 $)	7.5	19.6	22.5	22.5	30.1
Annual Compliance Cost (Millions of 1978 $)	2.5	4.9	5.8	5.8	8.6
Annual Compliance Cost/ Subcategory Revenues (%)	0.15	0.28	0.33	0.33	0.49
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)[a]	0.16	0.31	0.37	0.37	0.55
Price Change (%)	0.16	0.32	0.39	0.39	0.57
Production Change (%)	0.05	0.10	0.12	0.12	0.17
Average Industry Change in Return on Sales (%)	b	b	b	b	b
Foreign Trade Change	0	0	0	0	0
Industry Structure	n	n	n	n	n
Plant Closures	0	0	0	0	2
Employment at Closed Plants	0	0	0	0	35-70

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $1,700 million
- number of plants = 184
- baseline plant closures = 20-30
- employment at lead plus cadmium plus other storage battery plants equals 26 thousand.

a 117 plants incur costs

b Less than 0.5 percent

n Negligible increase in concentrations

TABLE S-4D. LECLANCHE ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Variable	Alternative 1
Investment Compliance Cost (Millions of 1978 $)	45.2
Annual Compliance Cost (Millions of 1978 $)	28.2
Annual Compliance Cost/ Subcategory Revenues (%)	0.01
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)[a]	0.02
Price Change (%)	0.01
Production Change (%)	0.01
Average Industry Change in Return on Sales (%)	b
Foreign Trade Change	0
Industry Structure	0
Plant Closures	0

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $317 million
- number of plants = 20
- baseline plants closures = 0
- employment for leclanche batteries not available. Employment for total primary batteries equals 11 thousand.

a Six plants incur costs

b Less than 0.5 percent

TABLE S-4E. LITHIUM ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Variable	Alternative 1
Investment Compliance Cost (Millions of 1978 $)	0
Annual Compliance Cost (Millions of 1978 $)	0.007
Annual Compliance Cost/ Subcategory Revenues (%)	0.91
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)[a]	1.0
Price Change (%)	0.91
Production Change (%)	0.73
Average Industry Change in Return on Sales (%)	b
Foreign Trade Change	0
Industry Structure	0
Plant Closures	0

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $0.723 million
- number of plants = 8
- baseline plant closures = 0
- total employment for all primary battery plants equals 11 thousand.

a Two plants will incur costs

b Less than a half percent

TABLE S-4F. MAGNESIUM ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Variable	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Investment Compliance Cost (Millions of 1978 $)	0.05	0.037	0.037	0.074
Annual Compliance Cost (Millions of 1978 $)	0.023	0.034	0.034	0.042
Annual Compliance Cost/ Subcategory Revenues (%)	0.12	0.18	0.18	0.22
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)	0.31	0.46	0.46	0.57
Price Change (%)	0.16	0.24	0.24	0.29
Production Change (%)	0.10	0.14	0.14	0.16
Average Industry Change in Return on Sales (%)	b	b	b	b
Foreign Trade Change	0	0	0	0
Industry Structure	0	0	0	0
Plant Closures	0	0	0	0

Baseline subcategory characteristis:
- value of shipments in 1978 dollars = $19 million
- number of plants = 8
- baseline plant closures = 0
- employment at magnesium anode plant is unknown; however, employment for all primary batteries is 11 thousand.

a Three plants will incur costs

b Less than a half percent

NA Not applicable

TABLE S-4G. ZINC ANODE BATTERIES
SUMMARY OF ECONOMIC IMPACTS FOR EXISTING SOURCES

Impact Measure	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Investment Compliance Cost (Millions of 1978 $)	0.31	0.44	0.51	0.51	0.66
Annual Compliance Cost (Millions of 1978 $)	0.11	0.12	0.20	0.20	0.31
Annual Compliance Cost/ Subcategory Revenues (%)	0.05	0.06	0.09	0.09	0.14
Annual Compliance Cost/ Revenues for Plants Incurring Costs (%)	0.05	0.06	0.10	0.10	0.16
Price Change (%)	0.05	0.06	0.07	0.07	0.12
Production Change (%)	0.04	0.05	0.06	0.06	0.09
Average Industry Change in Return on Sales (%)	b	b	b	b	b
Foreign Trade Change	0	0	0	0	0
Industry Structure	0	0	0	0	0
Plant Closures	0	0	0	0	0

Baseline subcategory characteristics:
- value of shipments in 1978 dollars = $216 million
- number of plants = 25
- baseline plant closure = 0
- employment for total primary batteries is 11 thousand.

a 22 plants will incur costs

b Negligible, less than 0.5 percent

battery production during the next 10 years, even without the proposed regulation. It cannot be stated, with any degree of certainty, whether or not these 20 plants would include the two that are predicted to close because of the regulations. These two plants account for less than one-tenth of a percent of industry production and contain fewer than 70 employees.

The primary mechanism for these effects is the intra-industry distribution of compliance costs. That is, the average compliance costs per unit for the large plants, which account for most of industry capacity, is significantly smaller than those of the smaller plants. Since these plants account for most of industry production, they will be able to maintain their profitability with very small price increases. Thus, the expected price changes are quite small. The smaller firms, except those in certain specialty markets, will have to absorb some, or most, of their compliance costs in order to sell their products at the market price.

The nickel-cadmium sector is likely to experience two plant closures under Alternative 5 and no plant closures at the other options. Closings of these two plants could significantly increase concentration in certain submarkets. These two plants employ 220 to 320 people and are parts of larger manufacturing establishments. The primary mechanisms for these effects are similar to those described above for the lead-acid sector -- intra-industry distribution of compliance costs. Specifically, these two plant closures involve production lines which produce sealed nickel-cadmium batteries and account for 15 to 25 percent of sealed nickel-cadmium battery shipments. There are six plants in the U.S. that manufacture sealed nickel-cadmium batteries. One of these plants accounts for 60 to 65 percent of industry shipments. Because this firm has potential for dominating the industry and because it will experience no compliance costs, it is expected that the regulations will have no impact on industry prices. Thus, the two smaller plants will be unable to pass on the compliance costs in the form of higher prices and must absorb the entire cost of the Alternative 5 option. At all other regulatory options, none of these plants are considered likely closure candidates, because the technologies are considerably less expensive.

If under the Alternative 5 option, these two nickel-cadmium plants closed, sealed nickel-cadmium industry capacity would drop substantially (15 to 25 percent). To the extent that this void is filled by the industry's largest producer (the firm with 60 to 65 percent of the market), this industry sector will become significantly more concentrated.

Compliance costs as a percent of revenue for most other of the nonlead-acid battery plants are significantly lower than those for the lead-acid plants. As seen in Table S-4, they are not enough to cause significant changes in the quantities of batteries demanded, nor in the general international competitiveness of the American battery manufacturing industry. However, as in the lead-acid sector, there is a variation in compliance costs from plant to plant that will force some plants to absorb some, but usually not all, of the increased cost of production. However, these changes are usually small fractions of a percent of the profit rates. Likewise, several plants will be able to increase their profit rates slightly since the industry price level would increase more than their costs. The magnitude of all the price, production, and profitability changes are extremely small in comparison to the projected growth rate of 3 to 5 percent annually to 1990 for the primary battery industry.

Impacts on Small Entities

The proposed regulations will have a greater impact on the profitabilities of small plants than they will on that of larger ones. This is primarily because of economies of scale in the water pollution control technologies. Because of these economies of scale, the average unit compliance cost for small plants are greater than that for larger ones. However, for most of these plants, compliance costs are no greater than a fraction of a percent of revenues. Consequently, these costs will not cause more than the aforementioned four plant closures.

All four projected plants expected to close as a result of the proposed Alternative 5 are small. Two of the four (the nickel-cadmium plants) belong to large corporations. The other two are small independent lead-acid plants. A Regulatory Flexibility Analysis appears in Chapter 8 and provides a description of the impacts on small entities.

General Impacts

As summarized in Table S-4, the estimated impacts on prices, production levels and foreign trade are small. The projected four plant closures involve between 255 and 390 jobs. However, these amounts are small relative to the size of the communities in which the plants are located; hence, there will be no significant community impacts. Because industry output is expected to grow around 3 to 5 percent annually, quantity reductions of fractions of a percent will not be noticeable.

Social Costs

The social costs of these regulations are estimated to provide an indication of the value of goods and services lost to society as a result of the regulatory action. The present value of social costs (PVSC) is defined as the discounted value of all costs incurred in perpetuity. Assuming that compliance expenditures begin in 1984 and that the real discount rate is 10 percent, the PVSC of the regulatory alternatives are:

Regulatory Alternatives	Social Cost millions of 1978 dollars
Alternative 1	20.5
Alternative 2	32.5
Alternative 3	39.7
Alternative 4	40.1
Alternative 5	62.1

New Source Impacts

Newly constructed facilities and facilities that are substantially modified are required to meet the New Source Performance Standards (NSPS) and/or the Pretreatment Standards for New Sources (PSNS). EPA considered three or more regulatory alternatives for selection of NSPS and PSNS technologies. The considered options are equivalent to those discussed for existing sources and are described in Chapters 6 and 7 and in the Development Document.

The cost of the new source standards are defined as those that are incremental over those for existing standards. The total industry new source costs are estimated for the period 1980 to 1990 under the assumption that (a) all of the increases in capacity during that period will be subject to new source standards (including substantially modified existing sources as well as newly constructed plants), and (b) new source compliance costs are equal to existing source compliance costs for comparable plants and compliance options.

Under these assumptions, new source investment costs are estimated to average 0.91 percent of plant assets and new source annual costs are estimated to be 0.18 percent of revenues of new sources, for all new sources in the entire industry. Using forecasts of industry capacity increase to 1990 (1,100 million in 1978 dollars), the new source selected option will total $2.0 million in annual costs and $10.0 million in investment costs for the entire industry. As reported in Chapter 7, these costs are not enough to cause significant barriers to the construction of new plants, nor are they likely to cause plant closures or job losses.

1. INTRODUCTION

1. INTRODUCTION

1.1 PURPOSE

This report identifies and analyzes the economic impacts of water pollution control regulations on the battery manufacturing industry. These regulations include effluent limitations and standards based on BPT (Best Practical Control Technology currently available), BATEA (Best Available Technology Economically Achievable), PSES (Pretreatment), NSPS (New Source Performance Standards), and PSNS (Pretreatment Standards for New Sources) which are being proposed under authority of Sections 301, 304, 306, 307, 308, and 501 of the Federal Water Pollution Control Act, as Amended (the Clean Water Act). The primary economic impact variables of interest include price changes, plant closures, substitution effects, changes in employment, shifts in the balance of foreign trade, changes in industry profitability, structure, competition, and impacts on small business.

1.2 INDUSTRY COVERAGE

Batteries store electrical energy through the use of one or more electrochemical cells in which chemical energy is converted to electrical current. A typical battery cell consists of two dissimilar materials (called cathodes and anodes) immersed in an electrolyte (a substance which in solution is capable of conducting an electric current). When the metal electrodes are connected to an electric circuit, current flows.

There are at least two dozen battery types, as defined by their basic electrolyte couple type, and many variations of each, depending on battery structure, variations in chemistry, and production methods. Sixteen of these battery types represent at least 98 percent of the volume of shipments of batteries in the U.S. For purposes of this study, the battery industry consists of establishments that manufacture these 16 types of batteries. A list of these appears in Table 1-1. The remaining battery types were omitted from detailed analysis in this study because they are either no longer in production, are of little commercial significance, or are experimental (e.g., nickel-zinc and fuel cells).

1.3 INDUSTRY SEGMENTATION

There are a number of ways in which battery types may be classified for study and different data sources often use one, ignore others, and/or confuse two or more classification schemes. Examples of some commonly used classification schemes include:

Nomenclature System	Example
end-use	flashlight
size	D
shape	cylindrical, rectangular
anode/cathode couple	carbon-zinc
inventor's name	Leclanche cell
electrolyte type	acid or alkaline
usage mode	primary cell.

No single classification system is ideal in every single context. The appropriateness of a given system is determined by its intended use. There are three methods of segmenting the industry that are pertinent to this study--the basic anode material used, whether it is primary or secondary, and anode-cathode couple (the dissimilar metals used; also called the negative and positive plates).

The companion technical study categorized the industry according to the basic anode material used and, to some extent, according to whether the electrolyte was acid or alkaline. The basic groupings are: Cadmium, Calcium, Lead, Leclanche, Zinc, Lithium, and Magnesium. This categorization seems appropriate since the primary purpose of the study was an evaluation of production processes and their effluents.

TABLE 1-1. RELATIONSHIP OF TECHNICAL INDUSTRY SUBCATEGORIES TO ECONOMIC INDUSTRY SEGMENTS

Battery Product Groups	Technical Subcategory
Lead Acid	Lead
Carbon Zinc and Related Types	Leclanche
Alkaline Manganese Carbon Zinc-Air Mercury Ruben Nickel Zinc Mercury Cadmium Zinc	Zinc Anode, Alkaline Electrolyte
Nickel Cadmium Mercury Cadmium Silver Oxide Cadmium	Cadmium Anode
Magnesium Carbon Magnesium Reserve Thermal	Magnesium Anode[1/]
Lithium	Lithium Anode[1/]
Calcium	Calcium[2/]

[1/] Does not include thermal

[2/] Includes magnesium, lithium, calcium anode, and other thermal batteries.

While the anode classification scheme may be appropriate from a technical viewpoint, it is expected that economic and financial impacts of the regulations will vary with the type of product, end use, and industry organization. This is because the determinants of demand, availability of substitutes, and pricing latitude will vary with these factors. For this reason, battery type as described by their cathode-anode pair is the primary segmentation scheme used in the economic study. Table 1-1 above shows the relationship between the technical and economic industry classification schemes.

Batteries are also classified according to whether they are storage (also called secondary) or primary. A storage battery can be recharged by connecting it to a source of electrical current. Primary batteries, on the other hand, are not rechargeable. Instead, such batteries are usually discarded after the charge has been drained. The standard SLI (Starting, Lighting, and Ignition) automobile battery is the most common example of a storage battery, while a calculator or flashlight battery are common examples of primary batteries. Some cathode-anode pairs can be made in either primary or storage configurations. However, one of the two usually accounts for most of industry volume and, for this reason, each cathode-anode pair is usually classified as being either primary or secondary.

In addition to classifying batteries by whether they are storage or primary, batteries may also be classified another way: dry cells and wet cells. Dry cells are generally smaller and more mobile, since their contents are nonspillable. Examples of these are flashlight and hearing aid batteries. Wet cells are generally larger, heavier, and less mobile. The automobile battery, weighing 35 to 40 pounds, is the most obvious example of this type. Battery sizes vary from large lead-acid industrial storage batteries weighing as much as 6,000 pounds to small hearing aid or watch batteries. Production and shipment data on each specific size is extremely difficult to find. For this reason, much of the analysis is done on the basis of weight or value of battery production. Wherever possible, however, reference is made to number of units.

1.4 ORGANIZATION OF REPORT

The remainder of this report consists of 8 additional chapters. Chapter 2 presents an overview of the methodology used in the study. Chapters 3 and 4 describe the basic industry characteristics of interest and Chapter 5 projects some of the critical parameters into the future to enable an understanding of the expected characteristics of the industry during the 1985 to 1990 time period, when the primary economic impacts of the proposed regulations will be felt. Chapter 6 describes the pollution control technologies being recommended by EPA and their associated costs. The information in this chapter is derived primarily from the companion technical study and is published in the Draft Development Document for Effluent Limitations Guidelines and Standards for the Battery Manufacturing Point Source Category (EPA-440/1801067-a), prepared by EPA's Effluent Guidelines Division in ________________ . Chapter 7 presents the economic impacts estimated to result from the incurrence of the costs described in Chapter 6. Chapter 8 discusses the impacts on small business, as a subset of the general impacts, and Chapter 9 outlines some limitations of the data, methodology, and assumptions used.

2. STUDY METHODOLOGY

2. STUDY METHODOLOGY

2.1 OVERVIEW

Figure 2-1 shows an overview of the analytical approach used to assess the economic impacts likely to occur as a result of the costs of each proposed regulatory option. For the lead-acid and cadmium battery industry segments there were five alternative regulatory options considered in the economic study; each option represents increasing levels of compliance costs and, generally, pollution abatement. For the other industry segments four regulatory options were considered. The basic approach used in this study was to develop a model of the price and output behavior of the battery manufacturing industry. This model explicitly considered the changes in output caused by reductions in quantity demanded due to higher prices as well as changes in supply due to plant closings, for each regulatory option.

The model, in conjunction with compliance cost estimates supplied by EPA, was used to determine new post-compliance industry price and production levels for each major battery product group and for each regulatory option. Individual plant data was then analyzed under conditions of the postcompliance industry price levels, for each regulatory option, to isolate those plants whose production costs would appear to change significantly more than the estimated change in their revenues. Those plants whose estimated production costs changed significantly more than their estimated revenue changes were subjected to a financial analysis that used capital budgeting techniques to determine likely plant closures. The industry model was then re-solved for each regulatory option to incorporate the reduced supply into the analysis. Finally, other effects which flow from the basic price, production, and industry structure changes were determined. These include employment, community, and foreign trade impacts. Specifically, the study proceeded in the following eight steps:

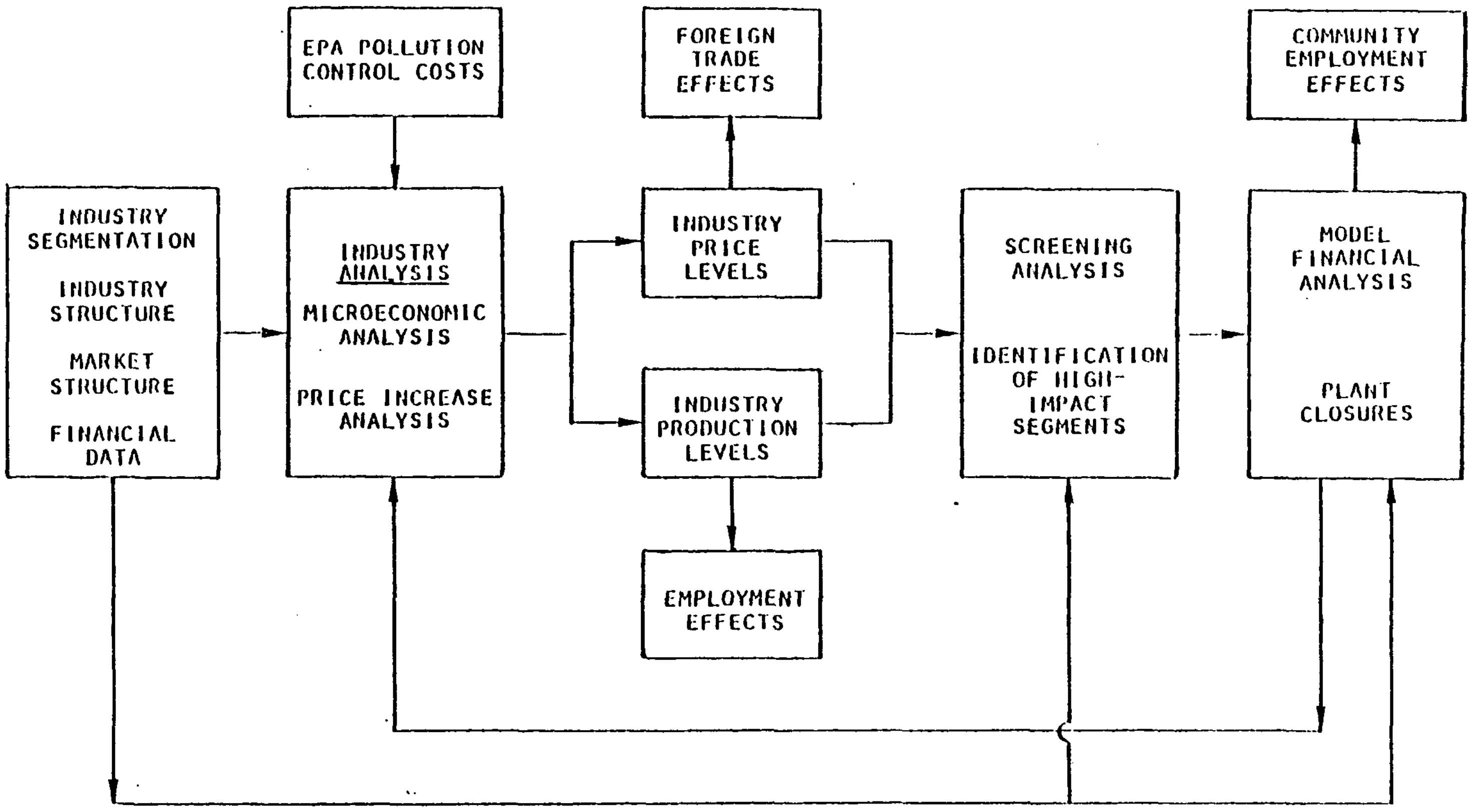


FIGURE 2-1. ECONOMIC ANALYSIS STUDY OVERVIEW

1. Description of industry characteristics
2. Industry Supply and Demand Analysis
3. Analysis of cost of compliance estimates
4. Plant level screening analysis
5. Plant level profitability analysis
6. Plant level capital requirements analysis
7. Assessment of plant closure potential
8. Assessment of other impacts
9. Estimation of social costs
10. Small business analysis
11. Assessment of new source impacts.

Although each of these steps is described separately in this section, it is important to realize that there were significant iterations between them, as shown in Figure 2-1.

2.2 STEP 1: DESCRIPTION OF INDUSTRY CHARACTERISTICS

The first step in the analysis was to develop a description of the basic industry characteristics that would enable estimation of key parameters which describe the initial impacts of the regulation. These characteristics, which include the determinants of demand (e.g., demand elasticities), market structure, the degree of intra-industry competition, and financial performance, are described in Chapters 3 and 4 of this report.

The sources for this information include government reports, proprietary market research studies, textbooks, trade association data, The Trade Press, discussions with various trade association representatives and individuals associated with the industry, visits to five battery manufacturing plants, an EPA industry survey, and plant-by-plant compliance cost estimates developed by EPA's Effluent Guidelines Division. From the first step, several observations were made which influenced the remainder of the analysis. These are:

- Generally low demand elasticity for the total industry, due primarily to a lack of substitutes for batteries

- Somewhat higher elasticities (although still generally inelastic) for individual battery product groups, due to the ability to substitute one battery type for another
- Relative price levels and demand elasticities between now and 1985 will not change significantly
- Low estimated compliance costs for most plants
- A wide variation in estimated unit compliance costs among plants
- A lack of plant-level data on a number of key variables, such as profitability.

These observations indicated that if significant economic impacts were to result from the compliance costs they would be caused by variations in conditions among plants and firms within the industry. For this reason, there was a need for analytical methods that would account for these inter-plant and inter-firm variations.

2.3 STEP 2: SUPPLY-DEMAND ANALYSIS

The purpose of the supply-demand analysis, step 2 of the study approach, is to determine the likely changes in market prices and industry production levels resulting from each regulatory option for each battery product group. The estimates of post-compliance price and output levels are used in the plant-level analysis to determine post-compliance revenue and profit levels for specific plants in each product group. If prices can be successfully raised without significantly reducing product demand and companies are able to maintain their current financial status, the potential for plant closings will be minimal. If prices cannot be raised to fully recover compliance costs because of the potential for a significant decline in product demand or because of significant intra-industry competition, the firms may attempt to maintain their financial status by closing higher cost/less efficient plants. The supply-demand analysis was divided into four basic components: determine industry (product group) structure, project changes in industry structure to 1985 (the expected effective date for the proposed regulations), determine plant- and firm-specific operational parameters (e.g., production costs, profit rates, etc.), and develop price-quantity algorithms.

Short run pricing behavior depends upon the market structure of the industry. Economic theory predicts different pricing behaviors for competitive, oligopoly, monopoly, or other types of markets. Many economic impact studies begin by assuming perfect competition. However, some of the product groups covered in this study exhibit some characteristics that are indicative of non-competitive markets. Each product group was characterized according to the market structure that appears to describe its nature. Three types of markets applied.

The first is a perfectly competitive market structure in which all firms have identical cost structures. In this situation, the industry marginal cost curve is found as a horizontal summation of individual marginal cost curves. Given similar compliance requirements among firms, the supply curve shifts upward by the exact amount of the compliance cost and the position of each firm relative to its competitors remains unchanged.

The second market structure involves markets which contain many buyers and sellers, each seller with a significantly different cost function from the others. In this situation, the price increase will approximate the amount that the lower-cost producers (including pollution control costs) would need to maintain their pre-compliance financial performance. The rationale for this conclusion is that producers will attempt to move toward their original equilibrium output, but at prices sufficient to maintain their equilibrium return on equity. That is, when required to incur pollution control expenses they will raise prices sufficiently to cover the additional variable and fixed costs (including a return to the additional invested capital). However, the price change necessary for the low-cost plants will generally be lower than that for the high-cost plants. If the high-cost plants attempt to recover their full costs they will be charging more than the low-cost plants and, consequently, would lose all their business, providing there is sufficient capacity among low-cost producers. Thus, the price change is generally determined from the cost functions of the low-cost plants. In Chapter 6, the plants that cannot operate at these new prices are isolated.

Because of the high concentration ratios for some of the product groups, oligopolistic pricing behavior might be expected. For this market structure, full cost pricing is assumed to characterize the behavior of oligopolistic firms. That is, price is assumed to cover average total cost (the sum of average variable cost, average fixed cost, and a fair return on investment) of the "price leaders" in the product group. It is assumed that one or a few firms will have the ability, because of their market power, to impose their most desired price and output strategy on the other firms in the market for the product group.

The oligopolistic pricing model is used for those product categories which exhibit characteristics of oligopoly markets, such as the following:

- Few firms in the product group
- High four-firm concentration ratio (greater than 75 percent)
- Low degree of foreign competition (less than 10 percent of U.S. sales)
- Abnormally high profitability (return on assets)
- Low demand elasticities
- Large capital requirements (ratio of fixed costs to variable costs)
- Large degree of integration of production, marketing, and distribution
- Large degree of specialized knowledge.

Industries which exhibit the first three of these characteristics are those in which the pricing and output actions of one firm will directly affect those of others in the industry. While these conditions do not guarantee oligopolistic behavior, they are necessary conditions for one and good indicators that one exists. Abnormally high profits in an industry would, in time, normally attract new entrants to the industry, thereby increasing price competition and industry marginal costs. However, very high profits over long periods of time which are not explained by such factors as excess risk, unusual amounts of technological innovation, or firm size may be an indicator of an imperfect market structure. Such conditions may occur when entry into an industry is difficult. The last three of the above points are indicators of difficulty of entry.

It was necessary to determine if the key industry structure parameters would change significantly by 1985. Projections of industry conditions began with a demand forecast. The demand in 1985 is estimated via a consensus of several economic forecasting techniques, including econometric models, trend analysis, and market research analysis. An examination was also made of the factors which might affect the real cost of manufacturing batteries. No reason was found to expect the real price of battery products to increase between now and 1985. It was concluded from the projections of industry conditions that only minor changes in market structure would occur in the base case. For this reason, the market structures previously described were used to develop the pricing algorithms.

A significant limitation to the analysis of market structure is that little information on the variation in key parameters, such as production costs and profit rates among plants, was available to the study team. In place of this data, industry-wide averages were used. For example, 12 percent return on assets was used for the lead battery subcategory. These averages were estimated from various published data sources and information from discussions with industry personnel during site visits. The key published sources include Census of Manufactures, company annual reports, Standard and Poor's Corporation Records, the FTC's Quarterly Financial Statistics, and other Government reports which include data from site visits. Compliance cost data, on the other hand, were available for specific plants and an examination of them showed wide variation in unit compliance cost from one plant to another within each subcategory. For this reason, the economic impact analysis was conducted under the assumption of equal profit margins among plants, but with varying compliance costs.

The use of the price-quantity algorithms assumes the following:

- Each battery product is a homogeneous good with a separate market mechanism of its own. (The substitution possibilities between battery types is considered in the determination of demand elasticities.)
- Each market is currently at "equilibrium", or will be when the regulations become effective.
- If possible, firms will attempt to maintain their current financial status by passing through industry-wide cost increases in the form of higher prices.

For competitive markets these forces are summed up in the interaction of elasticities of supply and demand. That is, the amount of a cost increase that will be passed through into higher prices is

$$\frac{E_s}{E_d + E_s} \quad (1)$$

where E_s is the elasticity of supply and E_d is the elasticity of demand.[1/] Since the available data precluded the estimation of E_s, a full-cost pricing strategy was used. Since the estimated impacts are so small, other pricing strategies are not explicitly covered in this report. Full-cost pricing appears to characterize the long-term behavior of battery firms in normal years in which price is assumed to cover average total cost. In this context, average total cost equals average variable cost plus average fixed cost plus a

---

1/ In a competitive market price = marginal cost, therefore

$E_s = \frac{dQ_s}{dp} \cdot \frac{P}{Qs} = \frac{dQs}{dmc} \cdot \frac{mc}{Qs}$, where mc = marginal cost, P = market price, and Qs = quantity supplied.

See Levenson, Albert M., and Solon, B. S., Outline of Price Theory, Holt, Rinehart and Winston, Inc., pp. 56-59, 1964.

target rate of return of investment. Thus, for each homogeneous product group and for each regulatory option the following algorithms were used:

(2) $$P_1 = P_o + \frac{CC}{Q_o} + ROI\ (Icc)$$

$$Q_1 = Q_o + \left(\frac{P_1 - P_o}{P_o}\right) \varepsilon Q_o$$

(3) $$P_2 = \frac{P_1 Q_1 + (Q_o - Q_1)(P_1)(AFC)}{Q_1}$$

$$Q_2 = Q_1 + \left(\frac{P_2 - P_1}{P_1}\right) \varepsilon Q_o$$

$$\vdots$$

where

P_o = initial pre-compliance price

P_1, P_2, P_3, etc. = successive rounds of price changes

CC = total annualized compliance cost

Q_o = initial pre-compliance quantity

ROI = return on net assets

Icc = investment compliance costs per unit of output

ε = demand elasticity

Q_1, Q_2, Q_3, etc. = successive rounds of quantity changes

AFC = average fixed costs = ratio of fixed cost to revenues

This algorithm is similar in intent to (1), except that Equations (2) and (3) are iterated to solve for successive price/quantity adjustments until it converges. This algorithm accomplishes the same theoretical result as Equation (1), except that it assumes that firms will attempt to approach the pre-compliance return on net assets, instead of maximization of revenues. For competitive battery product groups the compliance costs used were the mean for the product group. For those product groups in which one, two, or three firms appear to dominate the market and have relatively low compliance costs, the compliance costs of these firms are used in this algorithm. That is, it is assumed that these alleged "price leaders" will set the prices so as to maintain their pre-compliance return on investment and the remainder of the industry will be price takers.

The post-compliance market price levels are used, in a later step, to assess the financial condition of individual battery manufacturing facilities.

2.4 STEP 3: COST OF COMPLIANCE ESTIMATES

Investment and annual compliance costs for 239 production facilities were estimated by EPA's Effluent Guidelines Division. For three technical subcategories (lead, cadmium and zinc) there are five sets of costs, corresponding to increasing levels of pollution control. For the remaining subcategories only four options were considered. For purposes of this report the five regulatory options are labeled "Alternative 1, Alternative 2, etc." A description of the control and treatment technologies and the rationale behind these compliance cost estimates appear in Chapter 5.

2.5 STEP 4: PLANT LEVEL SCREENING ANALYSIS

The screening analysis uses two basic criteria to separate those plants with obviously small impacts from those with potentially significant impacts. The first criteria is the ratio of total compliance cost to revenue for each plant; if the ratio is less than one percent, that plant is considered as "low impact." For these plants, the changes in plant profitabilities are very small. Although some of these plants will probably experience some drop in their profitabilities, they would not be considered candidates for closure. Estimates of profitability changes for these plants are recorded, but they are not subject to a detailed financial analysis.

The second criteria is change in return on sales (ROS). In general, if a plant's ROS is estimated to fall by less than one percent, that plant is not considered to be a candidate for closure. Twenty-one plants had changes in ROS estimated to be greater than one percent. These plants were subjected to a more detailed financial analyses described in steps 5 through 7.

2.6 STEP 5: PLANT LEVEL PROFITABILITY ANALYSIS

Two different measures of financial performance were used to assess the impact of the proposed regulations on the profitabilities of individual plants: Return on Investment (ROI) and Internal Rate of Return (IRR). The use of these techniques involved a comparison of the measures with a critical value.

The return on investment represents the ratio of annual profits after taxes to the net assets of a plant. This measure is based on accounting income rather than cash flows and fails to account for the timing of cash flows, thereby ignoring the time value of money. However, this technique has the virtue of simplicity and common usage in comparative analysis of profitabilities of financial entities. Since ROIs for the individual plants were not available to the study team a broad range of estimates was developed using aggregate industry and sample plant data. The estimation procedure is described in Appendix A.

Discounted cash flow (DCF) approaches take into account both the magnitude and the timing of expected cash flows in each period of a project's life, and provides a basis for transforming a complex pattern of cash flows into a single number. There are two major techniques for applying DCF analysis: the internal rate of return (IRR) method and the net present value method (NPV).

Because of shortcomings of both approaches to capital budgeting decisions, and because of the limitations of available data, neither will provide both a theoretically correct and realistic estimate of plant closures. Although net present value (NPV) is the most theoretically correct method from an economic viewpoint, it was not used here for several reasons: first, the detailed data necessary to estimate fluctuations in cash flows were not gathered in this study. Second, a more efficient technique for applying the DCF rationale is available, given the data constraints. That is, it can be shown that under the assumption of a constant rate of net cash flows for any given plant, the DCF rationale could be applied, given only one year of data, by using the IRR technique. The IRR technique will generally provide the same plant closure decisions as the NPV technique. Moreover, because several estimates of cost of capital (or "hurdle" rates) can be used, IRR is more amenable to sensitivity analysis than NPV, and sensitivity analysis will be required for this problem. That is, several different estimates of hurdle rates can be used to test the sensitivity to the assumptions underlying the profitability estimates, for which we suspect wide confidence intervals around the estimates. In addition, the IRR technique will be easier to implement in this case, while under the aforementioned assumptions it will always lead to the same investment decisions as the NPV technique.

The IRR for an investment is the discount rate that equates the present value of the expected stream of cash outflows with that of the expected inflows. It is represented by that rate r, such that

$$\sum_{T=0}^{n} A_T (1 + r)^{-T} = 0$$

where A_T is the cash flow for period T, and n is the number of periods the cash flow is expected. Standard methodology calls for solving the equation for r and then comparing to some required cutoff, or hurdle rate, to determine acceptability of the investment. A relatively conservative approach is to select the cost of capital as the hurdle rate. If the initial cash outlay (A_0) occurs at time T = 0, and if the cash flow is a constant series (A), then

$$A_0/A = \sum_{T=1}^{n} (1 + r)^{-T}.$$

Since the values for r corresponding to various values of $\sum_{T=1}^{n} (1 + r)^{-T}$ are provided in standard present value tables, r can be found by simply dividing the initial outlay by the cash flow (i.e., A_0/A) to obtain a factor which can then be used in conjunction with a present value table to determine the discount rate. Appendix A provides a derivation of this relationship. Thus, the IRR is expressed as a function of A_0, A, and n. Since n may remain fixed in our analysis (e.g., 10 years), the IRR is a function only of A/A_0. In brief, if the cash flow is constant, and if the initial investment occurs at time T = 0, then the ratio of cash flow for any given year to initial investment is sufficient to calculate IRR. For this analysis, the initial investment is the market value of the plant plus the pollution control investment at purchased price, plus working capital.

Most of the data used in this analysis were estimated from a combination of publicly available information and the technical 308 Survey. The following are the most important variables:

- Pre-compliance plant revenues = P_1Q_1, where P_1 is average sales price reported by industry sources and Q_1 (production in pounds) is reported in the 308 Survey.
- Post-compliance revenues = P_2Q_2, where P_2 is defined in the microeconomic supply-demand analysis and $Q_2 = Q_1 + E\ \Delta P/P_1(Q_1)$, where E is the demand elasticity.
- Pollution control costs are supplied by EPA.
- Profits are estimated from industry sources and average factors from company annual reports.
- Depreciation charges are assumed to be a straight line over 10 years.
- Fixed assets are determined as a percent of revenues. Averages for the appropriate 4-digit SIC codes are used.
- Salvage value = current assets + 0.3 of fixed assets.

- Income tax rates are assumed to be 30 percent.
- The critical value is assumed to be 10 percent. The rationale for this value is presented in Appendix A.

The sources for these estimates are described in Sections 3, 4, and 7 and in Appendix A of this report.

2.7 STEP 6: CAPITAL REQUIREMENTS ANALYSIS

In addition to analyzing the potential for plant closures from a profitability perspective, it is also of interest to assess the ability of firms to make the initial capital investment needed to construct and install the required treatment systems. Some plants which are not initially identified as potential closures in the profitability analysis may encounter problems raising the amount of capital required to install the necessary treatment equipment. To assess the financial impact of committing the capital necessary to install the specified pollution control systems, two ratios are calculated:

- $\frac{\text{compliance capital investment}}{\text{estimated fixed plant assets}}$
- $\frac{\text{compliance capital investment}}{\text{estimated annual capital expenditures}}$.

The "investment requirements to assets" ratio provides a measure of the relative size of the required pollution control investment as compared to the size of the existing facility, and the "investment requirements to normal annual capital expenditures" ratio measures the magnitude of the capital investment required for compliance in relation to the pre-compliance average annual capital expenditures of the plant. The latter ratio reflects, to some extent, the practice of viewing the level of normal pre-compliance capital expenditures as a budget standard of what a firm considers to be a viable expenditure level. From this perspective, the ratio of "capital investment requirements to annual capital expenditures" suggests the extent that resources would have to be diverted from the normal investments used to sustain and improve the plant's competitive position.

Although these ratios provide a good indication of the relative burden created by the compliance requirement, they do not precisely indicate whether or not firms can afford to make the investments. If, for example, the same investment requirements were placed on a firm which is already highly leveraged (as indicated by a high debt/equity ratio) and a firm which is not leverged (as indicated by a debt/equity ratio of zero), the highly leveraged firm is likely to experience the most significant impact. In addition, the capital requirements must be evaluated together with other factors, such as profitability. For example, a plant that is extremely profitable would consider the risk of more leverage or increased cost of capital resulting from expansion more worthwhile than would a low profit plant.

The data to be used in these calculations are:

- Compliance capital investment is taken from the technical contractor's cost estimate.
- Plant fixed assets were estimated, as above, from industry-wide data published in Census of Manufactures and the FTC's Quarterly Financial Ratios.
- Annual capital expenditures at the plant level were extrapolated from industry-level ratios from Census of Manufactures, and annual reports (i.e., capital expenditures ÷ revenues).

Although the extrapolation of industry-level parameters to plant-specific parameters understates, somewhat, the variation in characteristics among plants and firms, the resulting estimates appear to provide a valid indication of the impacts that might occur as a result of the proposed regulations.

2.8 STEP 7: PLANT CLOSURE ANALYSIS

The plant level analysis examined the individual production units manufacturing each product group to determine the potential for plant closures and profitability changes. The decision to close a plant, like most major investment decisions, is ultimately judgmental. This is because the decision involves a wide variety of considerations, many of which cannot be quantified or even identified. Some of the most important factors are:

- Profitability before and after compliance
- Ability to raise capital
- Market and technological integration
- Technological obsolescence
- Market growth rate
- Other pending Federal, state, and local regulations
- Ease of entry into market
- Market share
- Foreign competition
- Substitutability of the product
- Existence of specialty markets.

Many of these factors are highly uncertain, even for the owners of the plants. However, this analysis was structured to make quantitative estimates of the first two factors, as described above, and to qualitatively consider the importance of the others. In this analysis, the first two factors are given the greatest amount of weight and the importance of the other factors vary from plant to plant. To provide a format to assess the combined effects of these factors, a matrix which clearly displays assessments for each of these factors was developed. This matrix provided a format which facilitates the evaluation of the combined effects of the key variables.

2.9 STEP 8: ASSESSMENT OF OTHER IMPACTS

"Other impacts" include economic impacts which flow from the basic price, production, and plant level profitability changes. These impacts include impacts on employment, communities, industry structure, and balance of trade.

The estimate of employment effects flows directly from the outputs of the industry level analysis and the plant closure analysis. The algorithms used are:

$$\Delta \text{ direct employment} = \text{employment at closed facilities} + (\Delta Qr)(Q/\text{employee})$$

ΔQ_r = change in quantity produced at the remaining plants, which is derived from the microeconomic and plant level analyses.

Q/employee = baseline quantity produced per employee (average for industry).

Employment estimates for the closed production facilities are taken from the technical industry survey.

Community impacts result primarily from employment impacts. The critical variable is the ratio of battery industry unemployment to total employment in the community. Data on community employment are available through the Bureau of the Census and the Bureau of Labor Statistics. Sometimes county-wide data will have to be relied upon in the absence of community-specific data.

The assessment of industry structure changes is based on examination of the following before and after compliance with the regulation:

- Numbers of firms and plants
- 4- and 8-firm concentration ratios
- Variance of average total production cost per unit
- Effects of plant closures on specialty markets.

Decreases in the first factor and/or increases in the second factor would indicate an increase in industry concentration and may change the pricing behavior of the industry. Such potential changes were qualitatively evaluated. An increase in variability of average costs would indicate that some firms have become more competitive than others, as a result of the regulation. The long-term implications of such developments were examined.

As described in Chapter 4, imports and exports are a very small portion of battery industry activity and, considering the small price effects projected in this study, it does not appear that significant changes in the balance of trade would result from the regulation.

2.10 STEP 9: ESTIMATION OF SOCIAL COSTS

This analysis assesses the total social costs that can be associated with the EPA effluent regulations. The social costs measure the value of goods and services lost by society due to a given regulatory action. These costs generally include the use of resources needed to comply with a regulation, the use of resources to implement and enforce a regulation, plus the value of the output that is forgone because of a regulation.

For this analysis only the real resource costs are considered. This provides an approximation of total social costs, since most of the social costs are directly related to compliance expenditures by the regulated entities. Consequently, the present value of social costs (PVSC) of regulations can be approximated by the following equation:

$$PVSC = I + (OM/.1)\ r^{-n}$$

where: PVSC = present value of social costs
I = investment cost
OM = annual operating and maintenance cost
r = real discount rate
n = number of years between now and the year the investment is incurred (1984; n=2)

The above equation assumes that:

- The regulations will be in effect in perpetuity
- Operating and maintenance costs will be incurred in the first year of investment

It is assumed that the discount rate = 10 percent (mandated by OMB) and that compliance expenditures will begin in 1984; therefore n equals 2.

2.11 STEP 10: SMALL BUSINESS ANALYSIS

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354), which amends the Administrative Procedures Act, required Federal regulatory agencies to consider "small entities" throughout the regulatory process. An initial screening analysis is performed to determine if a substantial number of small entities will be significantly affected. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered. This step in the study addresses these objectives by identifying the economic impacts which are likely to result from the promulgation of BPT, BAT, NSPS, PSES, and PSNS regulations on small businesses in the battery manufacturing industry. The primary economic variables covered are those analyzed in the general economic impact analysis such as compliance costs, plant financial performance, plant closures, and unemployment and community impacts.

Most of the information and analytical techniques in the small business analysis are drawn from the general economic impact analysis which is described above and in the remainder of this report. The specific conditions of small firms are evaluated against the background of general conditions in the industry as described in the remainder of the report. Since small firms account for only a small portion of battery manufacturing activity, they are assumed to be price takers and general market characteristics (demand, supply, equilibrium price), are considered exogenous variables to the small business analysis.

Five alternative definitions for "small" battery manufacturing plants were selected for examination and the impacts on small plants under each definition were assessed. In addition, the potential impacts of small business exemptions (tiering) under each of the five alternative sizes were examined. Value of production was the primary variable used to distinguish firm size. This is because plant level employment data were considered less reliable and plant level production data did not allow consistent comparisons across the product groups. The five size categories are less than $1 million, $1-$2.5 million, $2.5-$5 million, $5-$10 million, and greater than $10 million.

2.12 STEP 11: ASSESSMENT OF NEW SOURCE IMPACTS

The assessment of economic impacts on new sources is involved in two primary tasks. First, compliance costs are estimated and, second, the potential for economic impacts resulting from the compliance costs is evaluated. The cost estimates employed the following assumptions and definitions:

- Compliance costs for new source standards are defined as incremental costs from the costs of the selected standards for existing sources.
- The compliance costs per unit of output (pound of batteries) for new sources are assumed to be equal to the industry subcategory average for that of existing sources that use the same technology.

The second task in the new source analysis, the assessment of economic impacts, is based upon the aforementioned cost data and analogy to the impact conclusions for similar existing plants described above. The primary variables considered are identical to those for existing plants plus the potential of the regulation to foster barriers to entry or industry structure changes.

2.13 LIMITATIONS TO THE ACCURACY OF THE ANALYSIS

Various assumptions and estimates were made in the calculation of compliance costs and in the analyses performed to assess their impacts. These factors unavoidably affect the level of accuracy which can be assigned to the conclusions. The assumptions relating to the estimation of plant specific compliance costs are outlined in Chapter 6 of this report and are discussed in detail in the accompanying development document. Even though these assumptions have a bearing on the accuracy of the economic impact conclusions, the focus of this section will center on the assumptions and estimates made in the economic impact analysis.

The assumptions and estimates that have the greatest impact on the accuracy of the conclusions are related to the data used for the analyses. Since no economic survey was conducted to collect plant-specific financial data, the data used in this report had to be estimated and/or extrapolated from a variety of sources such as company annual reports, Census of Manufactures, Federal Trade Commission reports on major industries, and previous Federal government studies of the industry. Some of the major assumptions made in estimating and extrapolating these data are:

- An average industry price per pound of production was used to derive projected sales revenue estimates for each plant. The actual price per pound could vary considerably from one battery configuration to another, even within the same chemical system type. In some cases market research was able to identify specific battery types and prices, so that adjustments were made as required.

- The estimation of plant asset values and profit ratios are based upon only partial information from a number of sources that were not necessarily consistent with each other. This diverse information was used to develop a wide range of financial ratios which are believed to encompass those that actually exist. Thus, although there was limited information, the results were calculated for a wide range of possible conditions within the industry. Despite this caution and the conservative bias used in these estimation procedures, variation of conditions within the industry could escape the methodology.

- Lacking detailed data on the salvage value of assets, specific depreciation schedules and tax rates, it was assumed that net assets equal salvage value, depreciation equals 10 percent of fixed assets and the tax rate is 30 percent, for purposes of the internal rate of return analysis (IRR).

- The cost of capital used in estimating compliance costs was estimated to be 10 percent for the entire industry, despite the fact that it can differ from firm-to-firm. A sensitivity analysis of plus and minus 20 percent of this figure showed that the results of the study would not be significantly affected.

- To stress the conservative nature of the study effort, all quantity changes were calculated at the higher end of the elasticity estimate range and, usually, at the lower profitability estimates and plant revenue estimates.

These limitations inhibit the ability of the impact analysis to address specific plant closure decisions in cases where the regulations exert a significant, but not overwhelming, impact upon the plant (i.e., borderline cases). An overriding feature of the manner in which the limitations, inferences and extrapolations were dealt with in the analysis is that a "conservative" approach was followed. That is, judgments were made that would likely result in overstating the economic impacts rather than understating them.

Chapter 7 integrates the information of the preceding chapters to describe projected industry microeconomic behavior when faced with the compliance costs presented in Chapter 6. The output of Chapter 7 are estimates of the changes in such variables as price, production levels, employment, industry structure, and imports and exports which might be caused by each of the proposed regulatory options.

3. INDUSTRY DESCRIPTION

3. INDUSTRY DESCRIPTION

3.1 OVERVIEW

This chapter describes the operational characteristics of plants and firms in the battery manufacturing industry which are pertinent to determining industry behavior when faced with additional pollution control requirements. In subsequent chapters of this report this information is used to project general trends in the industry (Chapter 5) and to assess the potential economic impacts of the proposed regulations (Chapter 7).

The primary economic unit considered in this study is the individual establishment or product line. This is the basic unit around which capital budgeting decisions are made. That is, a single-plant or multi-plant firm will make decisions regarding opening, closing, or modifying operations on a plant-by-plant basis. For example, a specific plant considered unprofitable for one company may still be a viable operation for another and, if sold, may remain in operation. In addition, financial and economic characteristics at the company and industry levels must also be examined because they affect investment decisions at the plant level. By examining some basic industry parameters such as number, size, and location of plants and firms, employment, and financial characteristics, this chapter provides the basic descriptive information to be used to model the pertinent behavioral characteristics which lead to plant closings and other economic impacts.

3.2 FIRM CHARACTERISTICS

According to the 1977 Census of Manufactures, the battery industry consisted of 175 firms which operated 276 manufacturing establishments. The EPA Technical Survey (completed in 1979) identified 258 production facilities and

132 firms which account for most of industry production. Firms which manufacture batteries may be described as:

- Large diversified firms
- Large battery manufacturers - batteries as main line of business
- Small independents with more than one plant
- Independents with only one plant.

The number of firms in each of these categories is shown in Table 3-1. The majority of the plants are owned by small, private companies that deal primarily in one particular aspect of the battery market. The trend in recent years has been for major diversified firms to become more vertically integrated by buying many of the smaller dependents and using them as component suppliers and/or distributors of finished batteries.

As shown in Table 3-2, production of primary batteries is highly concentrated with four firm and eight firm concentration ratios of 87 percent and 94 percent, respectively. For storage batteries, the figures are 57 percent and 84 percent, respectively. Nevertheless, it should be noted that no single firm accounts for over 20 percent of the total market in the storage industry. As shown later in this report, production of individual battery types is even more concentrated. The majority of battery plants belong to small, private firms which serve regional demand. Little public information is available on these companies. However, because of OSHA, EPA, and the Department of Transportation regulations, there is concern that capital costs to install safety and health apparatus as well as environmental controls could pose economic problems for the smaller manufacturers in this industry. These regulations will be further explained in Chapter 5 (Baseline Projections of Industry Conditions).

TABLE 3-1. NUMBER OF FIRMS THAT MANUFACTURE BATTERIES BY TYPE OF FIRM, 1977

	Storage	Primary
Large diversified firms	5	8
Large Battery firms	4	3
Independents with more than one plant	8	2
Small independents with only one plant	155	64
	173	77

Note: These totals differ somewhat from those in the Census of Manufactures due to differences in sampling and survey techniques between D&B and Census.

SOURCE: Dun & Bradstreet Data Files of Plants by Primary SIC Code.

TABLE 3-2. CONCENTRATION RATIOS OF BATTERY MANUFACTURING INDUSTRY

	TOTAL ($ MILLIONS)	4 LARGEST COMPANIES	8 LARGEST COMPANIES	20 LARGEST COMPANIES
		PERCENT		
SIC 3691 - Storage Batteries				
1977	1,985.2	57	84	93
1972	950.3	58	85	93
1967	579.4	60	81	92
SIC 3692 - Primary Batteries				
1977	661.1	87	94	99
1972	318.3	91	96	99
1967	327.9	85	95	99

SOURCE: Concentration Ratios in Manufacturing - 1977 Census of Manufactures.

Thirteen major firms appear to dominate the field. Shown below is a list of these major producers of storage and primary batteries:

Storage Batteries

- ESB, Inc. (subsidiary of Inco, Ltd.)
- Globe-Union, Inc.
- Delco-Remy (division of General Motors Corporation)
- Eltra, Inc.
- General Battery (division of Northwest Industries)
- General Electric
- Eagle-Pitcher
- East-Penn
- Chloride, Inc. (British firm)
- Gould, Inc.

Primary Batteries

- Union Carbide
- ESB, Inc. (subsidiary of Inco, Ltd.)
- P. R. Mallory and Company (subsidiary of Dart Industries).

Some of these firms are highly diversified and integrated, such as General Electric, General Motors, and Union Carbide, while other major firms such as Globe-Union and P. R. Mallory are primarly engaged in the manufacture of batteries.

The primary battery market is dominated by these companies, with Union Carbide (Eveready Division) accounting for over 50 percent of the market, ESB (Ray-O-Vac Division) accounting for about 20 percent, and Mallory accounting for about 10 percent of the market. Most of the battery sales of the major producers are concentrated in the consumer market, while the smaller companies tend to specialize in industrial and commercial sectors. Yardney, for example, sells largely to the military, while Bright Star accounts for large shares of the burglar alarm and industrial flashlight markets.

The storage battery market is served by a few large producers and numerous small regional companies. In the SLI (Starting, Lighting, and Ignition) storage batteries sector, the major producers of batteries for installation by original equipment manufacturers are Delco-Remy division of General Motors, ESB (supplies to Chrysler), and Globe-Union (supplies several auto firms). Leaders in the SLI replacement market are ESB, Globe-Union, General Battery Corporation, Delco, Gould, Eltra Corp., and Chloride, Inc. The industrial lead-acid storage batteries sector is dominated by ESB, Gould, and Eltra. Finally, the leading suppliers of nickel-cadmium batteries are Marathon Battery, General Electric, Union Carbide (Eveready Division), Gould, SAFT Inc., and McGraw Edison.

3.3 FINANCIAL STATUS OF COMPANIES

To assess the financial status of the battery manufacturing industry, financial data has been obtained on the thirteen battery companies whose financial statements are publicly available. Of the thirteen firms, three are primarily engaged in battery manufacturing, while the other ten are more diversified. The nature of the business lines of most of these firms are discussed in Section 3.2 above. Table 3-3 lists these companies, their sales revenues, and their long-term debt to equity (D/E) and before tax return on equity (ROE) ratios. Between 1975 and 1977 more than half of the thirteen companies had better ROEs than the U.S. all manufacturing average. Among the less profitable companies are the two smaller companies of the sample, Yardney Electric Corporation and FDI, Inc. (battery operations now discontinued), whose ROEs have been below the all manufacturing average from 1975 to 1977. At this time, the financial characteristics of the smaller battery manufacturers have not been determined. Some industry sources report that many of the smaller companies have been finding their manufacturing operations to be less profitable than those of larger firms in the industry. As a result, many have become

TABLE 3-3. FINANCIAL CHARACTERISTICS OF SELECTED BATTERY MANUFACTURERS

	1977 Company Sales ($ Millions)		1977 Long-Term Debt/Equity	Before Taxes Return on Equity (%)				
	Total	Battery	(%)	1977	1976	1975	1974	1973
COMPANIES PRIMARILY ENGAGED IN BATTERY MANUFACTURING								
Globe-Union, Inc.	391.9	309.6	43.6	43.7*	24.8*	16.4	21.7	16.9
P. R. Mallory & Co.	341.8	207.5	28.5*	21.9	19.4	7.6	11.3	18.8
Yardney Electric Corp.	15.9	N/A	18.7*	13.8	7.0	7.8		
DIVERSIFIED COMPANIES								
Eagle-Picher Indus., Inc.	474.0	N/A	33.0	28.6*	27.6*	26.6*	29.3*	26.6*
Eltra Corp./Prestolite & C&D Batteries Division	922.1	N/A	25.9	21.6	22.7*	21.6*	23.2	23.7*
FDI, Inc.1/	74.2	N/A	277.3	17.6	11.7	-109.4		
General Electric Co.	17,518.6	N/A	21.6*	31.8*	31.0*	25.4*	31.9*	33.5*
General Motors Corp./ Delco-Remy Division	54,961.0	N/A	6.8*	39.8*	38.0*	18.1	13.4	35.9*
Gould, Inc.	1,619.6	330.1	36.7	25.7*	19.6	15.1	19.9	22.6*
Inco Ltd./ESB Inc.	1,953.3	703.2	53.3	9.2	22.2	21.7*	39.3*	28.3*
Marathon Mfg. Co.	306.1	N/A	28.0*	20.9	31.0*	35.1*	28.6*	-55.2
Northwest Indus., Inc./ General Battery Corp.	1,876.5	N/A	77.3	33.1*	32.1*	30.4*	29.4*	24.0*
Union Carbide Corp.	7,036.1	N/A	47.0	17.4	23.8*	27.1*	36.1*	26.1*
U.S. AVERAGE, ALL MANUFACTURING			32.7	23.2	22.7	18.9	23.4	21.8

*Better than All Manufacturing average

N/A - Not available

1/Has closed battery manufacturing operations.

SOURCE: Company Annual Reports and Quarterly Financial Report on Manufacturing, Mining and Trade, FTC.

assemblers of purchased parts, ceased manufacturing, opting instead to service and distribute batteries purchased from major manufacturers, or left the industry altogether.

3.4 PLANT CHARACTERISTICS

According to the Census of Manufactures, there were 218 storage battery establishments and 58 primary battery establishments in operation in 1977. EPA has identified 194 active production facilities that manufacture storage batteries and 64 active plants that manufacture primary batteries.[1/] Table 3-4 lists the number of firms and production facilities identified by EPA by type of battery. Table 3-5 presents the 1977 distribution of the battery establishments identified by the Department of Commerce and their value of shipments by employment size. Table 3-6 shows the distribution of battery establishments throughout the United States. In general, they are quite widely dispersed among the regions. Plant age varies widely--from new to over 80 years old. At present, new plants are being constructed and old plants are being expanded in both the primary and storage segments.

3.4.1 Storage Batteries

As shown in Table 3-5, the storage battery industry segment consists of many small plants existing alongside a number of large ones. However, these few large plants account for a major share of the total value of shipments (the 37 largest plants account for 58 percent of 1977 shipments). Moreover, during the last 20 years the number of smaller plants in the industry has been declining, while the number of plants with 20 or more employees has increased from 106 to 134 (between 1958 and 1977). The number of firms with less than 20 employees decreased from 170 to 84 during the same period.

1/ The census definition of "establishment" and the EPA definition of a "facility" are inconsistent. Therefore, the numbers do not precisely match.

TABLE 3-4. NUMBER OF FIRMS AND PRODUCTION FACILITIES MANUFACTURING BATTERIES IN EACH PRODUCT GROUP[1/]

BATTERY TYPE	NUMBER OF FIRMS	NUMBER OF PLANTS
Primarily Storage		
Lead-Acid	114	184
Nickel Cadmium	9	9
Silver-Oxide-Cadmium	1	1
Nickel Zinc	1	1
Mercury Cadmium	1	1
Primarily Primary		
Leclanche	9	19
Carbon Zinc Air	2	2
Alkaline Manganese	5	8
Mercury Ruben (Zinc)	3	4
Mercury Cadmium Zinc	1	1
Silver Oxide Zinc	6	9
Magnesium Carbon	3	3
Magnesium Reserve	4	4
Lithium	7	8
Thermal (Magnesium)	1	1
Calcium	3	3
	170	258

1/ Note that because of the existence of multi-product plants and firms, the actual number of establishments and firms is lower.

SOURCE: EPA Technical Survey.

TABLE 3-5. DISTRIBUTION OF BATTERY MANUFACTURING ESTABLISHMENTS BY EMPLOYMENT SIZE, 1977

NUMBER OF EMPLOYEES	NUMBER OF ESTABLISHMENTS	%	VALUE OF SHIPMENTS ($ MILLIONS)	%
SIC 3691 - Storage Batteries				
1 to 4 employees	39	18	4.8	0
5 to 9 employees	31	14	12.5	1
10 to 19 employees	14	6	14.1	1
20 to 49 employees	25	12	45.6	2
50 to 99 employees	24	11	120.9	6
100 to 249 employees	48	22	631.3	32
250 to 499 employees	31	14	849.3	43
500 to 999 employees	5	2	304.0	15
1,000 to 2,499 employees	1	0		
Total	218	99	1,982.5	100
SIC 3692 - Primary Batteries				
1 to 4 employees	15	26	0.8	0
5 to 9 employees	6	10	3.6	1
10 to 19 employees	4	7	8.1	1
20 to 49 employees	3	5	5.4	1
50 to 99 employees	4	7	7.7	1
100 to 249 employees	8	14	67.8	10
250 to 499 employees	12	21	214.4	32
500 to 999 employees	6	10	358.4	54
Total	58	100	666.1	100
Total of SICs 3691 and 3692	276		2,648.6	

NOTE: These census figures do not precisely match those in the EPA data base because these figures refer to "establishments" and the figures used in the EPA data base and in the economic impact analysis (in Chapter 7) refer to production facilities. Production facilities are individual product lines as defined by cathode-anode pair.

SOURCE: 1977 Census of Manufactures.

TABLE 3-6. GEOGRAPHIC DISTRIBUTION OF BATTERY PLANTS

DIVISION	ALL ESTABLISHMENTS TOTAL	%	≥ 20 EMPLOYEES	≤ 20 EMPLOYEES	VALUE OF SHIPMENTS[1/] ($ MILLIONS)	%
3691 - Storage Batteries						
New England	4	2	3	1	*	N/A
Middle Atlantic	29	13	20	9	325.4	16
East North Central	33	15	21	12	286.2	14
West North Central	24	11	16	8	42.5	2
South Atlantic	29	13	20	9	252.1	13
East South Central	14	6	11	3	33.6	2
West South Central	20	9	12	8	121.3	6
Mountain	4	2	2	2	*	N/A
Pacific	46	21	22	24	256.8	13
Unidentified	15	8	7	8	N/A	N/A
United States Total	218	100	134	84	1,982.5	100
3692 - Primary Batteries						
New England	1	2	1	0	*	
Middle Atlantic	15	26	8	7	20.6	3
East North Central	11	19	9	2	*	
West North Central	3	5	3	0	*	
South Atlantic	8	14	6	2	*	
East South Central	1	2	1	0	*	
Unidentified	19	32	5	14	*	
United States Total	58	100	33	25	666.1	100

*Not disclosed to avoid individual company disclosures

1/ Columns do not add to totals to avoid confidential disclosures.

SOURCE: _1977 Census of Manufactures_.

The storage battery industry consists basically of two types that are in commercial use: the lead-acid battery and the nickel-cadmium battery.

Lead-Acid Batteries

The lead-acid battery industry produces two basic types of batteries: SLI (starting, lighting, and ignition) batteries and industrial batteries. SLI batteries generally weigh 30 to 40 pounds each and are primarily used in automotive applications, either as original equipment for new cars or as replacement batteries. Industrial lead-acid batteries are a heterogeneous class of batteries used to power a wide variety of industrial, commercial, and consumer products.

Industrial lead-acid batteries can be further divided into two broad classes: wet and sealed. Wet industrial lead-acid batteries are similar in construction and operation to SLI batteries, but they are available in a much wider variety of shapes and sizes for use in a very wide range of applications. For example, there are 200 to 300 pound batteries for use in coal mining equipment and 5,000 to 6,000 pound batteries for use in locomotives and utilities. Sealed lead-acid batteries are different in construction and more portable than wet lead-acid batteries. They range in size from as little as one or two ounces to several pounds and come in a variety of shapes. They are used in a wide range of applications such as rechargeable lanterns, garden tools, and emergency lighting. The volume of production (by weight) of this type of battery is only a small fraction of that of total industrial batteries.

There are 205 individual establishments primarily engaged in the manufacture of lead-acid batteries in the United States. Eighty-two to 86 percent of the volume (by weight) is in SLI batteries and 14 to 18 percent is in industrial batteries. The SLI battery production is currently producing more than 60 million batteries per year. This production level represents approximately 80 percent of the SLI industry segment's estimated maximum capacity of 75.5 million batteries per year. About 25 percent of these batteries are sold to original equipment manufacturers, while the remainder goes to the replacement market.

Nickel-Cadmium Batteries

There are two types of Nickel-Cadmium (Ni-Cad) batteries made: a vented wet cell and a dry cell. EPA has identified nine plants in the United States that manufacture Ni-Cad batteries. These plants vary widely in size, ranging from several thousand to several million pounds in annual production.

3.4.2 Primary Batteries

Most primary batteries are manufactured in establishments having more than 250 employees (as shown in Table 3-5 above). Eighty-six percent of the production comes from only 18 of the 58 plants in the primary battery industry. A number of plants produce more than one primary battery type. A tabulation of these plants appears in Table 3-7. Primary batteries are manufactured in many shapes and sizes for use in a wide range of applications. For example, there are button cells weighing only a few grams for use in calculators or hearing aids and lantern batteries weighing five or six pounds or more. The number and size of establishments producing primary batteries are shown in Table 3-5 above, and the number of firms producing each battery type is shown in Table 3-4 above.

TABLE 3-7. COMPARISON OF SINGLE AND MULTI-PRODUCT NON-LEAD-ACID BATTERY PLANTS

PRODUCT GROUP	TOTAL NUMBER OF PRODUCT LINES IN SUBCATEGORY	NUMBER OF SINGLE PRODUCT PLANTS	NUMBER OF MULTI-PRODUCT PLANTS	ONE OTHER BATTERY PRODUCT	TWO OTHER BATTERY PRODUCTS	THREE OTHER BATTERY PRODUCTS
Alkaline Manganese	8	4	4	1	2	1
Carbon Zinc	19	13	6	3	2	1
Silver Oxide Zinc	8	1	7	3	2	2
Mercury Ruben	4	0	4	0	2	3
Mercury Cadmium Zinc	1	0	1	0	0	1
Carbon Zinc Air	2	1	1	0	1	0
Calcium	2	0	2	2	0	0
Magnesium Reserve	4	3	1	1	0	0
Magnesium Carbon	3	2	1	0	1	0
Lithium	7	6	1	1	0	0
Nickel Cadmium	9	4	5	2	3	0
Other	8	8	0	0	0	0
Total	74	34	32	14	12	6

SOURCE: EPA Technical Survey.

4. MARKET STRUCTURE

4. MARKET STRUCTURE

The primary determinants of the demand for battery products which are described in this section are the end-use markets, the nature of competitive products, price elasticity, and the role of imports and exports. This information is used in Chapter 5 to project the demand for batteries and to describe the expected characteristics of the battery industry in the 1985 to 1990 period, and in Chapter 7 to estimate the potential economic impacts of the proposed regulation.

4.1 OVERVIEW

The 1977 domestic production of both primary and storage batteries amounted to 2.6 billion dollars.[1/] Seventy-five percent of this amount represented storage batteries used in a multitude of products and applications. Table 4-1 presents the value of battery shipments by major end-use markets.

The storage battery market is dominated by the lead-acid and nickel-cadmium types. The lead-acid battery accounts for 90 to 95 percent of storage batteries. About 82 to 86 percent of lead-acid batteries are used for Starting, Lighting, and Ignition (SLI) applications, primarily for the automobile market. The other 14 percent goes to the industrial and consumer market. Nickel-cadmium batteries are used in a wide variety of consumer and industrial products.

Most primary batteries are used in consumer products such as flashlights, toys, games, watches, calculators, hearing aids, and electronic equipment. Sales of primary batteries for use in consumer products generally represent 70 to 75 percent of total primary battery shipments.

1/ Census of Manufactures, 1977; the 1980 figure was $3.5 billion (current dollars)

TABLE 4-1. VALUE OF BATTERY SHIPMENTS BY END-USE MARKET
1967-1977
(MILLIONS OF DOLLARS)

	1967	% of Total	1973	% of Total	1977	% of Total
Storage Batteries						
Automobile						
Original Equipment	102	17	176	17	277	15
Replacement	307	52	582	55	1,095	57
	409	69	758	72	1,372	72
Industrial						
Stand-by auxiliary power	33	6	49	5	51.5	3
Motive power	54	9	96	9	255.4	13
	87	15	145	14	306.9	16
Government, consumers, and other	95	16	157	15	223	12
TOTAL STORAGE BATTERIES	591	100	1,060	100	1,902	100
Primary Batteries						
Consumer						
Lighting	106	32	110	32	183	30
Electronic equipment	77	23	82	24	152	25
Toys and games	45	14	59	17	104	17
	228	69	251	73	439	72
Industrial	31	9	44	13	85	14
Government	69	21	50	14	85	14
TOTAL PRIMARY BATTERIES	338	100	345	100	609	100

NOTE: Percentages may not add due to rounding

SOURCE: Based on Predicasts, Inc., Batteries and Electric Vehicles E36, Cleveland, Ohio, 1974, and JRB extrapolation of trends for 1977.

In addition to segmenting the industry's products by whether they are storage or primary batteries, this study also makes use of another classification scheme: whether they are "dry cell" or "wet cell" types. This classification more accurately reflects end-use markets than the more traditional "primary versus storage" classification. The dry cell group is generally composed of small and light batteries primarily for portable use, such as flashlights and calculators, whether they are primary (e.g., carbon-zinc) or storage (e.g., nickel-cadmium). The wet cell type is usually larger, less portable, and of the storage type (e.g., lead-acid automobile or fork-lift truck batteries). A more detailed description of these battery types appears in the next section.

4.2 END-USE MARKETS AND SUBSTITUTES

For most applications, there is little or no substitution of other products for batteries. Substitution is generally limited to switching from one battery type to another. A description of major uses and substitutions for each battery type is provided below.

4.2.1 Storage Batteries

Lead-Acid Batteries

In 1977, $1.7 billion of lead-acid batteries were manufactured in the United States, representing about 67 percent of the value of all battery shipments and 90 percent of all storage batteries. Lead-acid batteries are mainly used in SLI and industrial applications.

In 1977, SLI batteries represented 82 percent of the overall lead-acid battery shipments, and were primarily used in automobiles, trucks, buses, aircraft, and boats. About 77 percent of the SLI battery production went to the replacement market, while the remainder was purchased by original equipment manufacturers. SLI batteries generally come in 6 or 12 volt types and are available in a number of sizes, depending on specific application. There are two major types of SLI batteries: those with lead-antimony grids and those with lead-calcium grids (or maintenance-free batteries).

Another major market for lead-acid storage batteries is the industrial sector (about 18 percent of the value of the 1977 lead-acid shipments). Major applications for industrial lead-acid batteries are for motive power in material handling equipment (e.g., fork lift truck), mining vehicles, yard locomotives, and for stand-by power sources and load leveling in telephone and electric utility systems. These industrial batteries can weigh as much as 6,000 pounds, whereas SLIs generally weigh between 35 and 40 pounds. Industrial batteries also include some smaller batteries used for both commercial and consumer products, such as emergency lighting, communications equipment, portable tools, and alarm systems. Many of these are sealed units with gel or paste electrolytes.

For most current uses, there is little or no ability to substitute other products for lead-acid batteries. Consumers of SLI batteries might postpone purchasing a new battery for a limited time by recharging their old ones, purchasing used batteries, driving less, or postponing the purchase of a new car. However, these measures would have only limited effect and are more responsive to income changes than price changes. Likewise, industrial lead-acid battery users may, in the short term, delay the purchase of new batteries by rebuilding or repairing used ones, or using equipment powered by other sources of energy.1/

1/ The literature contains a number of studies which indicate strongly that the elasticity of demand for auto travel with respect to price (i.e., cost of travel) is inelastic, whereas the income elasticities for products such as automobiles are quite elastic. See Consumer Demand in the United States by H. S. Houthaker and L. D. Taylor, Interindustry Forecasts of the American Economy by C. Almon, et al., and The Data Resources Inc. Model, 1977 edition, DRI, Lexington, Mass.

Nickel-Cadmium Batteries

The nickel-cadmium (Ni-Cad) battery is the second most common storage cell today. Total shipments of Ni-Cad batteries amounted to $103.8 million in 1977, representing 5 percent of total storage battery shipments.

Ni-Cad batteries are produced in both vented and sealed types. The structure of Ni-Cad vented cells is basically similar to that of the lead-acid battery, while the sealed cells are made in button, cylindrical, rectangular, and other shapes to suit various space and capacity requirements. Vented Ni-Cads are used primarily in aircraft, while the sealed type is used in consumer oriented products such as calculators, flashlights, portable appliances, and power tools. In consumer product applications, Ni-Cad batteries compete with primary cells such as carbon-zinc and alkaline types. While Ni-Cad batteries are generally four to six times more expensive than most primary batteries, their longer life, due to recharging capabilities, makes them more economical and convenient for many applications.

Recent marketing efforts by the sealed portable lead-acid battery producers may affect the competitive position of both primary and Ni-Cad batteries. The chief reason for this is that sealed lead-acid batteries have a self discharge rate (percent of ampere hour capacity left) of about two percent per month as compared to one percent per day for Ni-Cads. Thus, for applications in which the battery stands unused for long periods of time, the lead-acid battery will require less frequent recharging than the Ni-Cad battery.

Silver Oxide Zinc Cell

silver-zinc storage cells are composed of a silver oxide cathode, zinc anode, and a strong alkaline electrolyte. The most important feature of the silver-zinc cell is its high power-to-weight ratio (as much as six times that of the nickel-cadmium cell). However, silver-zinc cells have shorter life, in terms of the number of possible charge/discharge cycles, than nickel-cadmium and silver-cadmium batteries. Due to its high cost, the silver-zinc storage cell is mainly used in military and aerospace applications where cost is of lesser importance than performance. Primary silver-zinc cells are also available and are generally used as power sources in hearing aids.

Silver-Cadmium Cell

Silver-cadmium cells are similar in construction to silver-zinc cells but employ a cadmium anode. The principal advantage of silver-cadmium cells is a much more rugged construction which greatly increases the cell's life in terms of charge/discharge cycles. The energy density (power-to-weight ratio) of silver-cadmium cells are two to three times that of nickel-cadmium cells. Silver-cadmium systems may replace silver-zinc cells for relatively high discharge rate applications where a longer cycle life is needed. They may also substitute for nickel-cadmium cells in applications requiring higher power output at some sacrifice in cycle life. The greatest disadvantage of the silver-cadmium battery is its high cost. The utilization of the two most expensive electrode materials in the construction of this cell makes it more expensive than the silver-zinc system. This factor has limited the use of silver-cadmium cells to satellites and other space applications. Recently, however, this cell has been used commercially in appliances, tools, and portable television sets.

Thermal Cells

Thermal batteries are special purpose reserve systems in which the solid electrolyte is nonconducting at ambient temperatures. The battery is activated by melting the electrolyte, thus making the latter conductive. Activation is generally achieved by igniting a pyrotechnic heat source within the battery. The lifetime of the battery can range from minutes to days, and operating temperatures are generally between 400 and 600 degrees centigrade. Upon cooling, the electrolyte solidifies and the battery becomes inoperable.

Thermal batteries have the following special properties: rapid and reliable activation, virtually no deterioration during storage, moderately high discharge rates for short times after activation, require no maintenance, compactness, mechanically rugged, and operability over a wide ambient temperature range. They are used for military and aerospace systems and for alarm and sensing applications.

Nickel-Iron (Edison) Cell

Nickel-iron batteries were once used in applications such as material handling, railway lighting, and telephone exchange system equipment. They are not produced only in limited quantities primarily for experimental purposes. Substitution by lead-acid and nickel-cadmium batteries has taken place in most applications because of some major disadvantages of nickel-iron cells. These disadvantages are their high cost, inferior low temperature performance, lower terminal voltage requiring larger batteries for the same energy content, and the low maximum current which can be drawn from the battery.

4.2.2 Primary Batteries

Carbon-Zinc (Leclanche) Cell

This is the most popular and least expensive type of battery. In 1977, U.S. shipments of carbon-zinc cells were valued at $317 million, representing 52 percent of total primary battery shipments. This is a decrease from 60 percent in 1973 (see Table 4-2), which is due to competition from other types of batteries such as alkaline-manganese and nickel-cadmium.

Carbon-zinc cells are made in cylindrical, rectangular, or flat forms of various sizes. They are best used when they are run intermittently at relatively low drains (under 100 milliamperes), but are inefficient in heavy drain devices such as toys and electronic flashes. However, low prices (e.g., about 20 to 25 cents for "D" cells) make carbon-zinc batteries very popular in a wide range of applications such as flashlights, radios, clocks, and tape recorders.

TABLE 4-2. PRIMARY BATTERY PRODUCTION 1973-1977
(CURRENT DOLLARS)

TYPE	1973 $ MILLION	1973 % OF TOTAL	1975 $ MILLION	1975 % OF TOTAL	1977 $ MILLION	1977 % OF TOTAL	COMPOUNDED AVERAGE ANNUAL GROWTH (%)
Carbon-Zinc	208	60	263	59	317	52	11.1
Alkaline-Manganese	57	17	80	18	111	18	18.1
Mercury-Zinc	32	9	43	9	65	11	19.4
Silver-Zinc	7	2	18	4	54	9	66.7
Other	42	12	45	10	62	10	10.2
Total	346	100	449	100	609	100	15.2

SOURCE: Census of Manufactures, Portable Energy Sources: Batteries, Fuel Cells, Solar Cells, Business Communications Co., Stanford, CT, 1977, and EPA Technical Survey.

Alkaline-Manganese Cells

In 1977, there were $111 million worth of alkaline-manganese batteries shipped, representing 18 percent of the primary battery market (See Table 4-2). The alkaline dry cells are produced primarily in button, cylindrical, and rectangular shapes. They are usually interchangeable with carbon-zinc cells in a wide range of applications such as calculators, flashlights, camera equipment, battery powered toys, radios, tape recorders, etc. Alkaline cells cost about three to four times the cost of carbon-zinc cells, but have higher energy density, longer life, and better performance under heavy drain applications. For continuous heavy drain uses, the alkaline cell performs better than any other primary battery, although the nickel-cadmium storage battery is quite competitive in this regard. This battery is also often used for light and intermittent duties when cost is not a factor, because of its superior stability and long life. Some alkaline-manganese batteries are rechargeable and used as shorage batteries.

Mercury Cells

The Mercury-zinc (ruben) cell is the third largest selling primary battery type. Total shipments in 1977 amounted to $65 million, or 11 percent of total primary battery shipments (see Table 4-2). The mercury-zinc battery is composed of a zinc anode and a mercury oxide cathode. This battery has relatively steady discharge characteristics, a high capacity to volume ratio, good high temperature characteristics, and good resistence to shock, vibration, and acceleration. This cell is used as a power source for miniaturized electronic equipment such as hearing aids, electronic watches, calculators, light meters, and "electric eye" devices. Frequently, the cell is used as a secondary voltage standard in regulated power supplies, radiation detection meters, potentiometers, computers, and voltage recorders. Substitution by silver-zinc and lithium cells is possible for many of the mercury-zinc cell applications.

The weston cell differs from the ruben cell in that it uses a cadmium sulfate-mercury sulfate system and is contained in a glass vessel. Before production of the weston cell ceased in 1977, it was used as a primary voltage standard. However, there is currently no known commercial production.

Silver Oxide-Zinc Dry Cells

The silver-zinc dry cell has been the fastest growing primary battery in recent years. Although it started from a lower base, it averaged an annual growth rate of 67 percent between 1973 and 1977 and reached $54 million in sales in 1977 (see Table 4-2).

The usual configuration of the silver-zinc cell is similar to the mercury-zinc cell, but it uses a silver oxide cathode. Although more expensive than mercury cells, silver-zinc cells have been replacing mercury cells in many applications, such as hearing aids, electric watches, and electronic instruments. The primary reason for this is the performance advantages that silver-zinc cells have over mercury cells, such as higher voltage, greater capacity, and superior low-temperture capacity (silver-zinc cells remain operative at -50°F while mercury-zinc capacity drops considerably around 40°F and becomes virtually inert around the freezing point).

Magnesium-Carbon Cell

The magnesium-carbon cell is patterned after the carbon-zinc cell, but it uses a magnesium alloy anode. This cell has longer storage life and greater ability to withstand high heat and humidity than the carbon-zinc cell. Magnesium-carbon cells are primarily used in military applications where batteries are stored under severe conditions. This cell is also sometimes used commercially in aircraft emergency systems, and in marine and mining operations. Magnesium batteries are more expensive than carbon-zinc cells because of material costs.

Lithium Cell

Lithium is the earth's lighest solid element. While weighing only about one-thirtieth the weight of lead, lithium can generte up to eight times as much electricity. For this reason, major research efforts have been directed toward developing lithium storage batteries for electric cars. However, to date this type of battery is still in the development stage, and is produced in very limited quantities. The only lithium batteries produced in commercial quantities today are small primary types, mainly for use in pacemakers, electric watches, and lanterns. They compete strongly with mercury-zinc and silver-zinc batteries because of their longer life and thin designs.

Carbon-Zinc-Air Cell

The carbon-zinc-air cell is usually composed of an alkaline electrolyte, anode of amalgamated zinc, and air-depolarized carbon cathode. Some of these batteries contain acid electrolytes. The carbon zinc air systems offers a unique combination of high energy density and high power density at relatively low cost. Carbon-zinc-air cells are usedin portable transceivers, semaphore devices, highway flashing systems, lighthouses, railway signals, night-vision devices, and satellite communications.

Lead-Acid Reserve Cell

As a "reserve" cell, the lead-acid reserve battery is shipped to the user in an inert state, and must be activated immediately before use. Activation is accomplished by releasing an acid into the cell, and within a short period of time the cell is in a ready state. Lead-acid reserve cells are used in limited quantities in military applications.

Magnesium Reserve Cell

Magnesium reserve cells are used in situations requiring an extremely long shelf life and high reliability. The battery is shipped and stored in an inert state and activated when necessary. This type of battery is used for life jacket lights and life-raft lights, emergency radio beacons, life-buoy lights, signal flare initiations, divers' and frogmen's lights, depth charge initiations, and radio power supplies. In most of these uses the battery is not tested before use and when activated will be expected to operate continuously until completely discharged. Some types can be activated by immersion in seawater.

4.3 RECENT CONSUMPTION AND PRICE TRENDS

Between 1967 and 1980, shipments of storage batteries grew from $0.578 billion to $2.57 billion, representing a compounded average annual growth rate of 12.4 percent (see Table 4-3). During that time, primary battery shipments grew from $308 million to $953 million, averaging 9.1 percent per year. In constant dollars, the compounded annual average growth rates were 6.8 and 4.2 percent for storage and primary battery shipments, respectively. During the same period, the real Gross National Product (GNP) in constant dollars grew at an average rate of 3.0 percent. Longer term trends exhibit somewhat lower rates for storage and higher rates for primary batteries. These are described in Chapter 5 of this report.

Wholesale prices of storage and primary batteries both grew at an average annual rate of 4.8 percent during the 13-year period. This was significantly lower than the average growth of all commodities (7.6%).

The prices of lead and zinc, the two major metals used in battery manufacturing, grew at annual rates of 9.6 and 9.0 percent, respectively. However, this growth, along with the spectacular increases in lead prices from 1975 to 1979, are not expected to continue. There are several reasons for this conclusion. First, the rise in lead prices has been due largely to a number of structural shifts in its markets and in the industry, which have "one-time-only" changes which will not be perpetuated. These structural shifts include strikes, unusual sudden increases in world demand, especially from Japan and Eastern block

TABLE 4-3. HISTORICAL TRENDS IN THE BATTERY INDUSTRY

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	COMPOUNDED AVERAGE ANNUAL GROWTH RATE 1966-1967 (%)
STORAGE BATTERIES																
Number of Employees (000)	19.3	19.0	19.9	20.8	21.1	22.1	23.9	23.4	21.7	23.1	25.9	27.2	27.6	24.7	NA	
Value of Shipments																
(millions of current dollars)	577.5	633.7	697.0	769.8	828.2	968.6	1070.8	1234.2	1302.3	1519.7	1982.5	2269.6	2607.1	2571.8	NA	12.4
(millions of 1967 dollars)	577.5	628.7	677.4	696.0	737.5	857.2	938.5	980.3	899.4	1026.1	1218.5	1/	1/	1/	NA	6.8 2/
Price index for Storage Batteries	100.0	100.8	102.9	110.6	112.3	113.0	114.1	125.9	144.8	148.1	162.7	1/	1/	1/	NA	4.8 2/
PRIMARY BATTERIES																
Number of Employees (000)	11.0	11.3	10.8	9.4	9.4	8.4	8.7	9.5	9.0	10.4	11.0	12.2	12.1	11.8	NA	-
Value of Shipments																
(millions of current dollars)	307.6	330.8	340.5	329.5	350.5	348.1	380.7	423.3	473.7	627.1	666.1	759.1	851.5	952.9	NA	9.1
(millions of 1967 dollars)	307.9	327.2	329.6	312.9	294.8	262.5	307.3	329.2	313.1	395.6	412.4	468.6	500.6	539.9	NA	4.2
Price Index for Primary Batteries	100.0	101.1	103.3	105.3	118.9	123.2	123.9	128.6	151.3	158.5	161.5	162.0	170.1	176.5	182.2	4.8
PRICE OF LEAD (cents/lb)	14.00	13.21	14.93	15.69	13.89	15.34	16.31	22.49	21.52	23.10	30.74	33.70	52.60	44.36	36.50	9.6
PRICE OF ZINC (cents/lb)	14.35	14.00	15.15	15.82	16.92	17.72	20.84	35.94	38.89	37.38	35.21	31.00	37.30	37.00	44.50	9.0
ALL COMMODITIES WHOLESALE PRICE INDEX	100.0	108.7	113.0	110.4	113.9	119.1	134.7	160.1	174.9	183.0	194.2	209.3	235.6	268.8	NA	7.6
GNP (1972 dollars)	1008	1052	1079	1086	1108	1186	1255	1246	1234	1300	1372	1433	1483	1481	1510	3.0

1/ Price index of storage batteries unreported for years beyond 1977.

2/ Based on years 1967 to 1977.

SOURCE: U.S. Department of Commerce, Census of Manufactures and Survey of Current Business.

countries, and OSHA regulations, which are estimated to add about one cent to a pound of lead. According to industry sources, this price escalation is not expected to continue at such high levels. Moreover, as the data in Table 4-3 shows, the price of lead has dropped significantly from its 1979 high. Therefore, there is no reason to expect the price of lead to increase more or less than that of other raw materials over the long run.

4.4 IMPORTS AND EXPORTS

Imports and exports traditionally have been an insignificant factor in the storage battery market. In recent years, only 2.0 percent of the domestic consumption of storage batteries was from imports.

In the past, and to some extent today, transportation-associated problems have been a stumbling block in developing import-export markets. Shipping a vented battery with electrolyte is not only costly, but difficult as well, in that batteries could discharge while in transit. This explains the location of battery manufacturing plants near their markets.

In addition to direct imports of batteries, a number of foreign made batteries enter the U.S. market indirectly via imported automobiles. The number and origin of batteries entering the U.S. market in this way may be determined by examining sales of cars in the United States. During the late 1970's and early 1980's imports have been around 25 percent of the total number of automobiles sold in this country. Japan, with most of the imported automobile market, is the leading exporter of storage batteries in this sense. Germany, Italy, and the United Kingdom, in that order, are the other three major exporters of storage batteries contained in automobiles. If these indirect imports are counted together with direct imports, the growth rate of imports would exceed that of exports.

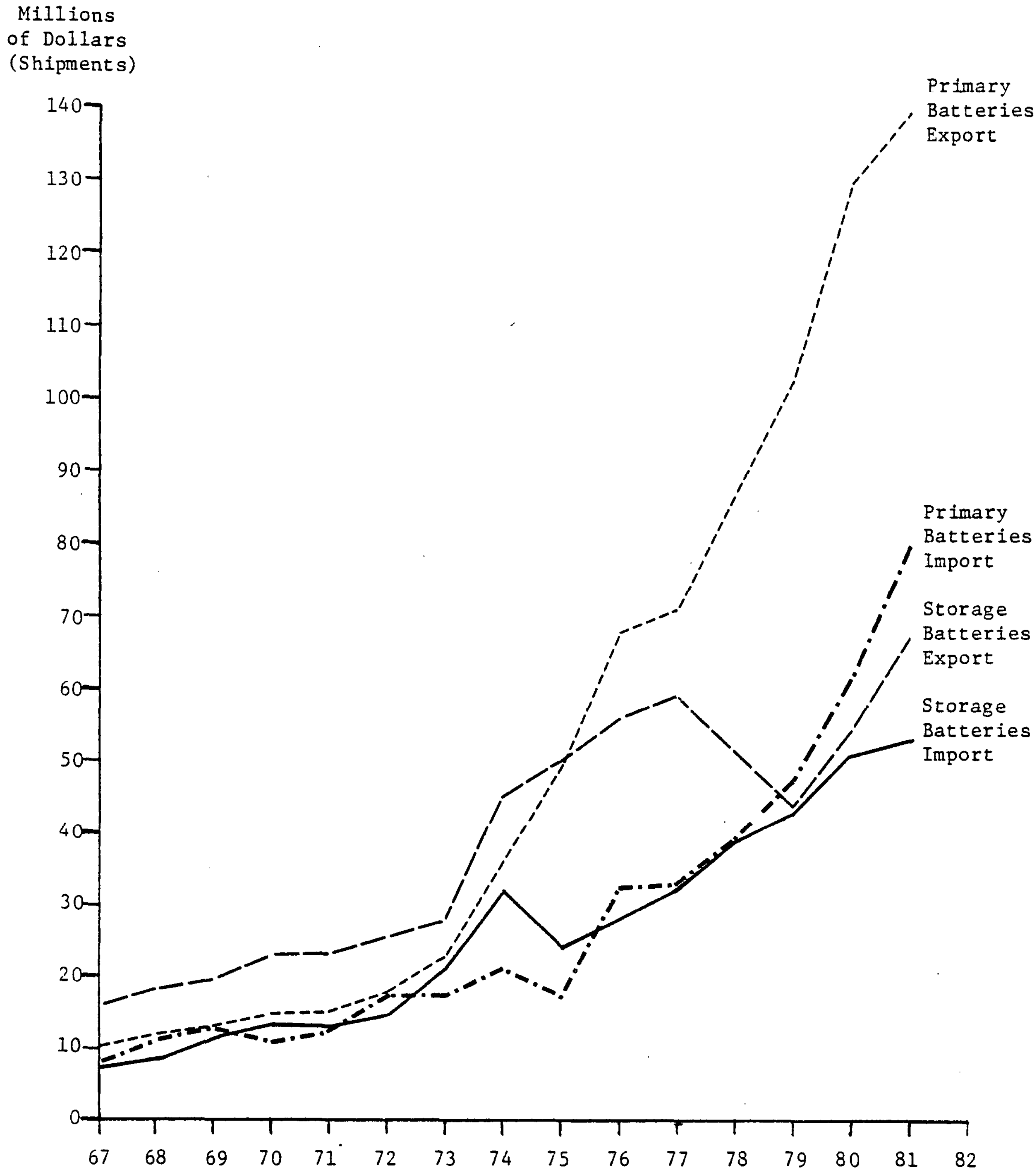
The SLI battery has also been imported to the United States indirectly via imported motorcycles. Recently, however, two of the major exporters of motorcycles, namely Taiwan and Japan, have found it advantageous to manufacture motorcycle batteries in the United States--a factor which may influence this trend.

Exports of American made storage batteries account for about two percent of the value of storage battery shipments. U.S. technology in primary batteries has enabled this country to successfully penetrate export markets, as evidenced by primary battery exports in 1975 and 1981 (see Figure 4-1). In past years, Japan and Taiwan were able to compete successfully with the U.S. for the market of flashlight and transistor radio batteries. However, there is no evidence to date that they can compete against U.S. technology in the high performance batteries. The data available in this area precludes a comprehensive assessment by product group. However, as the Figure shows, aggregate industry data indicates no evidence of secular changes that would significantly affect the conclusions of this study.

Import and export statistics are summarized from 1965 to 1981 in Table 4-4 and shown graphically in Figure 4-1.

4.5 UNIT VALUE OF BATTERY PRODUCTS

Since batteries within each subcategory are made in numerous sizes, configurations, and electrochemical properties, it is difficult to standardize the analysis on a single unit. Department of Commerce documents report battery activity in terms of millions of units and dollars. However, given the diversity of battery types and sizes, units are of little use to this study. The Technical Contractor reports production in the form of weight of product produced. They also report that the wastes at most battery plants are of the order of magnitude of 1 percent, with a possible upper bound of 5 percent. Thus, in this report the weight of the product is used as a unit of output measure and the average value per pound for each battery type is calculated. For some battery types, this figure is the value of industry shipments for the battery type divided by the number of pounds produced. The production



SOURCE: U.S. Bureau of the Census, U.S. Commodity Exports and Imports as Related to Output, U.S. GPO, Washington, D.C., and U.S. Imports for Consumption and General Imports.

FIGURE 4-1. VALUE OF IMPORTS AND EXPORTS, 1967-1981

TABLE 4-4. BATTERY INDUSTRY IMPORTS AND EXPORTS, 1967-1977
(Millions of Dollars)

	IMPORTS				EXPORTS			
YEAR	STORAGE	PERCENT OF DOMESTIC CONSUMPTION*	PRIMARY	PERCENT OF DOMESTIC CONSUMPTION**	STORAGE	PERCENT OF DOMESTIC CONSUMPTION	PRIMARY	PERCENT OF DOMESTIC CONSUMPTION
1967	7.8	1.4	8.5	2.8	16.0	2.8	10.3	3.4
1968	8.9	1.4	11.2	3.4	18.2	2.9	12.0	3.6
1969	11.7	1.7	12.2	3.6	19.5	2.8	12.6	3.7
1970	13.2	1.7	11.1	3.4	22.7	3.0	14.7	4.5
1971	12.8	1.6	12.2	3.5	22.5	2.7	15.1	4.3
1972	14.2	1.5	17.4	5.0	25.8	2.7	17.9	5.1
1973	21.6	2.0	17.4	4.6	28.1	2.6	22.9	6.1
1974	31.2	2.5	21.5	5.3	45.4	3.7	35.5	8.7
1975	24.0	1.9	17.6	4.0	50.0	3.9	49.3	11.2
1976	28.1	1.9	32.1	5.4	56.0	3.8	67.9	11.5
1977	32.0	1.6	33.0	5.3	59.0	3.0	73.0	11.7
1978	38.5	1.7	39.7	5.6	51.2	2.3	86.3	12.1
1979	44.8	1.7	47.6	6.0	43.8	1.7	102.2	12.8
1980	51.1	2.0	61.4	6.9	54.1	2.1	129.8	14.7
1981	53.1	NA	79.6	NA	67.3	NA	139.0	NA

*Domestic consumption estimates do not include changes in inventory.

**Data includes battery parts.

SOURCE: U.S. Bureau of the Census, U.S. Commodity Exports and Imports as Related to Output, U.S. GPO, Washington, D.C., and U.S. Imports for Consumption and General Imports.

weight and value of shipments for 1972 and 1973 were estimated from previous EPA reports on the industry and adjusted to January 1978 dollars using the Bureau of Labor Statistics wholesale price indexes for storage batteries and for primary batteries, as appropriate. For other battery types, price lists from such sources and the General Services Administration, retail store catalogues, and battery manufacturers were used. The resulting estimates of battery value per pound for each battery type are shown in Table 4-5.

4.6 BATTERY INDUSTRY PRICE DETERMINATION

Increased costs of battery manufacturing will, in whole or in part, be passed through to customers in the form of higher prices. The amount which can be passed through depends upon the market acceptance of price increases as measured by price elasticity of demand, and the price setting behavior in the industry.

4.6.1 Price Elasticity

Price elasticity estimates for the various product groups are presented in this section. These estimates are used later in this report to determine economic impacts of effluent control regulations. In the classical supply and demand situation, an increase in the price of a product produces a decline in the amount of the product sold. For example, an elasticity of minus 0.5 means that a one percent increase in the product prices will result in a 0.5 percent drop in quantity demanded. A measure of this relationship between a change in price and the change in production is defined by the following equation:

$$\varepsilon = \frac{\Delta q/q}{\Delta p/p}$$

where

ε = price elasticity

q = current production

Δq = change in production

p = current unit price

Δp = change in unit price.

TABLE 4-5. AVERAGE VALUE PER POUND OF PRODUCTION
(January 1978 Dollars)

BATTERY TYPE	AVERAGE $ VALUE PER POUND[1/]
Lead Acid	0.50
Sealed Portable Lead-Acid	5.59
Nickel Cadmium (vented)	31.70
Nickel Cadmium (sealed)	8.03
Leclanche	1.36
Alkaline Manganese	3.39
Miniature Alkaline-Manganese	4.00
Mercury-Ruben	10.36
Mercury Cadmium-Zinc	-
Silver Oxide Zinc	26.27
Silver Oxide Cadmium	160.00
Magnesium Carbon	4.08
Lithium	16.00
Nickel-Iron	-
Carbon Zinc Air	-
Lead Acid Reserve	-
Thermal	200+
Magnesium Reserve	26.27

[1/]January 1978 dollars.

SOURCES: EPA, Economic Impact Assessment of Proposed Effluent Limitation Guidelines for the Battery Industry Point Source Category, (Draft, by Kearney Management Systems, 1976-1977)
EPA, Assessment of Industrial Hazardous Waste Practices: Storage and Primary Batteries Industries, Office of Solid Waste Management Programs, 1975.
GSA, Federal Supply Service, Federal Supply Schedules 61, Parts I, II, III, and VIII.
Sears Roebuck, Inc., Merchandise catalog.
1977 Census of Manufactures.

Price elasticities for the various battery types are not available directly. However, they can be inferred from demand related factors. The following discussion presents an initial development of price elasticity estimates based on an examination of the availability of substitute products and the strength of consumer demand. Table 4-6 serves as a summary for this discussion.

In general, there is little or no ability to substitute other products for batteries in most applications. However, some switching from one battery type to another is possible. Thus, in addition to an overall industry analysis, a separate treatment of each battery type is included. For purposes of this discussion, batteries are classified as being wet cell types or dry cell types. This classification more accurately reflects end-use markets than does the "priimary versus storage" classification. The "dry cell" group can be thought of as smaller, lighter batteries primarily for portable use, such as in flashlights, calculators, hand held tools, etc., whether they are primary (e.g., carbon-zinc) or storage (e.g., nickel-cadmium). The lead-acid battery is a typical example of a wet cell battery. It is generally larger and less portable, and has specific applications, such as in automobiles and industrial trucks.

Eighty-two percent of the lead-acid battery production is for the automobile market. There is little or no ability to substitute other products in this application. Consumers might postpone purchasing a new battery for a limited time by recharging their old ones, purchasing used batteries, driving less, and postponing the purchase of a new car. However, these measures would have only a limited effect, and are more responsive to income changes than price changes. Industrial lead-acid batteries are used primarily in industrial vehicles such as fork lifts, mining equipment, and railroad equipment. Few economically feasible substitutes exist for these uses, although in the short term, delaying the purchase of new batteries by rebuilding or repairing used ones could occur. In short, the demand for storage batteries is highly price inelastic. For these reasons, an initial estimate for the price elasticity of -0.3 seems plausible as the high end of a likely range for the lead-acid subcategory.

TABLE 4-6. MAJOR END-USE MARKETS, SUBSTITUTES, AND PRICE ELASTICITIES FOR BATTERY SUBCATEGORIES

Battery Type	Major Markets	Percent of Product Value[1/]	Substitutes	Relative Price of Substitute[1/]	Relative Substitut-ability	Estimated Elasticity
Lead Acid	Autos Industrial	0.6-0.8	Rebuilt & used batteries, Public trans-portation	NA	very low	-0.3
Alkaline Manganese	Flashlights, Radios, Photo, Watches	1-75	Carbon Zinc Silver Oxide Nickel Cadmium	lower higher higher	moderate	-0.6 to -0.8
Carbon Zinc	Flashlights, Radios, Photo, Toys, Industrial	1-50	Alkaline Manganese Nickel Cadmium Silver Oxide	higher higher higher	high	-0.8 to -1.2
Nickel Cadmium	Calculators, Walkie Talkies, Portable tools & Appliances	1-50	Alkaline Silver Oxide	lower higher	moderate	-0.6 to -0.8
Silver Oxide-Zinc	Defense, Space, Watches, Hearing aids, Cameras	1-20	Mercury Alkaline	lower lower	moderate	-0.6 to -0.8
Mercury Ruben	Hearing aids, Watches, Cameras, Electronic Instruments	1-20	Silver Oxide Alkaline	higher lower	moderate	-0.6 to -0.3
Cadmium Silver Oxide	Space, Appliances, Tools, T.V. sets	1-20	Ni-Cad Silver Oxide Zinc	lower lower	moderate	-0.6 to -0.8
Mercury Weston	Voltage standard	NA	None	NA	NA	-0.3 to -0.6
Magnesium Carbon	Military, Aircraft, Marine, Mining	1-20	Alkaline	lower	low	-0.3 to -0.6
Lithium	Electric Watches	1-25	Mercury-Ruben Silver Oxide Zinc	lower higher	moderate	-0.6 to -0.8
Nickel Iron	Material handling, Railway lighting, Telephone exchange equipment	1-20	Lead Acid Ni-Cad	lower	moderate	-0.8 to -1.2
Lead Acid Reserve	Military	1-10	None	NA	NA	-0.3 to -0.6

1/ Includes only the purchase value, not total life-cycle cost.

NA - Not applicable.

SOURCE: JRB estimates.

While the price elasticity for dry cell batteries as a group is also inelastic, it appears to be greater than that of lead-acid batteries. This is because they generally represent a larger proportion of end-product value (ranging from about 1 to 75 percent), and, for some uses, can be eliminated through the use of direct electricity generation. For these reasons, the high end of the plausible range for dry cell batteries would appear to be about -0.5. There is, however, a possibility of substitution of one type of dry cell battery for another. For example, a flashlight or portable radio could use an alkaline, a carbon-zinc, or a nickel-cadmium battery. Alkaline batteries are considerably more expensive than carbon-zinc batteries, but provide a longer service life. Nickel-cadmium batteries, although quite expensive, are rechargeable, thus providing the potential for longer service life. However, their power reserve is generally somewhat smaller than alkaline batteries. Carbon-zinc batteries appear to have the highest price elasticity of the various types discussed in this report. This is because (1) they have the shortest useful life, making their price more visible to consumers, since they must purchase new ones more frequently; and (2) several other battery types are possible substitutes, since the uses for these batteries are most often of a general nature (e.g., toys, flashlights, radios), which requires no unusual performance characteristics. For these reasons, a price elasticity of between -0.8 and -1.2 seems plausible, assuming the prices relative to competing products remain constant. The remaining battery types are replaced less frequently and a larger proportion of their uses are for more specialized applications (e.g., calculators, space, defense, electronic equipment, watches, hearing aids, etc.). For these reasons, the estimated price elasticities are lower than that of carbon-zinc. As mentioned above, these elasticity estimates, along with the major contributing factors, are summarized in Table 4-6.

4.6.2 Industry Competitiveness

The ability of battery producers to pass along costs of compliance through higher prices also depends on the pricing behavior and power in the industry.

If large firms set prices, smaller firms may be forced to accept their lead. Since, in most cases, unit compliance costs are lower for larger or newer plants, firms operatng smaller or older plants could be forced to absorb the difference. If firms perceive their industry as competitive, they will be more reluctant to increase prices than firms in basically noncompetitive industries.

The lead acid subcategory is moderately concentrated with four firms accounting for 66 percent and eight firms accounting for 85 percent of industry production. Alongside these large firms there exist many small and medium sized firms that might be expected to have higher average costs and a lower availability of investment capital. Competition among the larger firms is likely to mitigate their ability to pass along immediately all increased costs of doing business. However, given the low price elasticities of demand, their costs will ultimately be passed along. The smaller firms, if they are faced with high unit compliance costs, will be in a poorer competitive position. The existence of localized specialty markets may mitigate competition between smaller and larger firms. However, information gathered is insufficient to fully assess the magnitude of this occurrence.

Production of primary batteries is highly concentrated with four-firm and eight-firm concentration ratios of 87 and 94 percent, respectively. Production of individual battery types is even more concentrated, since, as can be seen in Table 3-2 (Chapter 3), many of the subcategories have only a half dozen or fewer plants. High concentrations such as these imply that the industry's ability to increase their product prices to cover increased costs is limited only by the strength of market demand.

5. BASELINE PROJECTIONS OF INDUSTRY CONDITIONS

5. BASELINE PROJECTIONS OF INDUSTRY CONDITIONS

This section provides projections of conditions in the battery industry to 1990 under the assumption that there are no additional water pollution control requirements resulting from the Clean Water Act. These projections are used in Chapter 7, together with other information such as estimated compliance costs, to assess the incremental economic effects of the effluent control requirements on future industry conditions.

The baseline projections in this report provide a general point of reference for the analysis and is not intended to be a comprehensive, authoritative forecast of future industry conditions. Although minor changes to the baseline could result from a more comprehensive treatment of forecasting techniques, they are not likely to alter significantly the study's overall conclusions regarding the extent of the economic impacts of the effluent guidelines.

The primary variables of interest have been divided into two broad cate- categories for consideration in this report--Demand related factors and Supply related factors:

- Demand Factors
  -Quantity demanded
  -Types of Products demanded
  -Price elasticities of demand

- Supply Factors
  - Cost of goods sold
  - Employment
  - Profitability
  - Geographical locations
  - Discharger status
  - Industry structure (number and size of plants and firms, competitiveness, etc.).

The basic approach followed in developing the projections began with a forecast of demand related factors under the assumption that battery prices relative to general price levels remain constant. Then, using the resulting initial volume estimate, industry supply factors were assessed to determine if there would be any significant changes in the relative costs or profitability of producing batteries over the next decade, which would negate the initial assumption of constant relative prices. Since no reason has been found to expect the price of batteries to increase faster than that of other goods, the initial assumption has not been modified.

5.1 DEMAND RELATED FACTORS

The primary reason for beginning the baseline projections with the demand analysis is that it is hypothesized that the battery industry supply factors will adjust to demand conditions. This is expected because: (1) the battery industry is a very small proportion of total economic activity in the U.S. and is, therefore, more likely to react to general trends, rather than influence them; (2) the demand for batteries is a derived demand, depending on the sales and use of thousands of other products such as automobiles, flashlights, electronic calculators, and other electronic equipment, and is, therefore, complementary to the demand of these other products; and (3) the demand elasticity of batteries with respect to price is estimated to be low.

Demand forecasting is an inexact discipline, with considerable dependence on individual judgment and simplifying assumptions. Each forecasting technique has its own particular advantages and disadvantages, which could result in different types of errors. To mitigate the likelihood of bias because of such occurrences, two techniques were used and a range of plausible values was established - Time Series Analysis and Regression Analysis. To augment these techniques, information and estimates provided by other authors were used to adjust the forecasts in order to account for industry developments not measured in the quantitative analysis.

5.1.1 Time Series Analysis

Time series analysis is a useful, but sensitive, forecasting tool. The results are extremely sensitive to the time period selected for the analysis. Furthermore, the technique is generally more appropriate for broad economic/demographic variables than for very specialized industries. A particular industry may have undergone one or two influential technological or market changes during part of a 20- or 30-year history, which would bias the calculation of a long-term trend line. On the other hand, aggregate economic variables tend to "average out" such changes and, consequently, exhibit a more uniform growth pattern.

A 27-year time series for value of storage battery shipments (constant dollars) indicates the existence of such sharp shifts in industry growth patterns. For example, during the 1950s, the value of storage battery shipments were stagnant, showing no growth at all. In fact, the value for 1960 was 2 percent below that of 1950 (contant dollars). Through the 1960s and 1970s, industry growth steadily accelerated, having compounded average annual rates of 5.2 percent from 1960 to 1970, 5.7 percent from 1963 to 1973, and 7.3 percent from 1967 to 1977. The growth rate for the entire 27-year period was 3.8 percent. Because of these shifts, simple extrapolation of the trends could lead to serious bias in any resulting forecasts.

Several market and technological developments in the storage battery industry over the time period appear to explain, to a large extent, the sharp shifts in storage battery industry growth patterns. The first of these was the switch from 6-volt to 12-volt SLI batteries during the 1950's. Twelve-volt batteries have thinner plates, which might result in earlier replacement than 6-volt batteries. The second significant change is increasing power demands on SLI batteries resulting from increased popularity of power options (such as air conditioning) in automobiles. The third development is the general trend toward increased number of miles driven per year by motorists through the 1950-1977 period. The fourth development is that of maintenance-free batteries, which might be changing the value of shipments data more than volume of shipments data, because of their higher price. Finally, the growing commercialization of nickel-cadmium batteries during the 1970s has made possible a number of new consumer products as well as some replacement of primary batteries by these storage batteries. Although these developments are expected to continue influencing the growth rate, the most rapid part of their initial market penetration appears to have already occurred. For these reasons, a compounded average annual growth rate of 5.8 percent (the 1957-1977 rate) and a growth rate of 3.8 percent (the 1950-1977 rate) appear to be plausible upper and lower bound estimates for the storage battery industry. These growth rates would result in a 1990 value of shipments of from $1,898 million to $2,433 million (1967 dollars).

Time series data for the primary battery industry is, to a large extent, more readily interpreted than that of storage batteries. Between 1957 and 1977, the industry increased its value of shipments from $144.9 million to $376.8 million (1967 dollars), representing a compounded average annual growth rate of 4.0 percent. As was observed for the storage battery sector, this growth was uneven - about 3.5 percent from 1959 to 1973 and accelerating to a 7.8 percent rate during the 1973 to 1977 time period. After eliminating years that appear to be outliers, fitting exponential curves to the data, and considering general economic conditions over the period, it appears that the range of 2.9 to 4.9 percent growth is likely. This growth will probably be distributed unevenly among the various primary battery products, primarily because of innovation in the battery and battery-using industries. In the battery industry, this innovation includes the commercialization of new chemical systems and new sizes and shapes of batteries (e.g., nickel cadmium, silver oxide, and mercury-ruben batteries). In battery-using industries, recent innovations such as solid state electronic equipment (e.g., calculators, hearing aids, etc.), disposable flashlights, and smoke alarms have been quite successful in the marketplace and have caused rapid growth in the use of the "newer" batteries. Furthermore, the newer batteries have been replacing carbon zinc batteries in many applications. Thus, the rapid growth of the newer products is partially offset by falling share of market of the older products.

With the estimated rates of growth, the 1990 value of shipments is projected to be between $546 million and $700 million (1967 dollars), or from 45 to 86 percent higher than 1977.

5.1.2 Regression Analysis

Regression analysis is a statistical technique which is used to summarize the outcome of market forces by statistically describing the relationship between the fluctuations in the value of a variable and that of the variables that are believed to cause these fluctuations. In demand analysis, it is used to relate changes in quantities of a product demanded to the level of activity in industries or economic sectors that use the product and to prices of substitute and complementary products. Equations of the following general form were estimated and tested for statistical significance:

$$D_a = b_1 y_a + b_2 p_s + b_3 p_c + t + d + e$$

where D_a = Demand for batteries in market a

y_a = an appropriate activity variable in market a

p_s = the prices of substitutes, appropriately deflated

p_c = the prices of complementary products, appropriately deflated

b_1, b_2, and b_3 = the parameters of the relationship to be estimated

t = a measure of technological change

d = constant term

e = error.

In this analysis, it is assumed that there is a causative flow of activity which runs from macroeconomic activity to activity in industries that produce investment and consumer goods to activity in industries that produce battery-using products, to activity in the battery industry itself. Activity variables were sought for which exogenous forecasts are readily available from such sources as the Wharton EFU model, Predicasts, Inc., or the Data Resources, Inc., model. These activity variables consisted of general economic indicators such as the Federal Reserve Board index of industrial production, GNP, and personal consumption expenditures. The price of batteries is represented by the Bureau of Labor Statistics Wholesale Price index series. Complementary goods price variables included the wholesale price indices for automobiles and electrical machinery. Since there is no single, direct substitute for batteries, no single price variable is indicated for this effect; however, the price of batteries relative to an average price of all goods might capture some of this effect. A time trend is used as a proxy variable for the technological change effect, since this effect is so difficult to quantify in this type of anlaysis. However, statistical tests show that the variable is not statistically significant. Instead, this effect is dealt with by the use of dummy variables and sample segmentation to distinguish different periods in which unusual structural changes occurred which affected the industry. Technological change is also partially measured by relative prices. That is, to some extent, technological change is one aspect of a long-run substitution process; so that relative prices serve, at least partially, as a proxy variable for technological change, as well as for direct economic substitution.[1]

After testing a variety of functional forms, different estimation time periods and activity and price variables, the equations shown in Table 5-1 have been selected for use in the forecast. The primary variables that are significant in these equations are real GNP, the Federal Reserve Board index of industrial production, and the relative prices of storage batteries, primary batteries and electrical equipment. An evaluation of the general determinants of costs of producing batteries indicates no reason to expect production costs to increase or decrease at a greater rate than other goods and services over the next 13 years. Therefore, the relative price of batteries is assumed to be constant. Forecasts of the activity variables (i.e., GNP and Index of Industrial Production) are from Predicasts, Inc.'s economic forecasting service. These forecasts and assumptions are used in the estimated equations to provide the demand estimates shown in Table 5-2. Thus, according to the regression analysis, the 1990 value of storage battery shipments will be between $1.5 and 1.8 billion (1967 dollars), representing a compounded annual growth rate of between 1.9 and 3.2 percent. The projections for primary batteries are between 544 and 789 million, respectively. These figures represent compounded annual average growth rates of between 2.9 and 5.7 percent.

5.1.3 Forecasts of Other Authors

While a full survey of battery industry personnel and investment analysts was not conducted in this study, their general concensus regarding future industry growth can be inferred from various sources, such as the Trade Press (e.g., American Metal Market, Chemical Week, etc.), market research and previous

1/ Christopher I. Higgins, "An Economic Description of the United States Steel Industry," in Essays in Industrial Econometrics, Volume II, Lawrence R. Klein, ed., p. 10.

TABLE 5-1. REGRESSION FORECASTING EQUATIONS

Equation Number	Dependent Variable	Functional Form	GNP ($1972)	Index of Industrial Production (1967 = 100)	Relative Price of Storage Batteries	Relative Price of Primary Batteries	Relative Price of Electrical Equipment	Constant	Sample Time Period	Degrees of Freedom	Coefficient of Determination R^2	F Statistic	Standard Error
1	Value of storage battery shipments	linear	.69723 (17.64)		-1063.78 (7.81)			995.34	1950-77	25	.96	317	45.0
2	Value of storage battery shipments	linear	0.69339 (21.76)		- 200.41 (0.79)		-792.05 (3.81)	922.78	1950-77	24	.98	330	36.2
3	Value of storage battery shipments	linear	0.80523 (10.31)		- 835.65 (4.16)			666.64	1957-77	18	.96	242	46.01
4	Value of storage battery shipments	log	0.9466 (16.12)		- 1.4645 (6.96)			-0.1249	1950-77	25	.95	235	0.08
5	Value of storage battery shipments	log		0.7657 (26.90)	0.5242 (1.68)		-1.8235 (7.08)	2.8978	1950-77	24	.98	447	.05
6	Value of primary battery shipments	linear	0.2760 (8.50)			-100.44 (1.12)		78.656	1957-77	18	.82	40	29.94
7	Value of primary battery shipments	linear		4.3940 (6.61)		-410.76 (2.9)	671.85 (3.26)	-419.246	1957-77	17	.90	49	23.14
8	Value of primary battery shipments	linear		5.1133 (8.71)		-411.00 (4.41)	1106.43 (5.15)	-916.21	1957-73	13	.92	48	17.19
9	Value of primary battery shipments	log-rythmic	1.1247 (9.69)			.3158 (0.99)		-2.2361	1957-77	18	.85	51	0.11
10	Value of primary battery shipments	log-rythmic		1.4521 (8.62)		-1.4097 (3.71)	1.9120 (3.54)	-1.0541	1957-77	17	.9217	67	.083
11	Value of primary battery shipments	log-rythmic		1.6006		-1.3623	3.0240	-1.7108	1957-73	13	.9354	63	.070

TABLE 5-2. SUMMARY OF DEMAND PROJECTIONS OF THE VALUE OF SHIPMENTS OF BATTERY PRODUCTS
(Billions of 1967 Dollars)

	Time Series Analysis	Regression Analysis	Regression with Adjustments for Technological Change 6/	Business Communications Corp. (BCC) 1/	Battery Council Int'l. 2/	Kearney Management Systems 3/	Trade Press 4,5/	Concensus
STORAGE BATTERIES								
Value of Shipments								
1977 $ Billions	1.2	-	-	-	-	-	-	-
1985 $ Billions	1.6 - 1.8	1.3 - 1.6	1.4 - 1.8	1.9 - 2.2	1.6	1.6	1.8 - 1.9	1.4 - 1.8
1990 $ Billions	1.9 - 2.4	1.5 - 1.8	1.7 - 2.1	2.6 - 3.3	2.0	1.9	2.3 - 2.6	1.7 - 2.3
Growth Rates (annual)								
1950-1977 %	3.8%	-	-	-	-	-	-	-
1977-1985 %	3.8 - 5.8%	1 - 3.6%	2.2 - 4.8%	6 - 8%	4%	3.5%	5 - 6%	3 - 4.4%
1977-1990 %	3.8 - 5.8%	1.8 - 3.2%	3.0 - 4.4%	6 - 8%		3.5%	5 - 6%	3 - 4.4%
PRIMARY BATTERIES								
Value of Shipments								
1977 $ Billions	0.38	-	-	-	-	-	-	-
1985 $ Billions	0.47- 0.55	0.47- 0.54	-	0.56	-	.47	.47- .61	0.48- 0.56
1990 $ Billions	0.55- 0.70	0.55- 0.80	-	0.72	-	.55	.55- .81	0.56- 0.72
Growth Rates (annual)								
1957-1977 %	4.0%	-	-	-	-	-	-	-
1977-1985 %	2.9 - 4.9%	2.9 - 5.7%	-	5.0%	-	2.9%	5 - 6%	3 - 5%
1977-1990 %	2.9 - 4.9%	2.9 - 5.7%	-	5.0%	-	2.9%	5 - 6%	3 - 5%

1/ Business Communications Co., Stamford, Conn., Portable Energy Sources: Batteries, Fuel Cells, Solar Cells, October 1977. Storage battery figure was adjusted from "current dollars" forecast of 13.7%.

2/ American Metal Market, March 30, 1979.

3/ Kearney Management Systems, Draft Economic Impact Assessment of Proposed Effluent Limitation Guidelines for the Battery Industry Point Source Category, Contract No. EPA 68-01-1940, 1976.

4/ Chemical Week 1/10/79 - Estimate is for entire battery industry.

5/ Quote from Edward D. Hopkins, President of Gould, Inc.

6/ From the information in Section 4.1.3, an adjustment to the regression model is made to account for the potential growing use of electric vehicles (6%) and the other changes in the storage battery industry (6%).

government reports, and interviews with a number of industry personnel contacted during the course of the study (although not a statistically representative sample). From these sources, a number of trends are evident. These are:

- Maintenance free batteries will increasingly dominate the lead-acid battery industry. This will result in increased demand for lead-calcium alloy. To meet this demand, lead smelters will decrease the proportion of scrap lead to virgin lead.

- Research and development geared toward developing new types of batteries could threaten the long-term future for lead-acid batteries. Such R&D is also being done to improve lead-acid technology, but such improvements would be minor in comparison to the theoretical potential of some other systems (e.g., lithium batteries).

- The development of a practical electric vehicle holds the promise of revolutionizing this industry. Although there are a number of test vehicles on the road today, none appear to be able to replace completely the internal combustion engine at this time. Assuming that a fairly conventional lead-acid powered automobile becomes popular, each 100,000 vehicles sold could increase industry value of shipments by 6 percent. One hundred thousand vehicles represent about 1 percent of annual U.S. auto sales.

- The recent trend of considerable downsizing of SLI batteries is expected to continue. This is believed to be largely offset by an expected shorter average useful battery lifetime of the downsized batteries.

- The trend toward diesel engines will increase demand for SLI batteries, since diesel engines require two batteries.

- Increased cost of electric power production has made the storage of electrical energy by utilities for use during peak demand periods more cost-effective. This trend will have a positive effect on lead-acid battery growth.

The combined effects of these trends is to add 12 percent to the value of lead-acid battery shipments over the next 10 years. This estimate is used in Section 5.1.4 below, in conjunction with other information, to project industry activity.

5.1.4 Concensus of Demand Projections

Table 5-2 shows a number of alternative forecasts of battery shipments for the years 1985 and 1990. The first two columns show the results of the time series and regression analyses performed by the study team. The third column represents a modified version of the regression analysis which incorporates an adjustment made by the study team to account for expected technological innovation in the industry. The adjustment results from the incorporation of the opinions of industry experts discussed in Section 5.1.3 into the analysis. The next four columns are forecasts taken from or derived from other published sources that have appeared over the past few years and the last column is a consensus forecast based on the other information in the table as well as the information in Section 5.1.3 regarding potential technological and market shifts in the battery industry.

The five projections of 1990 primary battery shipments ranged in value from $470 million to $800 million in 1967 dollars. However, two of the five projections are considered less reliable than the other three. The projection based on the "trade press" source is based upon the entire battery industry and is therefore heavily weighted by the storage battery sector. The regression results, although useful in spotting possible turning points, has somewhat inconsistent results. Furthermore, the projections resulting from the other three sources are fairly close. For these reasons, the projections based on the regression analysis and the trade press source are eliminated from the forecast. The remaining three sources result in 1990 shipments estimates of from $550 to $700 million. These figures represent compounded average annual growth rates of 3 to 5 percent. Inherent in these projections is the expectation that the more rapid growth of the mid-1970s will taper off because of market saturation of the newer battery types and the new battery-using products.

The six projections of 1990 storage battery industry shipments ranged in value from $1.5 billion to $3.3 billion in 1967 dollars. The trade press projection reflects quotations from industry managers and marketers. Often, such estimates are an off-the-cuff "gut feeling" based upon only very recent experience. Thus;, if the last two or three years were up or down, the projections would be correspondingly overly optimistic or pessimistic. Since the last few years have shown unusually rapid growth in storage battery shipments and since the sources listed provided little or no explanation regarding their forecasts, the 5-6 percent growth rate obtained from the trade press is considered an overestimate, or at least an upper bound. The Business Communications Corporation (BCC) etimate appears too high, because they are based largely on conjecture regarding future technological developments in storage battery technology and markets. However, it is the judgment of the study team that technological "breakthroughs" are extremely difficult to forecast with accuracy and, therefore, such estimates should be accepted only at the very lower bounds. The BCC study appears to have used more optimistic estimates in this regard. For these reasons, the trade press and BCC estimates (the two highest estimates) are eliminated from further use in our forecast. However, in an intuitive manner they do serve to substantiate the remaining projections.

The remaining estimates are relatively consistent except that the time series analysis has a rather wide range of values. This is due primarily to the standard error of estimate of the time-fitted line. Thus, a range of $1.7 billion to $2.3 billion (1967 dollars) for 1990 storage battery shipments is selected as the consensus forecast. This represents compounded average annual growth rates of 3 to 4.4 percent, respectively. For comparative purposes, the GNP forecast for the time period is for average growth of 3.3 percent annually.

5.2 SUPPLY FACTORS

The primary supply related factors of interest are employment, industry establishments, prices, profits, and industry location.

5.2.1 Employment

In general, it is expected that employment will increase with growing industry activity, but at a lower rate than that of value of shipments or value added. The lower rate results from a trend of increasing productivity in the battery industry and inflation, in recent years. From 1963 to 1977, the value added and value of shipments of storage batteries grew at a compounded average annual growth rate of 6.8 percent, while industry employment grew 3.4 percent per year. Thus, the growth in production was largely the result of increased labor productivity. The value of shipments per employee increased almost steadily from $32,000 to $45,000 during the period, in 1967 dollars (2.5 percent per year). The increased productivity resulted from improvements in products and production processes, increases in the proportion of industry production at larger plants (which generally have greater capital investment per employee than smaller plants), and changing product mix. Since there is little evidence indicating significant changes in these trends, productivity is expected to continue to grow at the historic rate of 2.5 percent per year. Thus, at the lower range of the above forecast, 1990 storage battery employment is projected to be 27.4 thousand, about 12 percent higher than 1977.[1/]

Primary battery employment increased from 8,500 in 1963 to 10,700 in 1977, representing a compounded average growth rate of 1.8 percent per year. This figure is less than half (44 percent) of the growth in value of shipments over the period. During the period, the real value of shipments per employee increased from $26,300 to $35,200, which represents an average

---

1/ At the historical growth in shipments of 3.8 percent, employment would be 30.6 thousand in 1990.

growth of about 2.1 percent per year. Extrapolating this growth rate to 1990 results in $46,100 per employee. At the lower range of the demand forecast, this would mean 12,100 primary battery employees in 1990, about 13 percent higher than in 1977.

5.2.2 Number of Industry Establishments in 1990

Storage Batteries

The storage battery industry appears to be following a long-term trend toward fewer and larger plants. The Census of Manufactures reports that the number of establishments dropped 13 percent between 1963 and 1977, from 252 to 218. There are a number of reasons for this trend, most of which will probably be operating over the next 13 years. These are (1) rapidly increasing operating costs at older, more labor-intensive plants relative to newer and larger plants, (2) changes in products and production technology, (3) geographical shifts in markets, and (4) costs of compliance with health, safety and environmental regulations.

The basic problem of many older, labor intensive plants is their inability or unwillingness to keep up with changing, lower-cost production technologies developed during the past 20 years. The primary changes in production technology include the replacement of rubber battery cases with plastic ones, automatic battery lid sealers and other assembly equipment, faster grid casting machines, and the stamping and drawing grid making processes. Product changes have included a shift from using 6-volt to the use of 12-volt SLI batteries, and the development of "maintenance free" batteries which generally use a lead-calcium alloy instead of the more traditional lead-antimony alloy. The manufacture of lead-calcium grids requires more sophisticated and, therefore, more expensive equipment than that of lead-antimony grids. It is also expected that, in addition to a continuation of these trends over the next decade, there will be a general downsizing of the SLI battery and some possible new battery configurations to accomodate the growing popularity of electric vehicles. These technology changes require significant investments in capital equipment and product development, which makes it difficult for small firms with limited access to investment capital to survive.

Many smaller lead-acid battery firms serve local, regional, or specialty markets and, consequently, do not maintain a national marketing and advertising network to promote and distribute their products. In addition, battery manufacturing has traditionally been located near markets, because of the basic transportation economics of the industry. As a result, they are particularly vulnerable to geographic shifts in population distribution. Thus, as the U.S. population shifts West and South, the growth in volume of the older, smaller plants in the northeast will be limited and their financial position will likely deteriorate.

Lead-acid battery producers are particularly vulnerable to health, safety, and environmental regulations. EPA and OSHA lead air standards have already added significantly to production costs and investment expenditures.

For these reasons, it is projected that plants will continue to decline at the same rate as during the 1963 to 1977 time period (about 1.5 - 2.5 per year). Thus, by 1990, there will be an additional 20 to 33 plant closures in the lead-acid battery industry (if the lower end of the demand forecast occurs).

Primary Batteries

The number of primary battery plants have been increasing over the past 15 years. The size of these plants generally range from 40 to 500 employees, with less than a handful as small as the small lead-acid plants (i.e., less than 20 employees). Most of them are owned by large companies. In recent years there has been some consolidation of operations by these companies, that is, merging the operations of small plants with other small and large plants. Industry personnel report that some of these consolidations are encouraged by environmental regulations. At this time, there does not appear to be any significant reason to expect more than a handful of such consolidations or any baseline plant closures for other reasons in this industry segment over the next 10 years.

5.2.3 New Battery Plants

Little information has been uncovered which would allow a precise estimate of the number of new plants that might be built between now and 1990. However, using information in the previous sections of this report, several observations can be made. This discussion is based on the lower bound demand forecasts derived above.

Production and market economies in the storage battery industry make it highly unlikely that any plant of less than $20 to $30 million in capacity would be built today. With plants of this size, the projected increase in demand (assuming the lower-bound estimate of $800 million in 1977 dollars) could be met with 26-40 new plants. An additional one or two plants of this size would account for capacity lost from the closure of about 30 small plants. If, however, the increased capacity is installed at existing establishments, the number of new plants would be fewer. Industry sources report that the later scenario is more likely. Thus it is doubtful that, at the lower demand projections, there would be more than 5 or 6 new lead acid plants built by 1990.

The size of future primary battery plants can vary widely, depending upon the degree of specialization in specific battery types. However, a rough estimate of $5 to $10 million in capacity per plant is consistent with current trends. With plants of this size, it would take 30 to 60 new plants to meet the projected demand increase of $300 million (1977 dollars) capacity, if there wsa no expansion of current facilities. While, at this time, no consistent estimates have been found regarding expansion plans at current facilities in the primary battery segment of the industry, it appears that most of the required added capacity will be at existing facilities.

5.2.4 Prices

Over the past 20 years, average battery prices increased at a slower rate than the aggregate price levels and the price level in the electrical equipment industry. More recently, however, there has been an unusual jump in some prices, because of raw material and energy cost increases. This has been especially so for the lead-acid subcategory. Some industry sources project a retreat from these record high prices in the next couple of years.[1/] After this adjustment, it is expected that the prices of batteries will increase at approximately the same rate as the general economic price levels.

5.2.5 Profitability

Since the industry has generally low demand elasticities, it is anticipated that most increases in production costs occurring through 1990 will be passed on. Although industry competition and potential for foreign imports in some industry subcategories could mitigate, somewhat, their ability to maintain profit margins in the future, this potential occurrence has not been quantified in this study.

5.3 SUMMARY OF BASELINE CONDITIONS

A summary of baseline conditions appears in Table 5-3. Between now and 1990 shipments will increase at an annual rate somewhat greater than that of the long-term GNP trend. However, because of increasing labor economies of

---

1/ See page 4-4.

TABLE 5-3. SUMMARY OF BASELINE PROJECTIONS

	STORAGE BATTERIES			PRIMARY BATTERIES		
	1977	1985	1990	1977	1985	1990
Value of Shipments (Billions of 1977 Dollars)	$ 1.9	2.4-2.7	2.7-3.4	0.6	0.8-0.9	0.9-1.2
(%) (Annual)		3-4%	3-4.4%		3-5%	3-5%
No. of Employees 1/ (000)	24.5	26.2	27.4	10.7	11.5	12.1
No. of Plants 1/	215	195-202	182-195	57	57-75	57-75
No. of Firms	112-132	NA	NA	17	NA	NA
Price Level 2/	162 2/	3/	3/	161 4/	3/	3/
Return on Sales Before Taxes)	.06 - .14	.06 - .14	.06 - .14	.06 - .14	.06 - .14	.06 - .14
Industry Competition	Moderate	Moderate	Moderate	Mod.	Mod.	Mod.

1/ Estimated at the lower demand estimate.

2/ Bureau of Labor Statistics Wholesale Price Index for Storage Batteries.

3/ Price increases are projected to be equal to those of the general price levels.

4/ BLS, wholesale price index for Primary Batteries.

NA - Not Available

scale and a trend toward larger plants, growth in employment in the industry will be lower than that of output. In 1990 the average plant size will be significantly larger. This is especially true of the lead-acid segment of the industry, since it is projected that there will be many small plants that will cease to manufacture batteries and since the newer technologies in lead-acid battery production are only practicable for larger plants. Although increased industry concentration is expected in the lead-acid battery industry (because of the projected exists of small firms and, possible consolidations of larger firms), the information available did not allow a precise quantitative determination of the magnitude of this development. Similar forces at work in the primary battery sector would lead to consolidation in the mature product lines (e.g., carbon zinc batteries). However, the dynamic nature of technological developments in the newer battery types (including lithium batteries and some still in the research and development stage such as nickel-zinc) has made it difficult to project trends in consolidation of these products.

Prices of battery products are projected to increase at about the same rate as the general price levels in the economy. This is because no extraordinary relative price changes in the basic factors of production were projected. Thus, relative to other prices in the economy, battery prices are projected to remain constant.

Insufficient information is available to reliably estimate changes in profitability measures for the industry. This results from the dynamic nature of the technology and industry structure described previously. Because of this shortcoming the economic analysis was performed under the assumption that profit rates remain at current levels.

Although insufficient information was available to quantitatively disaggregate industry growth projections into the specific battery type, enough information was available to categorize the various battery types according to whether they are expected to be above, below, or approximately equal to the average growth rate for the industry. The results of this categorization are shown below:

Lower Than Industry Average Growth Rate

Carbon zinc-air
Lead Acid Reserve
Leclanche
Mercury cadmium zinc
Nickel zinc*

Average Industry Growth Rate

Lead Acid
Magnesium carbon
Magnesium reserve
Silver oxide - Cadmium
Calcium

Higher Than Industry Average Growth Rate

Alkaline manganese
Lithium
Mercury ruben
Nickel cadmium
Silver oxide - zinc
Thermal

* Nickel zinc batteries are experimental. If they become commercialized they would probably grow at a considerably higher rate than that of the industry.

6. COST OF COMPLIANCE

6. COST OF COMPLIANCE

6.1 OVERVIEW

The recommended water treatment control systems, costs, and effluent limitations for the battery manufacturing industry were enumerated in the development document for effluent limitation guidelines and standards of performance. That document identifies various characteristics of the industry, including manufacturing processes; products manufactured; volume of output; raw waste characteristics; supply, volume, and discharge destination of water used in the production processes; sources of waste and wastewaters; and the constituents of wastewaters. Using that data, pollutant parameters requiring limitations or standards of performance were selected by EPA. The primary criteria for this selection were that both the nature of the pollutant parameters and the volume of discharge must be significant.

The EPA draft development document also identified and assessed the range of control and treatment technologies within each industry subcategory. This involved an evaluation of both in-plant and end-of-pipe technologies that could be designed for each subcategory. This information was then evaluated for existing surface water industrial dischargers to determine the effluent limitations required for the best practical control technology currently available (BPT), and the best available technology economically achievable (BAT). New direct dischargers are required to comply with new source performance standards (NSPS), which require best available demonstrated control technology (BDT). New and existing dischargers to publicly owned treatment works are required to comply with pretreatment standards (PSNS and PSES). The technologies were analyzed to calculate cost and performance. Cost data were expressed in terms of investment, operating and maintenance costs, plus depreciation, and interest expense. Pollution characteristics were expressed in terms of median and mean concentration levels (per liter of water as well as volume of production) for each subcategory.

6.2 COST ESTIMATION METHODOLOGY

The estimation of the costs presented in this section began with the selection of specific wastewater treatment technologies and in-process control techniques. The components of these techniques were combined into alternative wastewater treatment and control systems appropriate for each battery industry technical subcategory. The selection of the specific treatment systems was based upon an examination of raw waste characteristics, considerations of manufacturing processes, and an evaluation of available treatment technologies discussed in Section V of the development document. The rationale for selection of these alternative systems is presented in Sections IX and X, and the selected techniques are enumerated and described in Sections VII and VIII of the development document. Investment and annual cost estimates for each treatment technique were based on wastewater flow rates and raw waste characteristics for each subcategory. The costs were then aggregated to represent the investment and annual operating costs for the appropriate treatment systems.

The final input data set comprises raw waste flow rates for each input stream for one or more plants in each subcategory addressed. Three cases corresponding to high, low, and typical flows encountered at existing facilities were used for each battery manufacturing subcategory to represent the range of treatment costs which would be incurred in the implementation of each control and treatment option offered. In addition, data corresponding to the flow rates reported by each plant in the category were used to provide plant-specific cost estimates for use in the economic impact analysis.

In general terms, cost estimation is provided by mathematical relationships in each subroutine approximating observed correlations between component costs and significant operational parameters such as water flow rate, retention times, and pollutant concentrations. Flow rate is usually the primary determinant of investment costs and of most annual costs with the exception of materials costs. In some cases, however, pollutant concentrations may also significantly influence costs.

6.3 COST FACTORS, ADJUSTMENTS, AND ASSUMPTIONS

In developing the compliance cost estimates a number of critical factors had to be estimated, and adjustments and assumptions made by EPA. These are described in the development document and summarized below:

- All costs are expressed in January 1978 dollars
- Nonsupervisory direct labor cost estimates assumed an average wage rate of $6.00 per hour, which is the hourly wage rate for nonsupervisory workers in water, stream, and sanitary systems for January 1978, as reported in the U.S. Department of Labor, Bureau of Labor Statistics' "Employment and Earnings." Indirect labor charges were estimated at 10 percent of the direct labor costs
- An average rate of 3.3 cents per kilowatt hour was used for all electrical energy costs. It was assumed that electrical needs would be satisfied by the existing electrical distribution system; i.e., no new meter would be required.
- Capital recovery costs assumed a straight line ten-year depreciation, whereas depreciation charges for various items of plant equipment were estimated to range from 10 to 25 years.
- Subsidiary costs associated with system construction are included in the system cost estimates. These include administrative and laboratory facilities, line segregation, yardwork, engineering, legal costs, fiscal and administrative expenses, interest during construction, and garage and shop facilities.
- No new land purchases were costed. That is, it was assumed that the land required for the treatment systems was already available at the plant.
- Where batch, continuous or haul-away treatment systems were possible, the system with the lowest life-cycle cost, over a 10-year period, was selected for presentation in the system cost table.

6.4 POLLUTANT PARAMETERS

The selection of pollutant parameters for the application of effluent limitation guidelines was primarily based on a review of laboratory analyses of wastewater samples from several battery manufacturing plants and on responses to a mail survey submitted to all known battery manufacturers. This information was used to estimate the concentration of each of the 129 priority pollutants as well as other variables considered to be "traditional parameters" in the study of water pollution. The specific approach to selecting pollutant parameters is presented in Sections V and VI of the development document. Table 6-1 lists the parameters selected as inputs to the cost program.

The values of these pollutant parameters were used in determining materials consumption, sludge volumes, treatment component sizes and effluent characteristics. Individual subcategories of the battery industry commonly encompass a number of widely varying waste streams, which are present to varying degrees at different facilities. The raw waste characteristics shown as inputs to the waste treatment systems represent a mix of these streams including all significant pollutants generated in the subcategory and will not, in general, correspond precisely to process wastewater at any existing facility. The process by which these raw wastes are defined is explained in Section X of the development document.

6.5 CONTROL AND TREATMENT TECHNOLOGY FOR EXISTING DISCHARGERS

Tables 6-2 to 6-7 provide an overview of the recommended BPT, and BAT treatment systems for six subcategories (treatment systems for the Leclanche subcategory were not described in the development document; zero discharge was proposed for this subcategory). Generally these treatment systems involve increasing levels of pollutant reduction and wastewater quality at each succeeding option (i.e., BAT level 1 provides greater pollution reduction than BPT, BAT level 2 provides greater pollution reduction than BAT level 1, and so on). The recommended compliance technologies for each option vary from one subcategory to another. However, the recommended BPT options generally rely upon

TABLE 6-1. COST PROGRAM POLLUTANT PARAMETERS

Parameter, Units	Parameter, Units
Flow, MGD	Oil, Grease, mg/l
pH, pH units	Hardness, mg/l $CaCO_3$
Turbidity, Jackson Units	Chemical Oxygen Demand, mg/l
Temperature, degree C	Algicides, mg/l
Dissolved Oxygen, mg/l	Total Phosphates, mg/l
Residual Chlorine, mg/l	Polychlorobiphenyls, mg/l
Acidity, mg/l $CaCO_3$	Potassium, mg/l
Alkalinity, mg/l $CaCO_3$	Silica, mg/l
Ammonia, mg/l	Sodium, mg/l
Biochemical Oxygen Demand mg/l	Sulfate, mg/l
Color, Chloroplatinate units	Sulfite, mg/l
Sulfide, mg/l	Titanium, mg/l
Cyanides, mg/l	Zinc, mg/l
Kjeldahl Nitrogen, mg/l	Arsenic, mg/l
Phenols, mg/l	Boron, mg/l
Conductance, microohms/cm	Iron, Dissolved, mg/l
Total Solids, mg/l	Mercury, mg/l
Total Suspended Solids, mg/l	Nickel, mg/l
Settleable Solids, ml/l	Nitrate, mg/l
Aluminum, mg/l	Selenium, mg/l
Barium, mg/l	Silver, mg/l
Cadmium, mg/l	Strontium, mg/l
Calcium, mg/l	Surfactants, mg/l
Chromium, Total, mg/l	Beryllium, mg/l
Copper, mg/l	Plasticizers, mg/l
Fluoride, mg/l	Antimony, mg/l
Iron, Total, mg/l	Bromide, mg/l
Lead, mg/l	Cobalt, mg/l
Magnesium, mg/l	Thallium, mg/l
Molybdenum, mg/l	Tin, mg/l
Total Volatile Solids, mg/l	Chromium, Hexavalent, mg/l

Source: EPA Development Document, Table VIII-1.

TABLE 6-2. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR CALCIUM SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT		BAT-1		BAT-2	
	HEAT PAPER PRODUCTION	CELL TESTING	HEAT PAPER PRODUCTION	CELL TESTING	HEAT PAPER PRODUCTION	CELL TESTING
End-of-Pipe Treatment						
• Settling	X		X		X	
• Chemical Chromium Reduction	X		X			
• Chemical Precipitation (Lime) and Settling	X	X	X	X		X
• Polishing Filtration			X	X		X
• Holding Tank					X	
• Recycling of Wastewater					X	X
• Sludge Dewatering by Vacuum Filtration	X	X	X	X		X
In-Process Control	N	N	N	N	N	N

N = None

TABLE 6-3. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR CADMIUM SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT	BAT-1	BAT-2	BAT-3	BAT-4
<u>End-of-Pipe Treatment</u>					
• Oil Skimming	X	X	X	X	X
• Chemical Precipitation (lime or acid) and Settling	X	X	X	X	
• Polishing Filtration			X	X	X
• Reverse Osmosis with Recycling of Permeate				X	X
• Ion Exchange				X	
• Chemical Precipitation and Settling of Brine				X	
• Sludge Dewatering by Vacuum Filtration	X	X	X	X	X
• Vapor Recompression Evaporation of Brine					X
• Centrifugation					X
<u>In-Process Control</u>					
• Recycling of Process Solutions	X	X	X	X	X
• Segregation of Noncontact Cooling Water	X	X	X	X	X
• Control of Electrolyte Drips and Spills	X	X	X	X	X
• Dry Cleaning of Floors and Equipment		X	X	X	X
• Control of Rinse Flow rates		X	X	X	X
• Recirculation of Wastewater from Air Scrubbers		X	X	X	X
• Dry Cleaning of Impregnated Electrodes		X	X	X	X
• Reduction of Cell Wash Water Use		X	X	X	X
• Countercurrent Rinse		X	X	X	X
• Reduction of Cadmium Powder Rework				X	X
• Elimination of Impregnation Rinse Wastewater Discharge					X

TABLE 6-4. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR LEAD SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT	BAT-1	BAT-2	BAT-3	BAT-4
End-of-Pipe Treatment					
• Oil Skimming	X	X	X	X	X
• Chemical Precipitation (Lime and Carbonate) and Settling	X	X	X		X
• Polishing Filtration			X		
• Filtration					X
• Reverse Osmosis with Recycling of Permeate					X
• Chemical Precipitation (Sulfide) and Settling				X	X
• Membrane Filtration				X	X
• Sludge Dewatering by Vacuum Filtration	X	X	X	X	X
In-Process Control					
• Reuse of Spent Formation Acid	X	X	X	X	X
• Multistage Settling and Recycling of Pasting Operations Wastewater	X	X	X	X	X
• Low Rate Charging in Case		X	X	X	X
• Recirculation of Air Scrubber Water		X	X	X	X
• Control Spills		X	X	X	X
• Countercurrent Rinse of Electrodes After Open Case Formation		X	X	X	X
• Eliminate or Recycle Process Water for Plate Dehydration		X	X	X	X
• Water Rinse of Batteries Prior to Detergent Wash		X	X	X	X
• Countercurrent Rinse of Batteries or Reuse of Battery Rinse Water		X	X	X	X

TABLE 6-5. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR LITHIUM SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT			BAT-1			BAT-2			BAT-3		
	A	B	C	A	B	C	A	B	C	A	B	C
<u>End-of-Pipe Treatment</u>												
• Aeration			X			X			X			X
• Settling	X			X			X			X		
• Chromium Reduction	X			X								
• Chemical Precipitation and Settling	X	X	X	X	X	X		X	X		X	X
• Polishing Filtration				X	X			X			X	X
• Sludge Dewatering by Vacuum Filtration	X	X		X	X			X			X	
• Holding Tank							X			X		
• Recycling of Wastewater							X			X		
<u>In-Process Control</u>	N	N	N	N	N	N	N	N	N	N	N	N

A = Heat paper production wastewater
B = Process wastewaters from the manufacture of iron disulfide cathodes, lead iodide cathodes, cell testing, cell wash, lithium scrap disposal, floor and equipment wash
C = Process wastewater from air scrubbers
N = None

TABLE 6-6. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR MAGNESIUM SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT			BAT-1			BAT-2			BAT-3		
	A	B	C	A	B	C	A	B	C	A	B	C
<u>End-of-Pipe Treatment</u>												
• Settling	X			X			X			X		
• Chromium Reduction	X			X								
• Carbon Absorption											X	
• Chemical Precipitation and Settling	X	X	X	X	X	X		X	X		X	X
• Polishing Filtration				X				X			X	X
• Sludge Dewatering by Vacuum Filtration	X	X	X	X	X	X		X	X		X	X
• Holding Tank							X			X		
• Recycling of Wastewater							X			X		
<u>In-Process Control</u>												
• Control of Rinse Water Flow		X			X			X			X	
• Countercurrent Cascade Rinse					X			X			X	

A = Heat paper production wastewater
B = Wastewaters from the manufacture of silver chloride cathodes, cell testing, and floor and equipment wash
C = Wastewater from air scrubbers

TABLE 6-7. RECOMMENDED CONTROL AND TREATMENT TECHNOLOGY FOR ZINC SUBCATEGORY

CONTROL AND TREATMENT TECHNOLOGY	BPT	BAT-1	BAT-2	BAT-3	BAT-4
End-of-Pipe Treatment					
• Oil Skimming	X	X	X	X	X
• Chemical Precipitation (Lime or Acid) and Settling	X	X	X		X
• Polishing Filtration			X		X
• Reverse Osmosis with Recycling of Permeate					X
• Chemical Precipitation (Sulfide) and Settling				X	X
• Membrane Filtration				X	X
• Sludge Dewatering by Vacuum Filtration	X	X	X	X	X
In-Process Control					
• Recycling or Reuse of Process Solutions	X	X	X	X	X
• Elimination of Use of Chromates in Cell Washing	X	X	X	X	X
• Segregation of Noncontact Cooling Water	X	X	X	X	X
• Segregation of Organic Bearing Cell Cleaning Wastewater	X	X	X	X	X
• Control of Electrolyte Drips and Spills	X	X	X	X	X
• Control of Rinse Water Flows	X	X	X	X	X
• Countercurrent Rinses for Eight Processes		X	X	X	X
• Recirculate Amalgamation Area Floor Wash Water		X	X	X	X
• Dry Cleanup of Floor and Equipment or Recirculation of Wash Water		X	X	X	X
• Elimination of Wastewater from Gelled Amalgam Production				X	X
• Amalgation by Dry Processes					X

chemical precipitation and settling technologies. The recommended BAT options usually include the BPT option components plus additional filtration and greater wastewater flow reduction gained from in-process controls. More detailed descriptions of the treatment technologies appear in Sections IX, X, XI and XII of the development document.

6.6 CONTROL AND TREATMENT TECHNOLOGIES FOR NEW SOURCES

The considered BDT options for new sources to achieve NSPS are identical to BAT options. Similarly, the pretreatment options for new sources (PSNS) are also identical to BAT options for existing dischargers to publicly-owned treatment works (PSES).

6.7 INDUSTRY COMPLIANCE COSTS

Tables 6-8 and 6-9 show the estimated investment and total annual compliance costs by battery type and industry technical subcategory in 1978 and 1981 dollars, respectively. The five alternatives shown correspond generally to those in the development document as follows:

Alternative 1 ≡ BPT/PSES-0
Alternative 2 ≡ BAT-1/PSES-1
Alternative 3 ≡ BAT-2/PSES-2
Alternative 4 ≡ BAT-3/PSES-3
Alternative 5 ≡ BAT-4/PSES-4

These alternatives were developed by arraying the technological options in order of increasing total annual costs. This alteration was necessitated by the fact that although the original options (i.e., BAT 1, BAT 2 ...) generally correspond to increasing levels of compliance cost, there are some plants for which this correlation does not hold. This is because reductions in flow rates, resulting from certain in-process control technologies, reduce the capacity requirements of the end-of-pipe-treatment systems, thereby lowering

TABLE 6-8. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS EXISTING SOURCES 1978 DOLLARS

SUBCATEGORY	ALTERNATIVE 1 CAPITAL COST $	ALTERNATIVE 1 ANNUAL COST $	ALTERNATIVE 2 CAPITAL COST $	ALTERNATIVE 2 ANNUAL COST $	ALTERNATIVE 3 CAPITAL COST $	ALTERNATIVE 3 ANNUAL COST $	ALTERNATIVE 4 CAPITAL COST $	ALTERNATIVE 4 ANNUAL COST $	ALTERNATIVE 5 CAPITAL COST $	ALTERNATIVE 5 ANNUAL COST $
Cadmium										
Direct Dischargers	60472.	23065.	122762.	37576.	146732.	48575.	181070.	65933.	624290.	133643.
Indirect Dischargers	330090.	75625.	318290.	109185.	416245.	140330.	622480.	183368.	1501581.	490754.
Subcategory Total	390562.	98690.	441052.	146761.	562977.	188905.	803550.	249301.	2125871.	624397.
Calcium										
Direct Dischargers	---	---	---	---	---	---	---	---		
Indirect Dischargers	4412.	3322.	4412.	3322.	4412.	3322.				
Subcategory Total	4412.	3322.	4412.	3322.	4412.	3322.				
Lead										
Direct Dischargers	551172.	255227.	1847257.	545971.	2251816.	670331.	2251816.	670331.	3560616.	1009569.
Indirect Dischargers	6935562.	2293924.	17773189.	4306833.	20237086.	5119444.	20237086.	5119444.	26565175.	7542289.
Subcategory Total	7486734.	2549151.	19620446.	4852804.	22488902.	5789775.	22488902.	5789775.	30125791.	8551858.
Leclanche										
Direct Dischargers	---	---	---	---	---	---	---	---		
Indirect Dischargers	45241.	28226.								
Subcategory Total	45241.	28226.								
Lithium										
Direct Dischargers	0.	494.	---	---	---	---	---	---		
Indirect Dischargers	0.	6080.								
Subcategory Total	0.	6574.								
Magnesium										
Direct Dischargers	20908.	8134.	0.	14230.	0.	14230.	0.	14230.		
Indirect Dischargers	28272.	14571.	37371.	20236.	37371.	20236.	73784.	27846.		
Subcategory Total	49180.	22705.	37371.	34466.	37371.	34466.	73784.	42076.		
Zinc										
Direct Dischargers	50294.	18219.	90013.	23918.	102156.	38187.	102156.	38187.	109028.	55191.
Indirect Dischargers	258474.	88243.	346662.	100197.	405624.	159308.	405624.	159308.	547387.	252265.
Subcategory Total	308768.	106462.	436675.	124115.	507780.	197495.	507780.	197495.	656415.	307456.
TOTAL										
Direct Dischargers	682846.	305139.	2060032.	621695.	2500704.	771323.	2535042.	788681.	4293934.	1198403.
Indirect Dischargers	7602051.	2509991.	18479924.	4539773.	21100738.	5442640.	21338974.	5489966.	28614143.	8285308.
Subcategory Total	8284897.	2815130.	20539956.	5161468.	23601442.	6213963.	23874016.	6278647.	32908077.	9483711.

TABLE 6-9. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS EXISTING SOURCES 1982 DOLLARS

SUBCATEGORY	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3		ALTERNATIVE 4		ALTERNATIVE 5	
	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $	CAPITAL COST $	ANNUAL COST $
Cadmium										
Direct Dischargers	81637.	31138.	165729.	50728.	198088.	65576.	244445.	89010.	842792.	180418.
Indirect Dischargers	445622.	102094.	429691.	147400.	561931.	189446.	840348.	247546.	2027134.	662518.
Subcategory Total	527259.	133232.	595420.	198128.	760019.	255022.	1084793.	336556.	2869926.	842936.
Calcium										
Direct Dischargers	---	---	---	---	---	---	---	---	---	---
Indirect Dischargers	5956.	4485.	5956.	4485.	5956.	4485.	---	---	---	---
Subcategory Total	5956.	4485.	5956.	4485.	5956.	4485.	---	---	---	---
Leclanche										
Direct Dischargers	---	---	---	---	---	---	---	---	---	---
Indirect Dischargers	61075.	38105.	---	---	---	---	---	---	---	---
Subcategory Total	61075.	38105.	---	---	---	---	---	---	---	---
Lithium										
Direct Dischargers	0.	667.	---	---	---	---	---	---	---	---
Indirect Dischargers	0.	8208.	---	---	---	---	---	---	---	---
Subcategory Total	0.	8875.	---	---	---	---	---	---	---	---
Magnesium										
Direct Dischargers	28226.	10981.	0.	19211.	0.	19211.	0.	19211.		
Indirect Dischargers	38167.	19671.	50451.	27318.	50451.	27318.	99608.	37592.	---	---
Subcategory Total	66393.	30652.	50451.	46529.	50451.	46529.	99608.	56803.	---	---
Zinc										
Direct Dischargers	67897.	24596.	121518.	32289.	137911.	51552.	137911.	51552.	147188.	74508.
Indirect Dischargers	348940.	119128.	467994.	135266.	547592.	215066.	547592.	215066.	738972.	340558.
Subcategory Total	416837.	143724.	589512.	167555.	685503.	266618.	685503.	266618.	886160.	415066.
Lead										
Direct Dischargers	744082.	344556.	2493797.	737061.	3039952.	904947.	3039952.	904947.	4806832.	1362918.
Indirect Dischargers	9363009.	3096797.	23993805.	5814224.	27320066.	6911249.	27320066.	6911249.	35862986.	10182090.
Subcategory Total	10107091.	3441353.	26487602.	6551285.	30360018.	7816196.	30360018.	7816196.	40669818.	11545008.
TOTAL										
Direct Dischargers	921842.	411938.	2781044.	839288.	3375951.	1041286.	3422308.	1064720.	5796812.	1617844.
Indirect Dischargers	10262769.	3388488.	24947897.	6128694.	28485996.	7347564.	28807614.	7411453.	38629092.	11185166.
Subcategory Total	11184611.	3800426.	27728941.	6967982.	31861747.	8388850.	32229922.	8476173.	44425904.	12803010.

the total cost of the given in-process technology. This re-arraying of the compliance cost data serves to maintain consistency in the underlying assumption that the owner or operators of a given plant will select abatement technologies on an economically rational basis. That is, for a given target level of abatement the lowest cost option will be used, even if it surpasses the target level.

As Tables 6-8 and 6-9 show, the most costly control option (Alternative 5) would add $9.5 million to the annual cost of manufacturing batteries in the United States (1978 dollars). Direct dischargers will incur $1.2 million and indirect dischargers will incur $8.3 million of this figure. Associated investment costs are $4.3 million for direct dischargers, $28.6 million for indirect dischargers, and $32.9 million for the entire industry. As shown in the tables, the costs for most other options are significantly lower. For example, Alternative 4 would incur a total industry annual cost of $6.3 million and an investment cost of $23.9 million. It should also be noted that the lead acid battery product group accounts for 92 percent of total industry annual costs and 94 percent of industry investment costs (for example, at the Alternative 4 level). Average unit compliance costs and the distributions of compliance costs among plants in the industry is discussed further in Chapter 7 of this report.

6.8 COST FOR SOLID AND HAZARDOUS WASTES

The battery manufacturing industry produces a variety of waste materials in the form of scrap metals, spent concentrated solutions, reject batteries, and wastewater treatment sludges. Under the Resource Conservation and Recovery Act (RCRA), battery manufacturing plants will be required to establish certain hazardous waste management practices as generators, shippers, storers, treaters, or disposers of hazardous waste. A preliminary estimate of the costs of these wastes was prepared by EPA and provided for this study. This estimate was that RCRA will cost the industry $287,000. However, this estimate is only preliminary because it is based upon an earlier version of the evolving RCRA regulations.

Table 6-10 shows the total annual RCRA costs broken out by technical subcategory and product group. These costs include operating, maintenance, depreciation and interest expenses. The distribution of the costs among the product groups within each subcategory was based upon the assumption that the compliance cost per pound of product output would be constant across the product groups. Because the estimated economic impacts from these costs are minimal, violation of these assumptions would not significantly affect the outcome of the economic impact analysis.

The aforementioned compliance cost estimates were used, in combination with the information on the battery industry characteristics contained in Chapters 1 through 5, to estimate the potential economic impacts of the proposed regulations. The results of that investigation are reported in the next chapter.

TABLE 6-10. TOTAL ANNUAL RCRA COMPLIANCE COSTS
(THOUSANDS OF 1978 DOLLARS)

Subcategory	Battery Product Group	Annual RCRA Costs (Thousands of Dollars)	
		Product Group Subtotal	Technical Category Subtotal
Leclanche (Zinc Anode, Acid Electrolyte)	Carbon Zinc, (Leclanche), Silver Chloride, Carbon Zinc Air	127,250	127,250
Zinc Anode, Alkaline Electrolyte			85,200
	Alkaline Manganese	68,564	
	Carbon-Zinc-Air	7,070	
	Mercury (Ruben)	4,601	
	Silver-Oxide-Zinc	4,733	
	Mercury-Cadmium-Zinc	144	
	Nickel Zinc	88	
Cadmium Anode			74,300
	Nickel Cadmium	74,177	
	Cadmium Silver Oxide	123	
	Silver Cadmium	NEG	
Magnesium Anode			0.0
	Thermal (Magnesium)		
	Magnesium Carbon		
	Magnesium Reserve		
Lithium Anode	Lithium	NA	NA
Calcium Anode	Calcium	NA	NA
Lead Anode	Lead Acid	NA	NA
Total		286,750	286,750

NEG = negligible.

Only $14,450 of the Leclanche costs and $2,700 of the Zinc costs are the result of wastewater treatment sludges, the remainder being for manufacturing process waste RCRA disposal costs.

7. ECONOMIC IMPACT ASSESSMENT

7. ECONOMIC IMPACT ASSESSMENT

This chapter describes the economic impacts likely to occur as a result of the costs of the effluent control technologies described in Chapter 6. It is based upon an examination of the estimated compliance costs and other economic, technical and financial characteristics of each of 239 battery manufacturing facilities of various sizes and configurations and the analytical methodology described in Chapter 2. These plants represent 93 percent of the production facilities estimated to be in the industry and at least 98 percent of the production capacity of the industry. The primary areas of interest include the effect of the pollution control costs on prices, battery industry profitability, industry structure and competition, small business, employment, communities, imports and exports, and the potential for plant closures.

7.1 PRICE AND QUANTITY CHANGES

Table 7-1 shows the price and production changes estimated from the full-cost pricing strategy model described in Chapter 2. For most product groups price changes are small, exceeding one-half percent of before compliance prices for only four product groups for the most costly option (alternative 5 or, where this is no alternative to 5, the next most costly option). The price increases for alternative 5 range from a low of zero for several products to a high of one percent in the magnesium reserve battery group. The quantity reductions were obtained by multiplying the expected price increases by the demand elasticities shown in Table 4-6. The resulting quantity reductions range from zero for several subcategories to 0.7 percent for cadmium silver-oxide batteries. For the other alternatives price and production changes are considerably lower. For example, for alternative 2, only two product groups will experience price changes greater than 0.5 percent.

TABLE 7-1. PRICE AND PRODUCTION CHANGES (%)

BATTERY TYPE	NUMBER OF FACILITIES IN INDUSTRY[2]	NUMBER OF FIRMS[2]	ANNUAL PRODUCTION (MILLIONS OF LBS.)[2]	VALUE OF PRODUCTION (MILLIONS OF $)[3]	ESTIMATED PRICE CHANGES (PERCENT)[5]					ESTIMATED QUANTITY CHANGES (PERCENT)[5]				
					ALT-1	ALT-2	ALT-3	ALT-4	ALT-5[1]	ALT-1	ALT-2	ALT-3	ALT-4	ALT-5[1]
Leclanche	19	9	228.62	294.07	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
Alkaline-Manganese	8	5	38.80	140.96	.04	.04	.06	.06	.11	.03	.03	.05	.05	.09
Carbon-Zinc-Air	2	2	D	D	0	0	0	0	0	0	0	0	0	0
Mercury (Ruben)	4	3	2.60	26.97	.08	.09	.16	.16	.31	.06	.07	.13	.13	.25
Nickel Zinc	1	1	e	e	-	-	-	-	-	-	-	-	-	-
Silver Oxide-Zinc	9	6	2.68	70.36	.10	.12	.18	.18	.24	.08	.10	.14	.14	.19
Mercury Cadmium-Zinc	1	1	D	D	.09	.11	.13	.23	.23	.07	.09	.11	.19	.19
Nickel Cadmium	9	9	11.53	230.14	.03	.04	.05	.07	.12	.03	.03	.04	.06	.10
Mercury Cadmium	1	1	D	D	0	0	0	0	0	0	0	0	0	0
Cadmium-Silver Oxide	1	1	D	D	.04	.09	.13	.36	.88	.03	.07	.10	.29	.71
Thermal (Magnesium)	1	1	D	D	.13	.13	.13	.13	NA	.08	.08	.08	.08	NA
Magnesium Carbon	3	3	D	D	0	0	0	0	0	0	0	0	0	0
Magnesium Reserve[4]	4	4	.174	4.56	.40	.50	.50	.80	NA	.40	.30	.30	.48	NA
Lithium[4]	8	7	.045	.72	.91	NA	NA	NA	NA	.73	NA	NA	NA	NA
Calcium	3	3	D	D	.03	.03	.03	NA	NA	.02	.02	.02	NA	NA
Lead-Acid	184	114	2,974.0	1,487.0	.16	.32	.39	.39	.57	.05	.10	.12	.12	.17

D = Detailed data withheld to maintain confidentiality of data.

e = experimental NA = not applicable

[1] For Lead Acid and Cadmium and Zinc batteries only. The data shown for the other battery types are identical to the Alternative-4 option.

[2] From EPA Technical Survey.

[3] Calculated using average dollars per pound and EPA Survey data and may not precisely match total production figures reported elsewhere in this report.

[4] Excludes Thermal Batteries.

[5] Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-2, etc." in the development document.

SOURCE: JRB Associates estimates

The price changes estimated in Table 7-1, when added to existing price levels represent the prices that firms will probably be able to obtain for their products after compliance with the regulations. It is expected that those firms that cannot earn a profit at these new price levels will suffer financial losses by most measures of financial performance (e.g., return on investment, sales, or equity, etc.) and probably will leave the industry. An assessment of the ability of individual plants to earn a profit at these estimated post-compliance price levels is presented in Sections 7.3 through 7.5.

7.2 RESULTS OF SCREENING ANALYSIS

As described in Chapter 2, the screening analysis proceeded in two steps. First, the ratio of total annualized compliance cost to annual plant revenues was calculated for each of the 239 facilities for which compliance cost and other data was available. The total annualized compliance cost figure includes variable costs (operating, maintenance, fuel, labor, etc.) plus capital costs (depreciation plus interest expense). Plant revenues were estimated by multiplying production volumes (reported in the technical 308 survey) by the average product prices per pound (reported in Table 4-5, page 4-19). The distribution of the compliance cost to revenue ratios are shown in Table 7-2. For alternative 5, 39 production facilities had ratios of costs to revenues in excess of the threshold value of one percent. For the other alternatives, fewer facilities have ratios greater than one percent. For example, for alternative 4, 16 facilities exceed the threshold value, for alternative 2 the figure is 12 facilities and for alternative 1, 9 facilities had ratios of cost to revenues exceeding 1 percent. All other facilities are considered to have a low probability for plant closure.

The second step in the screening analysis involved a calculation of expected declines in return on sales (ROS) for each plant. The estimated decline in ROS results from the reduced quantity demanded due to higher prices and the assumption that these plants must absorb the difference between compliance costs and the changes in market prices which were reported in Section 7.1. The estimated profit declines are shown in Table 7-3. As the table shows, 21

TABLE 7-2. NUMBER OF PLANTS BY TOTAL ANNUAL COMPLIANCE COST TO REVENUES RATIO[1/]
(Number of Plants)

		COMPLIANCE COST AS A PERCENTAGE OF REVENUES[1/]																			
PRODUCT GROUP	NUMBER OF FACILITIES SAMPLED	ALTERNATIVE 1				ALTERNATIVE 2				ALTERNATIVE 3				ALTERNATIVE 4				ALTERNATIVE 5[2/]			
		≤1%	1-2%	2-4%	≥4%	≤1%	1-2%	2-4%	≥4%	≤1%	1-2%	2-4%	≥4%	≤1%	1-2%	2-4%	≥4%	≤1%	1-2%	2-4%	≥4%
Leclanche	19	19				19				19				19				19			
Alkaline-Manganese	8	8				8				8				8				5	3		
Carbon-Zinc-Air	2	2				2				2				2				2			
Mercury (Ruben)	4	4				4				4				4				4			
Nickel Zinc	1	1				1				1				1				1			
Silver-Oxide-Zinc	9	8		1		8		1		8		1		7		1		7	1	1	
Mercury-Cadmium-Zinc	1	1				1				1				1				1			
Nickel Cadmium	9	9				9				9				8	1			5	2	2	
Mercury Cadmium	1	1				1				1				1				1			
Cadmium-Silver-Oxide	1	1				1				1				1				1			
Thermal (Magnesium)	1	1				1				1				1				1			
Magnesium Carbon	3	3				3				3				3				3			
Magnesium Reserve	4	4				4				4				4				4			
Lithium	8	8				8				8				8				8			
Calcium	3	3				3				3				3				3			
Lead-Acid	165	157	7		1	154	9	1	1	153	10	1	1	151	10	3	1	135	20	6	4
TOTAL	239	230	7	1	1	227	9	2	1	226	10	2	1	223	11	4	1	200	26	9	4

1/ Total Compliance Costs include operating and maintenance, depreciation, interest and profit. Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-1, etc." in the Development Document.

2/ Alternative 5 applies only to the lead, cadmium anode (nickel cadmium, mercury cadmium, and cadmium-silver oxide), and zinc categories. The other figures shown in this column are for costs identical to alternative 4.

SOURCE: EPA Development Document and JRB Associates estimates.

TABLE 7-3. NUMBER OF PLANTS BY ESTIMATED CHANGE IN RETURN ON SALES (NUMBER OF PLANTS)[1/]

PRODUCT GROUP	NUMBER OF FACILITIES SAMPLED	ALTERNATIVE 1				ALTERNATIVE 2				ALTERNATIVE 3				ALTERNATIVE 4				ALTERNATIVE 5[2/]			
		<1%	1-2%	2-4%	>4%	<1%	1-2%	2-4%	>4%	<1%	1-2%	2-4%	>4%	<1%	1-2%	2-4%	>4%	<1%	1-2%	2-4%	>4%
Leclanche	19	19				19				19				19				19			
Alkaline-Manganese	8	8				8				8				8				5	3		
Carbon-Zinc-Air	2	2				2				2				2				2			
Mercury (Ruben)	4	4				4				4				4				4			
Nickel Zinc	1	1				1				1				1				1			
Silver-Oxide-Zinc	9	8	1			8	1			8		1		8		1		7	1	1	
Mercury-Cadmium-Zinc	1	1				1				1				1				1			
Nickel Cadmium	9	9				9				9				8	1			6	1	2	
Mercury Cadmium	1	1				1				1				1				1			
Cadmium-Silver-Oxide	1	1				1				1				1				1			
Thermal (Magnesium)	1	1				1				1				1				1			
Magnesium Carbon	3	3				3				3				3				3			
Magnesium Reserve	4	4				4				4				4				4			
Lithium	8	8				8				8				8				8			
Calcium	3	3				3				3				3				3			
Lead-Acid	165	160	5			160	5			158	6	1		158	6	1		152	8	4	1
TOTAL	239	233	6	1	0	233	6	1	0	233	6	2	0	229	7	3	0	218	13	7	1

1/ Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-1, etc." in the Development Document.

2/ Alternative 5 applies only to the lead, zinc, and calcium anode (nickel cadmium, mercury cadmium, and cadmium-silver oxide) categories. The other figures shown in this column are for costs identical to Alternative 4.

SOURCE: JRB Associates estimates.

plants are expected to experience profit declines of more than one percent of sales under the most costly scenario. Of these, 13 are lead acid battery plants and 3 are nickel cadmium battery manufacturing facilities, 3 are alkaline manganese plants and 2 are silver oxide plants. Under the alternative 4 option, only 8 lead-acid and 1 nickel-cadmium, 2 silver oxide, and 3 alkaline manganese plants would experience profit declines of more than one percent. For the other alternatives, the number of plants with significant declines in ROS is significantly smaller. The likelihood of closures for these plants as a result of the regulation is described in Section 7.5.

In summary, all but 21 plants in the industry will experience impacts greater than the ROS threshold values due to the highest options available. The following two sections present a more detailed financial analysis for these 21 plants.

7.3 PLANT LEVEL PROFITABILITY ANALYSIS

Two different measures of financial performance were used to assess the impact of the regulation on the profitabilities of individual plants: return on investment (ROI) and internal rate of return (IRR). The use of these techniques involved a comparison of the measures before and after compliance. Since no precise data was available on before compliance profitability, a range of values was estimated based on industry-wide data from the Census of Manufactures, "model plant" data appearing in the literature, and discussions with industry representatives. This range of values indicates upper and lower bounds for before compliance ROI of 12 and 16 percent respectively for the lead acid product group and 12 and 20 percent for the other product groups. A description of these estimates appear in Chapter 2 and Appendix A, along with the rationale for the IRR technique.

Table 7-4 shows the estimated ROI before and after compliance with the proposed regulations for each of the 21 potentially affected plants. The upper and lower bounds in the table correspond to the extremes of the baseline ROI estimates. Although the full range of profitability estimates were calculated,

TABLE 7-4. POST-COMPLIANCE RETURNS ON TOTAL ASSETS (Percent)

Product Group	Plant I.D.	Lower Bound: ROI Before Compliance	Lower Bound: ROI After Compliance[1] ALT.1	ALT.2	ALT.3	ALT.4	ALT.5	Upper Bound: ROI Before Compliance	Upper Bound: ROI After Compliance[1] ALT.1	ALT.2	ALT.3	ALT.4	ALT.5
Alkaline Manganese	1	12	12	12	11	11	09	20	20	20	19	19	17
	2		12	12	11	11	09		20	20	20	19	16
	3		12	12	10	10	09		20	20	18	18	17
Silver Oxide	4	12	08	06	06	06	08	20	14	12	12	12	16
	5		10	10	09	09	08		18	18	18	18	15
Nickel Cadmium	6	12	10	10	10	09	07	20	19	18	18	16	13
	7		10	09	09	08	04		17	17	16	15	09
	8		11	10	10	09	04		18	18	18	16	09
Lead Acid	9	12	08	08	07	07	03	16	12	12	10	10	06
	10		09	08	06	06	04		13	10	10	10	08
	11		10	10	09	09	05		14	14	12	12	09
	12		10	10	09	09	06		14	14	13	13	10
	13		09	09	09	09	07		13	13	12	12	10
	14		11	11	10	10	07		15	15	13	13	10
	15		10	10	10	10	07		14	14	14	14	11
	16		11	10	10	10	09		15	14	14	14	13
	17		12	11	10	10	08		16	15	14	14	12
	18		09	09	09	09	08		13	13	13	13	12
	19		11	11	10	10	08		15	15	14	14	12
	20		09	09	09	09	09		13	13	13	13	13
	21		09	09	09	09	10		13	13	13	13	14

[1] Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-1, etc." in the development document.

SOURCE: JRB Associates estimates.

most evaluations in this study are made on the basis of the lower bound estimates in order to emphasize a conservative approach to the study. These estimates indicate that there would be a significant drop in the profitabilities of these plants, although it may not be enough to cause many plant shutdowns. Although it is difficult to set specific threshold values for ROI, the estimated ROI can be compared to averages for 33 major industry groups, which are published by the Federal Trade Commission (FTC). The range of ROIs for these 33 major manufacturing industries was 6 to 18 percent during the time period for which the plant data base was developed.[1/] All but four lead-acid plants and two cadmium plants are well within this range. These six plants have post-compliance ROI's near or just below the lower end of the range for the major industry averages under the alternative 5 scenario. At the upper profitability estimates five of these six plants would be well within the profitable range of values for the various major industry groups. As the table shows the financial performance projected for the lower regulatory alternatives are significantly better.

To confirm these results, estimates of the Internal Rates of Return (IRR) were also calculated using the methodology described in Chapter 2 and Appendix A. The estimated post-compliance IRR's are shown in Table 7-5. The upper and lower bounds correspond to those of the baseline IRR estimates described in Appendix A. For the alternative 5 option, seven plants have IRR's below the critical value of 10 percent. Three of these are small lead-acid plants, three are nickel cadmium production facilities, and one is a silver oxide zinc facility. For the alternative 4 option, only the silver oxide plant would have an IRR below the critical value. All other facilities would be profitable by this measure. The IRR values for the 21 affected plants will be used in Section 7.5, together with other information, to assess the plant closure potential for the industry.

1/ Federal Trade Commission, Quarterly Financial Report for Manufacturing, Mining and Trade Corporations.

TABLE 7-5. POST-COMPLIANCE INTERNAL RATES OF RETURNS (Percent)

		Lower Bound					Upper Bound				
	Plant	IRR After Compliance[1]					IRR After Compliance[1]				
Product Group	I.D.	ALT.1	ALT.2	ALT.3	ALT.4	ALT.5	ALT.1	ALT.2	ALT.3	ALT.4	ALT.5
Alkaline Manganese	1	13	13	11	11	10	20	20	19	19	17
	2	13	13	12	12	10	20	20	19	19	17
	3	13	13	11	11	10	20	20	18	18	17
Silver Oxide	4	09	08	07	07	09	14	14	12	12	17
	5	13	11	11	11	10	19	18	18	18	17
Nickel Cadmium	6	13	11	11	10	09	19	18	18	17	14
	7	11	10	10	10	05	18	17	17	16	09
	8	12	11	11	10	04	19	18	18	17	08
Lead Acid	9	12	12	11	11	03	15	15	14	14	12
	10	13	11	10	10	08	16	15	14	14	12
	11	14	14	12	12	09	17	17	15	15	11
	12	14	14	12	12	10	17	17	15	15	14
	13	13	13	12	12	11	16	16	15	15	14
	14	15	14	13	13	17	18	17	16	16	14
	15	14	14	14	14	11	17	17	17	17	14
	16	16	14	14	14	13	21	19	20	20	18
	17	17	17	16	16	12	22	22	21	21	17
	18	14	14	13	13	12	20	20	18	18	16
	19	16	16	15	15	12	21	21	20	20	16
	20	13	14	14	14	14	18	20	20	20	20
	21	14	14	14	14	14	20	20	20	20	21

[1] Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-1, etc." in the development document.

SOURCE: JRB Associates estimates.

7.4 CAPTIAL REQUIREMENTS ANALYSIS

As described in Chapter 2, two ratios were calculated to assess the financial impact of committing the capital necessary to install the specified pollution control systems:

- $\frac{\text{compliance capital investment}}{\text{estimated fixed plant assets}}$

- $\frac{\text{compliance capital investment}}{\text{estimated annual capital expenditures}}$

The "investment requirements to assets" ratio provides a measure of the relative size of the required pollution control investment as compared to the size of the existing facility, and the "investment requirements to annual capital expenditures" ratio measures the magnitude of the capital investment required for compliance in relation to the pre-compliance average annual capital expenditures of the plant.

These ratios were calculated for each of the 21 potentially high-impact plants. Since complete plant-level financial data was unavailable, the pre-compliance values of the ratios were estimated from industry-level data for SIC 3691 and SIC 3692 appearing in the 1977 Census of Manufactures. The compliance investment costs were taken from the Draft Development Document, and the production data; from which plant revenues and assets were estimated, were taken from the EPA Technical Survey. The resulting ratios measure the relative burden of the investment requirements and are shown in Table 7-6.

Compared to plant fixed assets, compliance investment costs are substantial for a number of lead-acid and nickel cadmium battery manufacturing facilities. The ratio ranges from zero to 64 percent of fixed asset value (fixed assets are one-third to one-half of total assets). The pollution control equipment would add substantially to the asset base of these plants. For

TABLE 7-6. COMPLIANCE CAPITAL COSTS RELATIVE TO FIXED ASSETS AND ANNUAL CAPITAL EXPENDITURES
(Percent)

Product Group	Plant I.D.	Compliance Capital Cost as A Percent of Fixed Assets[1]					Compliance Capital Costs As A Percent of Annual Capital Expenditures[1]				
		ALT.1	ALT.2	ALT.3	ALT.4	ALT.5	ALT.1	ALT.2	ALT.3	ALT.4	ALT.5
Alkaline Manganese	1	0	0	06	06	12	0	0	29	29	56
	2	0	0	04	04	08	0	0	18	18	41
	3	0	0	05	05	07	0	0	24	24	36
Silver Oxide	4	22	33	35	35	0	106	159	169	169	0
	5	07	10	10	10	15	33	47	47	47	72
Nickel Cadmium	6	04	06	06	12	31	17	31	31	60	150
	7	10	11	12	17	46	50	54	60	82	222
	8	07	06	06	14	35	32	29	29	66	167
Lead Acid	9	34	34	34	35	64	138	138	142	142	261
	10	0	33	0	0	0	0	133	0	0	0
	11	12	14	20	20	39	49	57	80	80	161
	12	12	13	14	14	29	49	55	59	59	119
	13	20	19	21	21	31	83	78	85	85	126
	14	0	23	25	25	39	0	94	101	101	161
	15	13	13	14	14	35	52	52	57	57	141
	16	0	0	0	0	0	0	0	0	0	0
	17	0	08	14	15	25	0	34	57	59	100
	18	26	26	26	29	35	106	106	106	116	142
	19	08	16	16	16	28	34	64	64	66	116
	20	0	0	0	0	0	0	0	0	0	0
	21	0	0	0	0	0	0	0	0	0	0

[1] Alternatives refer to different pollution control technologies with increasing levels of cost from lower numbered alternatives to the higher numbers. These increasing alternatives correspond to either increases or no change in the level of pollution abatement. The alternative numbers correspond generally, but not precisely, to the options labeled "BPT/PSES-0, BAT-1/PSES-1, etc." in the development document.

SOURCE: JRB Associates estimates

example, the two plants with the highest compliance investment costs would have to increase their fixed assets by 64 and 46 percent, respectively. These estimates do not, by themselves, indicate whether or not a plant closure will occur. They are evaluated, simultaneously with other financial and nonfinancial variables, to determine the potential for closure, in Section 7.5.

Compliance investment costs are large in comparison to normal annual capital expenditures in the industry. Alternative 5 investment costs for most of the 21 plants are greater than their estimated pre-compliance annual capital expenditures. Compliance costs for alternatives 4 and 3, though significantly lower than that of alternative 5 are, nevertheless, substantial. For most plants they amount to more than half of annual pre-compliance capital investment expenditures. Alternative 1 and 2 costs, though lower, are also substantial. Investment expenditures of this magnitude indicate a significant burden on the firms' ability to maintain their existing capital investment plans, although they do not, by themselves, indicate a plant closure. That is, they indicate that significant investment resources would have to be diverted from pre-compliance "normal" investments for a period of 1 to 3 years. "Normal" investments are those used to sustain and improve the plants' operations.

7.5 PLANT CLOSURE POTENTIAL

Although major investment decisions, such as plant closure decisions, are made largely on the basis of their financial performance, they are ultimately judgmental. That is, in addition to financial variables, decision makers must consider a number of other factors, such as market growth potential, the existence of specialty markets, intra-industry competition, the potential for technological obsolescence, marketing techniques, and substitution potential for the products. Table 7-7 summarizes a number of factors relevant to the investment decisions relating to the 21 plants shown in Tables 7-4, 7-5, and 7-6. The information in the table was drawn from earlier sections of this report. The last column contains the study team's evaluation of the potential for plant closures, based on a review of the combined effects of the other columns in the the table.

TABLE 7-7. SUMMARY OF DETERMINANTS OF POTENTIAL FOR PLANT CLOSURES DUE TO THE REGULATION

PRODUCT GROUP	PLANT	MARKET SHARE	GROWTH OF PRODUCT GROUP	DEGREE OF SUBSTITUTION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULATORY ALTERNATIVE	RATIO OF COMPLIANCE COST TO REVENUE (%)	ESTIMATED CHANGE IN RETURN ON SALES (%)	ESTIMATED[1/] RETURN ON ASSETS AFTER COMPLIANCE (%)	ESTIMATED[1/] INTERNAL RATE OF RETURN AFTER COMPLIANCE (%)	RATIO OF COMPLIANCE INVESTMENT COST TO PLANT FIXED ASSETS(%)	RATIO OF COMPLIANCE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES(%)	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Alkaline-Manganese	1	Small	High	Moderate	.6 - .8	Low	1	0	0	12 - 20	13 - 20	0	0	Low
							2	0	0	12 - 20	13 - 20	0	0	Low
							3	0.4	0.36	11 - 19	11 - 19	6	29	Low
							4	0.4	0.36	11 - 19	11 - 19	6	29	Low
							5	1.2	1.15	9 - 17	10 - 17	12	56	Low
Alkaline-Manganese	2	Small	High	Moderate	.6 - .8	Low	1	0	0	12 - 20	13 - 20	0	0	Low
							2	0	0	12 - 20	13 - 20	0	0	Low
							3	0.4	0.33	10 - 18	11 - 18	4	18	Low
							4	0.4	0.33	10 - 18	11 - 18	4	18	Low
							5	1.3	1.21	9 - 17	10 - 17	8	41	Low
Alkaline-Manganese	3	Small	High	Moderate	.6 - .8	Low	1	0	0	12 - 20	13 - 20	0	0	Low
							2	0	0	12 - 20	13 - 20	0	0	Low
							3	0.7	0.68	10 - 18	11 - 18	5	24	Low
							4	0.7	0.68	10 - 18	11 - 18	5	24	Low
							5	1.3	1.17	9 - 17	10 - 17	7	36	Low
Silver-Oxide Zinc	4	Small	High	Moderate	.6 - .8	Med.	1	1.4	1.3	8 - 14	9 - 14	22	106	Low
							2	1.9	1.7	6 - 12	8 - 14	33	159	Low
							3	2.7	2.0	6 - 12	7 - 12	35	169	Med.
							4	2.8	2.0	6 - 12	7 - 12	35	169	Med.
							5	2.8	2.0	8 - 16	9 - 17	0	0	Med.
Silver-Oxide Zinc	5	Small	High	Moderate	.6 - .8	Med.	1	0.4	0.27	10 - 18	12 - 19	7	33	Low
							2	0.6	0.45	10 - 18	11 - 18	10	47	Low
							3	0.8	0.65	9 - 18	11 - 18	10	47	Low
							4	1.5	0.65	9 - 18	11 - 18	10	47	Low
							5	1.5	1.21	8 - 15	10 - 17	15	72	Low

1/ Lower and upper bounds

TABLE 7-7. SUMMARY OF DETERMINANTS OF POTENTIAL FOR PLANT CLOSURES DUE TO THE REGULATION (Continued)

PRODUCT GROUP	PLANT	MARKET SHARE	GROWTH OF PRODUCT GROUP	DEGREE OF SUBSTITUTION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULATORY ALTERNATIVE	RATIO OF COMPLIANCE COST TO REVENUE (%)	ESTIMATED CHANGE IN RETURN ON SALES (%)	ESTIMATED[1/] RETURN ON ASSETS AFTER COMPLIANCE (%)	ESTIMATED[1/] INTERNAL RATE OF RETURN AFTER COMPLIANCE (%)	RATIO OF COMPLIANCE INVESTMENT COST TO PLANT FIXED ASSETS(%)	RATIO OF COMPLIANCE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES(%)	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Nickel-Cadmium	6	Small	Medium	Low	0 - .3	N/A	1	.6	.36	10 - 19	12 - 19	04	17	Low
							2	.6	.54	10 - 18	11 - 18	06	31	Low
							3	.6	.54	10 - 18	11 - 18	06	31	Low
							4	1.0	.88	9 - 16	10 - 17	12	60	Low
							5	1.7	1.61	7 - 13	9 - 14	31	150	Med.
Ni-Cad.	7	Small	High	Moderate	.6 - .8	Low	1	.7	.66	10 - 17	11 - 18	10	50	Low
							2	.8	.78	9 - 17	10 - 17	11	54	Low
							3	.8	.82	9 - 16	10 - 17	12	60	Low
							4	1.1	1.10	8 - 15	10 - 16	17	82	Low
							5	3.1	3.10	4 - 9	5 - 9	46	222	High
Ni.-Cad.	8	Small	High	Moderate	.6 - .8	Low	1	.5	.22	11 - 18	12 - 19	07	32	Low
							2	.6	.57	10 - 18	11 - 18	06	29	Low
							3	.6	.57	10 - 18	11 - 18	06	29	Low
							4	1.0	.98	9 - 16	10 - 17	14	66	Low
							5	3.7	3.67	4 - 9	4 - 8	35	167	High
Lead-Acid	9	insig.	Medium	Low	0 - .3	Low	1	1.6	1.47	8 - 12	12 - 15	34	138	Low
							2	1.6	1.31	8 - 12	12 - 15	34	138	Low
							3	2.2	1.81	7 - 10	11 - 14	35	142	Low
							4	2.2	1.81	7 - 10	11 - 14	35	142	Low
							5	4.9	4.36	3 - 6	3 - 12	64	261	High
Lead-Acid	10	insig.	Medium	Low	0 - .3	Low	1	1.7	1.53	9 - 13	13 - 16	0	0	Low
							2	2.2	1.92	8 - 10	11 - 15	.33	133	Low
							3	3.2	2.80	6 - 10	10 - 14	0	0	Low
							4	3.2	2.80	6 - 10	10 - 14	0	0	Low
							5	4.4	3.86	4 - 8	8 - 12	0	0	High

TABLE 7-7. SUMMARY OF DETERMINANTS OF POTENTIAL FOR PLANT CLOSURES DUE TO THE REGULATION (Continued)

PRODUCT GROUP	PLANT	MARKET SHARE	GROWTH OF PRODUCT GROUP	DEGREE OF SUBSTITUTION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULATORY ALTERNATIVE	RATIO OF COMPLIANCE COST TO REVENUE (%)	ESTIMATED CHANGE IN RETURN ON SALES (%)	ESTIMATED[1/] RETURN ON ASSETS AFTER COMPLIANCE (%)	ESTIMATED[1/] INTERNAL RATE OF RETURN AFTER COMPLIANCE (%)	RATIO OF COMPLIANCE INVESTMENT COST TO PLANT FIXED ASSETS(%)	RATIO OF COMPLIANCE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES(%)	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	11	insig.	Medium	Moderate	0 - .3	N/A	1	.9	.72	10 - 14	14 - 17	12	49	Low
							2	.9	.62	10 - 14	14 - 17	14	57	Low
							3	1.8	1.44	9 - 12	12 - 15	20	80	Low
							4	1.8	1.44	9 - 12	12 - 15	20	80	Low
							5	3.7	3.10	5 - 9	9 - 11	39	161	Med.
Lead-Acid	12	Small	Medium	Moderate	0 - .3	Low	1	.8	.66	10 - 14	14 - 17	12	49	Low
							2	1.0	.72	10 - 14	14 - 17	13	55	Low
							3	1.4	.99	9 - 13	12 - 15	14	59	Low
							4	1.4	.99	9 - 13	12 - 15	14	59	Low
							5	3.1	2.50	6 - 10	11 - 14	29	119	Low
Lead-Acid	13	Small	Medium	Moderate	0 - .3	Low	1	1.2	1.07	9 - 13	13 - 16	20	83	Low
							2	1.3	.98	9 - 13	13 - 16	19	78	Low
							3	1.6	1.17	9 - 12	12 - 15	21	85	Low
							4	1.6	1.17	9 - 12	12 - 15	21	85	Low
							5	2.6	2.03	7 - 10	11 - 14	31	126	Low
Lead-Acid	14	Small	Medium	Moderate	0 - .3	Med.	1	.2	.03	11 - 15	15 - 18	0	0	Low
							2	.8	.43	11 - 15	14 - 17	23	94	Low
							3	1.0	.61	10 - 13	13 - 16	25	101	Low
							4	1.0	.61	10 - 13	13 - 16	25	101	Low
							5	2.4	1.80	7 - 10	11 - 14	39	161	Low
Lead-Acid	15	Moderate	Medium	Moderate	0 - .3	Some	1	0.5	.39	10 - 14	14 - 17	13	52	Low
							2	0.5	.23	10 - 14	14 - 17	13	52	Low
							3	0.9	.56	10 - 14	14 - 17	14	57	Low
							4	0.9	.56	10 - 14	14 - 17	14	57	Low
							5	2.3	1.72	7 - 11	11 - 14	35	141	Low

TABLE 7-7. SUMMARY OF DETERMINANTS OF POTENTIAL FOR PLANT CLOSURES DUE TO THE REGULATION (Continued)

PRODUCT GROUP	PLANT	MARKET SHARE	GROWTH OF PRODUCT GROUP	DEGREE OF SUBSTITUTION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULATORY ALTERNATIVE	RATIO OF COMPLIANCE COST TO REVENUE (%)	ESTIMATED CHANGE IN RETURN ON SALES (%)	ESTIMATED[1/] RETURN ON ASSETS AFTER COMPLIANCE (%)	ESTIMATED[1/] INTERNAL RATE OF RETURN AFTER COMPLIANCE (%)	RATIO OF COMPLIANCE INVESTMENT COST TO PLANT FIXED ASSETS (%)	RATIO OF COMPLIANCE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES(%)	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	16	Small	Medium	Moderate	0 - .3		1	.9	.71	11 - 15	16 - 21	0	0	Low
							2	1.3	1.00	10 - 14	14 - 19	0	0	Low
							3	1.6	1.25	10 - 14	14 - 20	0	0	Low
							4	1.6	1.25	10 - 14	14 - 20	0	0	Low
							5	2.2	1.67	9 - 13	13 - 18	0	0	Low
Lead-Acid	17	insig.	Medium	Low	0 - .3	Some	1	.2	0	12 - 16	17 - 22	0	0	Low
							2	.5	.21	11 - 15	17 - 22	08	34	Low
							3	.8	.38	10 - 14	16 - 21	15	59	Low
							4	.8	.38	10 - 14	16 - 21	15	59	Low
							5	2.0	1.40	8 - 12	12 - 17	25	100	Low
Lead-Acid	18	insig.	Medium	Low	0 - .3	Sig.	1	1.0	.79	9 - 13	14 - 20	26	106	Low
							2	1.0	.63	9 - 13	14 - 20	26	106	Low
							3	1.2	.80	9 - 13	13 - 18	29	116	Low
							4	1.2	.80	9 - 13	13 - 18	29	116	Low
							5	1.2	1.32	8 - 12	12 - 16	35	142	Low
Lead-Acid	19	insig.	Medium	Low	0 - .3	Small	1	.6	.41	11 - 15	16 - 21	08	34	Low
							2	.7	.37	11 - 15	16 - 21	16	64	Low
							3	1.0	.58	10 - 14	15 - 20	16	66	Low
							4	1.0	.58	10 - 14	15 - 20	16	66	Low
							5	1.8	1.24	8 - 12	12 - 16	28	116	Low
Lead-Acid	20	insig.	Medium	Low	0 - .3	Small	1	1.7	1.51	9 - 13	13 - 18	0	0	Low
							2	1.7	1.34	9 - 13	14 - 20	0	0	Low
							3	1.7	1.28	9 - 13	14 - 20	0	0	Low
							4	1.7	1.28	9 - 13	14 - 20	0	0	Low
							5	1.7	1.09	9 - 13	14 - 20	0	0	Low

TABLE 7-7. SUMMARY OF DETERMINANTS OF POTENTIAL FOR PLANT CLOSURES DUE TO THE REGULATION (Continued)

PRODUCT GROUP	PLANT	MARKET SHARE	GROWTH OF PRODUCT GROUP	DEGREE OF SUBSTITUTION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULATORY ALTERNATIVE	RATIO OF COMPLIANCE COST TO REVENUE (%)	ESTIMATED CHANGE IN RETURN ON SALES (%)	ESTIMATED[1/] RETURN ON ASSETS AFTER COMPLIANCE (%)	ESTIMATED[1/] INTERNAL RATE OF RETURN AFTER COMPLIANCE (%)	RATIO OF COMPLIANCE INVESTMENT COST TO PLANT FIXED ASSETS(%)	RATIO OF COMPLIANCE INVESTMENT COST TO ANNUAL CAPITAL EXPENDITURES(%)	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	21	insig.	Medium	Low	0 - .3		1	1.5	1.38	9 - 13	14 - 20	0	0	Low
							2	1.5	1.22	9 - 13	14 - 20	0	0	Low
							3	1.5	1.15	9 - 13	14 - 20	0	0	Low
							4	1.5	1.15	9 - 13	14 - 20	0	0	Low
							5	1.5	.97	10 - 14	14 - 21	0	0	Low

In general, the market factors for these products are strong, so that the bulk of the impacts will result from the intra-industry distribution of compliance costs and the subsequent change in the competitiveness among the various plants. Four plants are likely closures at the alternative 5 option, and another plant would be a "borderline" closure. Their after compliance internal rates of return are below the threshold level for the "worst case" (lower bound) scenario, but above the threshold level at the upper ranges of the IRR estimate. The same is true for their estimated ROIs. The other plants are believed to have a low potential for closure, since their profitability measures are adequate and their capital investment requirements are small relative to fixed assets and annual capital expenditures. The plants estimated to be likely closures under Alternative 5 are quite small and the loss of their combined capacity would have a negligible effect on the rest of the industry. There are no estimated plant closures for Alternatives 1 through 4.

Table 7-8 summarizes plant closure potential by regulatory option before consideration of any baseline plant closures (i.e., plants that might close, even without the regulation). As described in Chapter 4, baseline closures are projected to include around 20 to 33 small lead-acid plants between 1977 and 1990. Consequently, it is possible that the lead-acid plants would close even without the regulation. However, it is difficult to determine, from the data, whether or not the baseline closures would be the same lead-acid establishments that are listed in Table 7-8 as having a high potential for closure.

7.6 OTHER IMPACTS

7.6.1 Employment, Community and Regional Effects

As shown in Table 7-9, the 4 plants estimated to have a high potential for closure under Alternative 5 employ between 255 and 390 people out of a total industry employment of 37,000. Since each of these firms is located in different areas of the country no significant community impacts are expected.

TABLE 7-8. SUMMARY OF POTENTIAL PLANT CLOSURES BEFORE CONSIDERATION OF BASELINE CLOSURES

BATTERY PRODUCT GROUP	NUMBER OF PRODUCTION FACILITIES	REGULATORY[1/] OPTION	NUMBER OF PROBABLE CLOSURES
Lead Acid	184	Alternative 5	2
Nickel-Cadmium	9	Alternative 5	2
Other	65	ALL	0
Total	258	Alternative 5	4

1/ There are no closures estimated for Alternatives 1 through 4.

SOURCE: Table 7-7.

TABLE 7-9. SUMMARY OF POTENTIAL EMPLOYMENT IMPACTS

	Number of Plants	Number of Employees (000)	Regulatory Option	Number of Probable Closures	Employment in Closed Production Lines
Lead-Acid	184	24 - 25	Alternative 5	2	35 - 70
Nickel-Cadmium	8	1 - 2	Alternative 5	2	220 - 320
Other	65	9 - 11	All	0	0
Total	258	37	Alternative 5	4	255 - 390

SOURCES: Tables 7-7 and 7-8 and EPA Technical Survey.

7.6.2 Foreign Trade Impacts

As described in Chapter 3 foreign trade has not been a major factor in the battery industry. However, the possibility exists that during the 1980s, competition for markets from far eastern producers could intensify as their technology advances. If there were a significant price effect from the regulations, the U.S. competitive position could be damaged. However, as shown in Table 7-1, the price increases estimated to result from the regulations are quite small, amounting to fractions of a percent. Price increases of this magnitude would not be large enough to induce consumers to switch battery brands.

7.6.3 Industry Structure Effects

The potentially high impacted plants (the 21 plants that passed through the screening analysis), are small relative to the plants that produce most of the industry output. The average compliance cost per unit of production for these plants are significantly higher than those of the larger plants. As shown in Chapters 5 and 6, the baseline conditions of the industry indicate increasing industry concentration and closing of small plants. Moreover, unit costs of compliance of other Federal regulations are also higher for small than for large plants. The combined effect of these developments will be a substantial shift in the competitive position of small versus large plants. This is especially true in the lead-acid product group. The combined effect of all Federal regulations on these plants could be so great that only those small plants with specialty markets can remain in the industry over the long run. Specialty markets, in this context, may be a specific type of battery with very narowly defined specifications meant for a particular use, the volume of which will not support a major portion of the industry. A specialty market may also be a specific geographic region in which a local producer has a cost advantage over nationwide firms, because of high transportation costs to the region. In a specialty market a small battery manufacturer may earn more than the "normal" profit margin, so that the firm can absorb much of the compliance costs and still remain profitable.

A substantial shift in industry concentration is likely to occur in the sealed nickel-cadmium industry segment under the Alternative 5 option. There are six plants that manufacture about $90 million worth of sealed nickel-cadmium batteries in the U.S. These plants belong to large firms. One of these six plants accounts for 60 to 65 percent of industry output. This plant will incur no compliance costs, since it has no effluent. About 15 to 20 percent of output is accounted for by two plants whose compliance costs will be substantial (Alternative 5 annual costs amount to over 3 percent of annual revenues). These two plants are estimated to be likely closures under the Alternative 5 option. A third nickel cadmium plant will experience significant profit reduction; but this reduction will not be enough to cause the plant to close. This plant is considered to have a low closure potential. At all other options, none of these plants are considered likely or borderline closure candidates, because the technologies are considerably less expensive.

If these two plants closed, industry capacity would drop substantially (15 to 20 percent). To the extent that this void is filled by the industry's largest producer (the firm with 60 to 65 percent of the market), this industry sector will become significantly more concentrated. The long-run impact of increased concentration could be a reduction in price competition within this industry segment.

7.7 SOCIAL COST ESTIMATES

This section assesses the total social costs that can be associated with the EPA effluent regulations. The social costs measure the value of goods and services lost by society due to a given regulatory action. These costs generally include the use of resources needed to comply with a regulation, the use of resources to implement and enforce a regulation, plus the value of the output that is foregone because of a regulation.

7.7.1 Conceptual Framework

The partial equilibrium analytical framework is conceptually the most practical means for estimating total social costs. This framework, in its most sophisticated form, is based on an analysis of supply and demand relationshipos in the directly-affected markets. When an industry is regulated, compliance requirements result in increased unit costs of production. This, in turn, leads to an upward shift in the industry's supply curve. The supply curve shift normally results in higher prices and a lower production level. Compliance costs, production losses, and net welfare losses incurred by producers and consumers due to decreased output are measurable within this framework. There are other costs that are not measurable within this framework. Costs of implementing and enforcing a regulation must be added. Also, other social costs do not appear in this static analysis such as productivity effects, innovation impacts, and costs of reallocating resources that become unemployed. Unfortunately, the data does not exist to carry out such analysis at this time, and a compromise which captures the major costs to society was carried out.

7.7.2 Social Cost Analysis

For this analysis only the real resource costs are considered. This provides a reasonable estimate of social costs, since most of the social costs are directly related to compliance expenditures by the regulated entities. Consequently, the present value of social costs (PVSC) of regulations can be approximated by the following equation:

$$PVSC = I/(1 + .1)^n + (OM/.1)/(1 + .1)^n$$

where:

PVSC = present value of social costs
I = investment cost
OM = annual operating and maintenance cost
n = number of years between now and year of investment.

This equation assumes that:

- The regulations will be in effect in perpetuity
- Operating and maintenance costs will be incurred in the first year of investment
- The real discount rate (imposed by OMB) is 10 percent.

Assuming the compliance expenditures will begin in 1984, n would equal 2 and PVSC (in 1982) of the proposed regulations for the industry are calculated and presented below.

Regulatory Alternative	Social Cost $ millions of 1978 dollars
Alternative 1	20.5
Alternative 2	32.5
Alternative 3	39.7
Alternative 4	40.1
Alternative 5	62.1

7.8 NEW SOURCE IMPACTS

Newly constructed facilities and facilities that are substantially modified are required to meet the New Source Performance Standards (NSPS) and/or the Pretreatment Standards for New Sources (PSNS). EPA considered three or more regulatory alternatives for selection of NSPS and PSNS technologies. The considered options are equivalent to those discussed for existing sources and are described in Chapter 6 above and in the Development Document. The final selections were found to be identical to the alternatives shown in the second column of Table 7-10. The following paragraphs discuss the costs and impacts of these alternatives.

TABLE 7-10. SELECTED REGULATORY ALTERNATIVES AND INCREMENTAL COMPLIANCE COSTS FOR NEW SOURCES IN BATTERY MANUFACTURING INDUSTRY AND SUBCATEGORY AVERAGES

SUBCATEGORY	SELECTED EXISTING SOURCE ALTERNATIVE	SELECTED NEW SOURCE ALTERNATIVE	INCREMENTAL[c] COSTS ÷ ASSETS (PERCENT)	ANNUAL COSTS[c] ÷ REVENUES (PERCENT)
Cadmium				
Direct	2	5	1.6	0.16
Indirect	2	5	3.2	0.53
Calcium				
Direct	None	1	0.06	0.03[c]
Indirect	None	1	0.06	0.03
Lead				
Direct	2	5	1.18	0.13
Indirect	2	5	0.88	0.19
Leclanche				
Direct	None	1	0	0[a]
Indirect	1	1	0	0
Lithium				
Direct	None	1	0	0.10
Indirect	None	1	0	6.25[b]
Magnesium				
Direct	None	3	0	0.08
Indirect	1	3	0.32	0.13
Zinc				
Direct	2	5	0.06	0.05
Indirect	2	5	0.16	0.06
TOTAL	-	-	0.91	0.18

[a] This estimate is based on that for indirect dischargers

[b] This cost is based on that for a low production, prototype facility

[c] These costs are for the difference between the new source alternatives and the existing source selected alternatives

7.8.1 New Source Compliance Costs

The cost of implementing the new source technologies depends upon the nature of new sources in the battery industry, the number of new sources, and the definition of costs used. There is considerable uncertainty regarding the first two factors and this uncertainty has affected the approach used to assess new source costs and impacts. Although projections of general activity levels in the industry are presented in Chapter 5 of this report, the data is insufficient to reliably forecast the number of plant modifications and the proportion of output that will be at new versus existing plants. In addition, insufficient information is available to estimate the impacts of the regulatory requirements on the design of new plants nor, alternatively, the impacts of new production technologies on pollution control requirements. For these reasons, the following two assumptions were employed in estimating new source compliance costs:

- The compliance costs per unit of output (pound of batteries) for new sources are assumed to be equal to the industry subcategory average for that of existing sources which use the same treatment technology
- Compliance costs for new sources are to be expressed as ratios, or percents, relative to the unit value of output or plant assets, as appropriate (e.g., annual compliance costs ÷ revenues and investment compliance costs ÷ plant assets).

The first assumption implies that the costs may include retrofitting costs which are incurred when the same technology is applied to existing plants. To the extent that retrofitting costs are significant, the resulting compliance costs are overestimated. Moreover, because there are economies to scale in most of the considered pollution control technologies and because the average new plant size for some subcategories is expected to be larger than the average existing plant (as described in Chapter 5), it is expected that the new source cost estimate will be biased upward. The effect of this bias on the economic impact analysis would be to overstate the impacts. There is insufficient information available to the study teams to quantify the bias. However, it is believed that the estimates shown are reasonable approximations for use in an industry-wide assesment of impacts.

For purposes of evaluating new source impacts, compliance costs for new source standards are defined as incremental costs from the costs of selected standards for existing sources. For example, the cost shown for the cadmium subcategory is the cost of alternative 5 minus that of alternative 2. For those subcategories with no regulation for existing sources, the cost shown represents that of installing the system over the current practice in the industry. For those subcategories where the existing and new source options are identical, there is zero incremental cost.

Table 7-10 shows annual compliance costs as a percent of revenues and investment compliance cost as a percent of plant assets. New sources will incur annual costs equal to 0.2 percent of revenues and investment costs equal to 0.9 percent of plant assets. The costs ratios vary considerably from one subcategory to another. For example, new source incremental annual costs are zero for the Leclanche subcategory and 0.5 percent of revenues for indirect discharger cadmium battery manufacturers. Similarly, capital costs range from zero to 3.2 percent of plant assets.

7.8.2 Economic Impacts on New Sources

The assessment of economic impacts on new sources is based upon the cost data shown in Table 7-10 and analogy to the impact conclusions for similar existing plants described in Sections 7.1 through 7.7. The primary variables of interest are identical to those for existing plants plus the potential of the regulation in fostering barriers to entry or causing intra-industry shifts in competitiveness.

As sections 7.1 through 7.6 demonstrate, the impacts of each of the regulatory alternatives will cause no plant closures and price increase and profit reduction of less than one percent for all but the cadmium and lead subcategories. Thus, the new source alternatives will cause no general economic impact for these five subcategories. The cost ratios shown in Table 7-10 indicate differences in cost of production of significantly less than one percent of revenues. Moreover, the new source requirements will add only a fraction of a percent to the asset value of a plant for the five subcategories. Cost differentials of this magnitude do not constitute a significant competitive advantage or disadvantage for new versus existing plants; nor do they imply significant incremental barriers to entry of new capacity into the industry.

For the cadmium and lead subcategories, the incremental annual costs are larger than for the other subcategories, although they are still less than one percent of revenues. Costs of this magnitude were found to cause a high potential for four plant closures among existing plants. By analogy, the profitabilities of some new plants may be adversely affected. However, the magnitudes of the differential profits would not, by themselves, deter construction of a new plant.

The investment costs for the new source cadmium plants are 3.2 percent of assets for indirect dischargers and 1.6 percent of assets for direct dischargers. The significant difference between these two figures may be due to a bias introduced by the cost estimating methods and assumptions used. That is, compliance costs for existing sources were estimated for each existing plant, with treatment in place used as the baseline. If the direct dischargers had more treatment in place, their compliance costs would be lower than those for indirect dischargers. This situation may not accurately represent the baseline treatment in place for new sources. For example, if the baseline treatment in place for direct and indirect dischargers was equal, then the differences in their estimated compliance costs would be smaller than those estimated above. Nevertheless, the affect of these costs on the investment decision cannot be determined with certainty. However, taken together with other business decision factors, they are certainly noticeable.

7.8.3 Total New Source Compliance Costs

Estimates of the cost of the new source standards were developed by (a) forecasting the increase in industry output from 1980 to 1990, (b) estimating the proportions of the added output that will be subject to new source requirements, (c) estimating the compliance costs per unit of output for new sources, and (d) multiplying compliance cost per unit of output by estimated increase in capacity. In following these steps, three assumptions and inferences were made. These are:

- The increase in industry output is taken from the base case demand forecast in Chapter 5 ($800 million for storage batteries and $300 million for primary batteries in 1978 dollars)
- The amount of industry output subject to new sources standards is assumed to be equal to the above forecasted growth in industry output
- The annual compliance cost per unit of output and the investment compliance cost as a percent of plant assets are assumed to be equal to that for existing sources for the same pollution control technology. (To the extent that new plants are larger and that these costs include retrofitting costs, these estimtes could be overestimated.)

Using this approach, the new source selected option will cost the industry $10.0 million in investment costs and $2.0 million in annual costs by 1990, in 1978 dollars.

7.9 LIMITATIONS TO THE ACCURACY OF THE ANALYSIS

Various assumptions and estimates were made in the calculation of compliance costs and in the analyses performed to assess their impacts. These factors unavoidably affect the level of accuracy which can be assigned to the study's conclusions. The assumptions relating to the estimation of plants' specific compliance costs are outlined in Chapter 6 of this report and are discussed in detail in the technical development document. Even though these assumptions have a bearing on the accuracy of the economic impact conclusions, the focus of this section will center on the assumptions and estimates made in this report.

The major assumptions and estimates that have the greatest impact on the accuracy of the conclusions are related to the data used for the analyses. Since no economic survey was conducted to collect plant-specific financial data, the data used in this report had to be estimated and/or extrapolated from a variety of sources such as average industry, corporation, and "model plant" operating and financial ratios. Some of the major assumptions made in estimating and extrapolating these data are:

- An average industry price per pound of production was used to derive projected sales revenue estimates for each plant. The actual price per pound could vary considerably from one battery configuration to another, even within the same chemical system type. In some cases market research was able to identify specific battery types and prices, so that adjustments were made as required.

- The estimation of plant asset values and profit ratios are based upon only partial information from a number of sources that were not necessarily consistent with each other. This diverse information was used to develop a wide range of financial ratios which are believed to encompass those that actually exist. Thus, although there was limited information, the results were calculated for a wide range of possible conditions within the industry. Despite this caution and the conservative bias used in these estimation procedures, variation of conditions within the industry could escape the methodology.

- Lacking detailed data on the salvage value of assets, specific depreciation schedules, and tax rates, it was assumed that net assets equal salvage value, depreciation equals 10 percent of fixed assets, and the tax rate for small firms is 30 percent for purposes of the internal rate of return analysis (IRR).

- The cost of capital was estimated to be 12 percent for the entire industry, despite the fact that it can differ from firm to firm. A sensitivity analysis of plus and minus 20 percent of this figure showed that the results of the study would not be significantly affected.

- To stress the conservative nature of the study effort, all quantity changes were calculated at the higher end of the elasticity estimate range and, usually, at the lower profitability estimates and plant revenue estimates.

These limitations inhibit the ability of the impact analysis to address specific plant closure decisions in cases where the regulations exert a significant, but not overwhelming, impact upon the plant (i.e., borderline cases). An overriding feature of the manner in which the limitations, inferences, and extrapolations were dealt with in the analysis is that a "conservative" approach was followed. That is, judgments were made that would more likely result in overstating the economic impacts than understating them.

8. REGULATORY FLEXIBILITY ANALYSIS

8. REGULATORY FLEXIBILITY ANALYSIS

8.1 INTRODUCTION

The Regulatory Flexibility Act (RFA) of 1980 (P.L. 96-354), which amends the Administrative Procedures Act, requires Federal regulatory agencies to consider "small entities" throughout the regulatory process. The RFA requires an initial screening analysis to be performed to determine if a substantial number of small entities will be significantly impacted. If so, regulatory alternatives that eliminate or mitigate the impacts must be considered. This analysis addresses these objectives by identifying and evaluating the economic impacts of the aforementioned regulations on small battery manufacturers. As described in Chapter 2, the small business analysis is developed as an integral part of the general economic impact analysis and is based on the examination of the distribution by plant size of the number of battery manufacturing plants, compliance costs and potential closures as a result of the regulations. The primary economic impact variables include production cost, profitability, plant closures, capital structure, equality of goods, industry structure and competition, changes in imports and exports, and innovation and growth in the industry. Most of the information in this section is drawn from the general economic impact analysis which is described in Chapters 1 through 7 of this report. Specifically, the areas covered in the Regulatory Flexibility Analysis (RFA) include:

- Description of the analytical approach to the RFA
- Definitions of small entities in the battery manufacturing industry
- Baseline conditions of small entities in the battery manufacturing industry
- Direct compliance cost

- Economic impacts
- Effects of special considerations for small entities.

8.2 ANALYTICAL APPROACH

8.2.1 Overview

The analytical appraoch used for the RFA follows the basic approach used for the general analysis of the economic impacts of the regulations described in Chapter 2 of this report. That is, the industry is divided into product groups that correspond, as closely as possible, to homogeneous markets. The demand and supply characteristics of each of these markets are then studied to project pre-compliance industry conditions at the time the proposed regulations are expected to become effective (1984-1985). The specific conditions of small firms are evaluated against the background of the general conditions in each product group market. Since small firms account for only a small portion of battery manufacturing activity, they are assumed to be price takers and general market characteristics (demand, supply, and equilibrium price) are considered exogenous variables to the small firm analysis.

8.2.2 Definition of Small Entities

A specific problem in the methodology was the development of an acceptable definition of small entities. The Small Business Administration (SBA) defines small entities in SIC 3691 (Storage Batteries) and SIC 3692 (Primary Batteries) as firms of fewer than 2,500 employees. Since there are about 200 firms in the industry and since employment in the two industry sectors are 11,000 and 25,000, respectively, the SBA definition would include almost the entire industry. It was also observed that many battery plants are owned by major Fortune 500 corporations (e.g., Union Carbide, General Motors, Dart Industries). For these reasons the SBA definition was not used as a basis for defining small entities in the battery manufacturing industry. Instead, a definition was sought which would account for firm size in comparison to total industry size and to unit compliance costs (unit compliance costs increase significantly in reverse proportion to plant size) and would provide EPA with alternative definitions of "small" plants. Moreover, since the available data on compliance cost and production was on a plant basis, the individual production facility, rather than firm was used as the basis for the analysis.

Five alternative definitions for "small" battery manufacturing plants were selected for examination and the impacts on small plants under each definition were assessed. In addition, the potential impacts of small business exemptions (tiering) under each of the five alternative sizes were examined. Value of production was the primary variable used to distinguish firm size. This is because plant level employment data were considered less reliable and plant level production data did not allow consistent comparisons across the product groups. The five size categories are less than $1 million, $1-$2.5 million, $2.5-$5 million, $5-$10 million, and greater than $10 million.

8.3 BASELINE CONDITIONS

The number of battery manufacturing plants falling into each size category is shown in Tables 8-1 and 8-2. The table also shows the value of production of different sized plants, along with the percentages of the industry totals for each. As the table shows, the industry is characterized by a few large plants which account for most of the production and many smaller plants producing a smaller portion of industry output. As described in Chapter 4, between 20 and 30 closures of small lead acid plants are expected between 1980 and 1990, even without the proposed regulations. Any new lead acid plants to be build in the future are expected to be large ones, because only large plants are currently considered economically feasible. Thus, small lead acid plants are considered to be economically weak, except for those serving specialty markets.

TABLE 8-1. COMPLIANCE COSTS OF LEAD ACID BATTERY MANUFACTURING FACILITIES BY SIZE OF FACILITY (1978 DOLLARS)2/

Facility Size (by Value of Production)	Number of Facilities in Sample 1/	Value of Production ($ Millions)	Alternative-1 Compliance Costs Investment	Alternative-1 Compliance Costs Annual	Alternative-1 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-2 Compliance Costs Investment	Alternative-2 Compliance Costs Annual	Alternative-2 Annual Compliance Cost as a Percent of Revenues (Percent)
<$1 Million % of Total	43 (28.8%)	13.606 (0.9%)	193,362 (2.9%)	88,575 (4.2%)	.65	267,682 (1.6%)	95,654 (2.3%)	.70
$1-2.5 Million % of Total	14 (9.6%)	22.260 (1.5%)	307,606 (4.7%)	108,877 (5.2%)	.49	471,978 (2.8%)	136,447 (3.2%)	.61
$2.5-5 Million % of Total	12 (8.2%)	45.128 (3.0%)	563,342 (8.6%)	157,280 (7.5%)	.35	854,031 (5.1%)	209,258 (5.0%)	.46
$5-10 Million % of Total	26 (17.8%)	184.195 (12.4%)	1,532,519 (23.4%)	437,184 (20.7%)	.24	3,634,735 (21.5%)	770,777 (18.3%)	.42
>$10 Million % of Total	52 (35.6%)	1,221.874 (82.2%)	3,963,692 (60.4%)	1,314,739 (62.4%)	.11	11,643,753 (69.0%)	2,992,872 (71.2%)	.24
TOTAL INDUSTRY % of Total	146 (100%)	1,487,094 (100%)	6,560,521 (100%)	2,106,655 (100%)	.14	16,872,179 (100%)	4,205,208 (100%)	.28

Facility Size (by Value of Production)	Alternative-3 Compliance Costs Investment	Alternative-3 Compliance Costs Annual	Alternative-3 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-4 Compliance Costs Investment	Alternative-4 Compliance Costs Annual	Alternative-4 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-5 Compliance Costs Investment	Alternative-5 Compliance Costs Annual	Alternative-5 Annual Compliance Cost as a Percent of Revenues (Percent)
<$1 Million % of Total	280,502 (1.7%)	113,183 (2.7%)	.83	331,160 (1.7%)	146,113 (2.9%)	1.07	609,308 (2.4%)	256,102 (3.4%)	1.87
$1-2.5 Million % of Total	471,978 (2.8%)	139,547 (3.3%)	.63	504,363 (2.6%)	183,680 (3.6%)	.83	920,885 (3.6%)	335,157 (4.5%)	1.51
$2.5-5 Million % of Total	912,361 (5.4%)	225,738 (5.3%)	.50	975,160 (5.1%)	272,540 (5.4%)	.60	1,433,119 (5.6%)	471,980 (6.3%)	1.05
$5-10 Million % of Total	3,424,730 (20.5%)	770,815 (18.2%)	.42	4,408,405 (22.9%)	973,412 (19.2%)	.53	5,652,931 (22.0%)	1,542,399 (20.6%)	.84
>$10 Million % of Total	11,643,748 (69.6%)	2,992,845 (70.5%)	.24	13,067,475 (67.7%)	3,493,388 (68.9%)	.29	17,075,412 (66.4%)	4,885,352 (65.2%)	.40
TOTAL INDUSTRY % of Total	16,733,319 (100%)	4,247,163 (100%)	.29	19,286,563 (100%)	5,069,133 (100%)	.34	25,691,655 (100%)	7,490,990 (100%)	.50

1/ Data for 38 of the 184 faciities were not adequate for inclusion in this table.

2/ Note the industry totals differ throm those reported in Chapter 6, because of differences in sample size.

SOURCE: EPA and JRB estimates.

TABLE 8-2. COMPLIANCE COSTS OF NON-LEAD ACID BATTERY MANUFACTURING FACILITIES BY SIZE OF FACILITY (1978 DOLLARS)

Facility Size (by Value of Production)	Number of Facilities in Sample 1/	Value of Production ($ Millions)	Alternative-1 Compliance Costs Investment	Alternative-1 Compliance Costs Annual	Alternative-1 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-2 Compliance Costs Investment	Alternative-2 Compliance Costs Annual	Alternative-2 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-3 Compliance Costs Investment	Alternative-3 Compliance Costs Annual	Alternative-3 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-4 Compliance Costs Investment	Alternative-4 Compliance Costs Annual	Alternative-4 Annual Compliance Cost as a Percent of Revenues (Percent)	Alternative-5 Compliance Costs Investment	Alternative-5 Compliance Costs Annual	Alternative-5 Annual Compliance Cost as a Percent of Revenues (Percent)
< $1 Million	21 (32.3%)	5.2 (0.6%)	77,944 (8.1%)	28,771.5 (7.2%)	.56	84,505 (8.3%)	29,600 (8.7%)	.57	87,374 (8.0%)	30,335 (7.3%)	.59	69,763 (4.1%)	37,099 (5.7%)	.71	49,130 (1.7%)	38,018 (3.7%)	.73
$1-2.5 Million	8 (12.3%)	13.6 (1.7%)	126,389 (11.0%)	40,256 (13.2%)	.30	124,750 (13.4%)	54,276 (12.2%)	.40	115,943 (10.6%)	54,457 (13.0%)	.40	193,519 (11.5%)	89,263 (13.7%)	.66	193,379 (6.5%)	89,263 (8.7%)	.66
$2.5-5 Million	8 (12.3%)	28.8 (3.6%)	132,129 (16.2%)	50,600 (14.9%)	.18	160,860 (14.0%)	61,292 (15.3%)	.21	169,495 (15.5%)	61,580 (14.7%)	.21	238,965 (14.2%)	85,212 (13.1%)	.30	507,784 (17.1%)	130,462 (12.7%)	.45
$5-10 Million	6 (9.2%)	42.2 (5.2%)	169,689 (16.3%)	52,391 (15.5%)	.14	170,088 (18.0%)	62,834 (15.9%)	.14	181,738 (16.6%)	64,564 (15.4%)	.15	241,447 (14.3%)	88,197 (13.5%)	.21	525,845 (17.7%)	168,170 (16.3%)	.40
$10-20 Million	8 (12.3%)	121.3 (15.0%)	189,493 (18.7%)	55,326 (20.2%)	.05	194,897 (20.1%)	83,057 (16.8%)	.07	194,897 (17.8%)	83,057 (19.9%)	.07	403,664 (23.9%)	151,140 (23.2%)	.12	780,681 (26.3%)	349,729 (34.0%)	.28
> $20 Million	14 (21.5%)	596.9 (73.9%)	248,043 (29.5%)	102,550 (29.1%)	.02	307,371 (26.3%)	119,538 (31.1%)	.02	346,087 (31.6%)	127,317 (29.7%)	.02	539,052 (32.0%)	201,653 (30.9%)	.03	910,306 (30.7%)	253,856 (24.7%)	.04
TOTAL Non-Lead Industry	65 (100%)	808.0 (100%)	963,681 (100%)	329,094.5 (100%)	.04	1,040,689 (100%)	410,597 (100%)	.05	1,095,334 (100%)	418,350 (100%	.05	1,686,420 (100%)	652,364 (100%)	.08	2,967,475 (100%)	1,029,498 (100%)	.13

1/ Data for 9 of the 74 production facilities were not adequate for inclusion in this table.

SOURCE: EPA and JRB estimates

In contrast to the lead acid category, no baseline closures are expected in the non-lead acid industry segment; although like the lead acid segment, the average plant size is also expected to increase. Thus, it is likely that the small plants counted in Table 8-1 will still be in operation in 1985. Moreover, there is no reason to expect the proportion of industry output produced by these small plants to change.

The projections of baseline conditions are based on industry-level data provided by Census of Manufactures. Limitations to this data preclude estimation of plant-specific activities. Consequently, the assessment of impacts on small business was developed primarily with the data base of exiting plants from the EPA 308 survey and industry trade sources.

8.4 COMPLIANCE COSTS

This section describes the compliance costs that will be incurred by small firms. The economic impacts which result from the proposed regulation begin with the compliance costs incurred at the plant level. Table 8-1 shows the compliance cost estimates for the lead acid battery manufacturing sector by plant size. For each of the five alternative definitions for "small plant" and for each regulatory option, the table shows the estimated investment and total annual compliance costs. This table was taken from the same data sources as used in Chapter 6 (Cost of Compliance). The table also shows the proportion of total lead acid battery output and industry sector compliance costs attributed to both small and large plants. For example, 29 percent (42 plants) of the lead acid plants in the sample produce less than $1 million annually. Plants in this size produce 0.9 percent ($13.7 million) of industry output and will incur 4.2 percent ($88,575) of the industry's annual compliance cost and 2.9 percent ($193,362) of the industry's investment costs under Alternative 1. The annual alternative 1 compliance costs for these 42 plants would be 0.65 percent of their combined revenues.

In contrast to these very small plants, 36 percent (52 plants) of the plants have annual production values in excess of $10 million. These 52 plants produce 82 percent ($1.2 billion) of the lead acid batteries in the sample and account for 62 percent ($1.3 million) of the industry sector's annual cost and 60 percent ($4.0 million) of the industry sector's investment cost under Alternative 1. The annual compliance cost for these 52 plants would be 0.11 percent of their combined revenues. For all regulatory options, compliance costs as a percent of revenues is significantly larger for the smaller than for the larger plants.

Table 8-2 shows compliance costs estimated for the non-lead acid sector. The observations made from Table 8-2 are also similar to those made for the lead acid sector (Table 8-1). That is, unit compliance costs are generally inversely proportional to plant size. For this reason, the proposed regulations will reduce the profitabilities of small plants more than it will for large plants.

With one notable exception, most indirect costs were estimated by the Effluent Guidelines Division under the term "subsidiary" costs. Subsidiary costs include administrative and laboratory facilities, line segregation, yardwork, engineering, legal costs, fiscal and administrative expenses, interest expenses during construction, and garage and shop facilities. The one exception includes that of downtime of manufacturing facilities during construction of the pollution control systems and changes in daily work routines.

8.5 ECONOMIC IMPACTS ON SMALL ENTITIES

As described previously and shown in Tables 8-1 and 8-2, the average unit compliance costs of small plants are expected to be higher than those of larger plants. Following the assumptions of relatively homogeneous product groups and relatively free market conditions described in Chapters 2 and 7, the costs of the proposed regulation will foster a drop in the returns on sales (ROS) of many small plants. It is estimated that at the most costly pollution control option (alternative 5) there will be 21 plants whose ROSs will fall by more than one percent. For most of these plants the drop in ROS will not be enough to cause a plant shutdown. However, it is likely that under alternative 5, four small plants will close. Two of these are lead acid plants which belong to single plant firms and have annual production values of $2.5 million or less. They employ between 15 and 35 people each. The other two production facilities likely to close manufacture cadmium batteries and are either subsidiaries or divisions of large corporations. In addition, these 2 facilities are parts of larger production establishments. One of these facilities falls into the $1-$2.5 million category and the other falls into the $2.5-$5 million category. These facilities employ between 95 and 170 people each. As shown in Table 8-3, plant closures under regulatory alternatives 1 through 4 are not likely.

8.6 POTENTIAL EFFECTS OF SPECIAL CONSIDERATIONS FOR SMALL ENTITIES

For purposes of this study, the granting of special considerations for small entities is considered in terms of the most extreme special consideration the exemption of small entities from the regulation. Such an exemption would have the following impacts:

- It would decrease the total cost of implementing the regulations
- It would mitigate the negative economic impacts of the proposed regulations
- It would decrease the effectiveness of the regulations (i.e., amount of pollutants removed from the effluent).

The amount of total costs of compliance avoided by special exemptions increases with the size definition of small entities. These figures are shown in Tables 8-1 and 8-2 above. For example, under regulatory alternative 5, $256 thousand

TABLE 8-3. NUMBER OF PLANT CLOSURES BY SIZE OF PLANT

Facility Size by Value of Production	Number of Plants in Sample	Lead Acid Plants					Number of Plants in Sample	Non-Lead Acid Plants				
		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5		Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
< $1 Million	42	0	0	0	0	1	21	0	0	0	0	0
$1-2.5 Million	14	0	0	0	0	1	8	0	0	0	0	1
$2.5-5 Million	12	0	0	0	0	0	8	0	0	0	0	1
$5-10 Million	26	0	0	0	0	0	6	0	0	0	0	0
> $10 Million	52	0	0	0	0	0	22	0	0	0	0	0
Total	146	0	0	0	0	2	65	0	0	0	0	2

SOURCE: JRB estimates

of annual cost and $609 thousand of investment cost and one plant closure would be avoided in the lead acid sector if the plants with production values of under $1 million were exempted. In addition, 42 very small plants would incur no additional costs. If an exemption were set for plants with production values of under $10 million, 35 percent ($2.6 million) of the lead acid sector's annual costs and 34 percent ($8.6 million) of the lead sector's investment cost would be avoided at the alternative 5 option. Moreover, two thirds of the plants in the industry would be exempt from the regulation; there would be no plant closure and price, production, and profit impacts would be small. The implications of the other definitions for "small entities" can be seen in Tables 8-1, 8-2, and 8-3. For example, under regulatory alternative 5, $256 thousand of annual cost and $609 thousand of investment cost and one plant closure would be avoided in the lead acid sector if the plants with production values of under $1 million were exempted. In addition, 42 very small plants would incur no additional costs. If an exemption were set for plants with production values of under $10 million, 35 percent ($2.6 million) of the lead acid sector's annual costs and 34 percent ($8.6 million) of the lead sector's investment cost would be avoided at the alternative 5 option. Moreover, two thirds of the plants in the industry would be exempt from the regulation; there would be no plant closure; and price, production, and profit impacts would be small. The implications of the other definitions for "small entities" can be seen in Tables 8-1, 8-2, and 8-3.

APPENDIX A

PROFITABILITY ANALYSIS METHODOLOGY

This appendix describes the methodology used in the plant level profitability analysis. It includes the rationale for the use of the profitability measures selected (return on investment and internal rate of return) and the methods used for estimating values for the specific data used in the calculation of these profitability measures.

General

Analysis of plant-level profitability, for purposes of capital budgeting decisions, can be grouped into three general approaches: the payback period, financial ratio analysis, and discounted cash flow (DCF) techniques. The payback period is not applicable for plant closure analysis since the plant receives no financial return on its pollution control investment.

Financial Ratio Analysis

The second approach to measuring product and plant profitability is to compare financial ratios that are key measures of profitability, such as returns on equity, assets, and sales. Of these, return on equity and assets are the most useful measures and the average rate of return on average investment is the most direct. This rate represents the ratio of annual profits after taxes to either the original or the average investment in the project. The principal virtue of this method is its simplicity and its common usage in comparing overall profitabilities of financial entities. Its principal shortcomings are that it is based on accounting income rather than cash flows, and that it fails to account for the timing of cash flows, thereby ignoring the time value of money. Since the ROIs for the individual battery plants were not available to the study team a broad range of estimates were developed using aggregate industry and sample plant data. The estimation procedure is described later in this appendix.

Discounted Cash Flow Analysis

Discounted cash flow (DCF) approaches take into account both the magnitude and the timing of expected cash flows in each period of a project's life, and provide a basis for transforming a complex pattern of cash flows into a single number. There are two major techniques for applying DCF analysis: the internal-rate-of-return (IRR) method and the present-value method (PV).

Because of shortcomings of each of the four approaches to capital budgeting decisions, and of available data, none of them will provide both a theoretically correct, and realistic estimate of plant closures. Although PV is the most theoretically correct method from an economic viewpoint, it is not recommended here for several reasons: first, the detailed data necessary to estimate fluctuations in cash flows will not be gathered in this study. Second, without detailed estimates of cash flows, the assumption of a constant rate of net cash flows for any given plant is reasonable; which, as shown below, implies that the DCF rationale could be applied, given only one year of data, by using the IRR technique. The IRR technique will generally provide the same plant closure decisions as the PV technique; and because several estimates of IRR can be used, in comparison to the cost of capital, to test its sensitivity to the assumptions underlying the profitability estimates, it is more appropriate to the problem at hand (in which there are wide confidence intervals around the estimates of profitability). In addition, the IRR technique will be easier to implement, in this case, while it embodies the same rationale as the PV technique. The remainder of this paper describes the suggested implementation of this technique.

The IRR for an investment is the discount rate that equates the present value of the expected stream of cash outflows with that of the expected inflows. It is represented by that rate r, such that

$$\sum_{T=0}^{n} A_T (1 + r)^{-T} = 0$$

where A_T is the cash flow for period T, and n is the last period in which the cash flow is expected. Standard methodology calls for solving the equation for r and then comparing to some required cutoff, or hurdle rate, to determine acceptability of the investment. A relatively conservative approach is to select the cost of capital as the hurdle rate. If the initial cash outlay (A_0) occurs at time T=0, and if the cash flow is an even series (A), then $A_0/A = \sum(1+r)^{-T}$. Since the values for r corresponding to various values of $\sum(1+r)^{-T}$ are provided in standard present value tables, r can be found by simply dividing the initial outlay by the cash flow (i.e., A_0/A) to obtain a factor which can then be used in conjunction with a present value table to look up the discount rate. Exhibit A provides a derivation of this relationship. Thus, the IRR is expressed as a function of A_0, A and n. Since n may remain fixed in our analysis (e.g., 10 years) the IRR is a function only of $\frac{A}{A_0}$. In brief, if the cash flow is constant, and if the initial investment occurs at time 0, then the cash flow for any given year as a ratio of initial investment is sufficient to calculate IRR. For this analysis, the initial investment is the market value of the plant plus the pollution control investment, plus working capital.

Data Sources

Since no survey of industry financial and economic data was conducted, information from published sources was used to develop a range of values that are likely to include the actual values in the affected plants. The range of values results from imputing rather wide confidence intervals around industry-wide data and data on "model" or "typical" plants found in the literature. Since the resulting estimates are not precise calculations of the variables, they cannot be used to make exact predictions of plant-level impacts. However, they allowed us to develop a reasonable range of likely impacts that could result from the regulations. The following data sources were used in the analysis:

- Census of Manufacturers, 1972 and 1977
- Company Annual Reports for Union Carbide Corp., Eltra Corp., ESB Inc., Glove Union, Inc., P.R. Mallory, Inc.
- Lead-Acid Battery Manufacture - Background Information for Proposed Standards (DRAFT), EPA 450/3-79-028a, EPA, Office of Air Quality Planning and Standards, November, 1979.

The last source used data obtained at site visits to develop financial statements for two model "representative" lead acid battery plants - a 100 battery per day plant (about one million pounds per year) and a 250 battery per day plant (about 2.5 million pounds per year). The model financial statements are shown in Tables A-1 and A-2. The financial characteristics of this data was confirmed, to some extent (as the data permitted), by information gathered at plant visits. Separate calculations were done for "very small" (less than one million pounds per year) and small plants (between one and 10 million pounds per year). However, since the data on "small" plants conflicts with data in corporate annual reports and site visit reports, only the ROI for the "very small" plants were actually used in the analysis. This decision favors a conservative approach to impact assessment since the ROI for the latter is lower than that of the former. To account for possible variations in profitability in the industry and to insure conservative estimates, the ROI and IRR estimates were varied by using financial ratios calculated from FTC and company annual reports. The resulting estimates of ROI and IRR are shown in Table A-3. Although the study team had only limited access to plant-level financial data, these estimates represent a range of plausible conditions under which the regulation will be promulgated.

Available financial data for the non-lead acid product groups was scarcer than that for the lead acid plants. A number of values for return on investment and internal rate of return were developed for corporations and industry groups related to battery manufacturing. None of the sources used had directly measured the financial parameters for any single battery product group. However, the range of values developed appear to be reasonable for an industry-wide assessment of the probable impacts. The variables whose values were taken from the above sources include sales, total gross assets, net assets, total fixed assets and net profit for corporations engaged in the manufacture of electronic equipment, and battery manufacturing. These variables were used to calculate a range of values for the following ratios: return on sales, sales to assets, profits to net assets and cash flow. Then, using the following relationships, return on net assets and IRR were calculated:

- $\frac{\text{Net Profits}}{\text{Sales}} \times \frac{\text{Sales}}{\text{Net Assets}} = \frac{\text{Net Profits}}{\text{Net Assets}}$

Table A-1

ESTIMATED FINANCIAL DATA

for

SMALL LEAD-ACID BATTERY MANUFACTURING PLANTS[1]

BEFORE NSPS LEAD AND SULFURIC ACID MIST CONTROLS

	Model Plant Size	
	100 BPD	250 BPD
Revenue[2]	$540,000	$1,350,000
Operating Expenses	$470,400	$1,168,500
Earnings Before Taxes	$ 69,600	$ 181,500
Earnings Rate Before Taxes	12.9%	13.4%
Taxes[3]	$ 20,400	$ 74,100
Earnings After Taxes	$ 49,200	$ 107,400
Earnings Rate After Taxes	9.1%	8.0%

[1]For Wet and Wet/Dry Formation.

[2]Based on operating rate of 80% and battery price of $27.00 per battery.

[3]Calculated at 22% of first $50,000 and 48% on remainder of earnings before taxes rather than at official rate of 20% of first $25,000, 22% of next $25,000 and 48% of remainder over $50,000.

Source: Lead-Acid Battery Manufacture-Background Information for Proposed Standards (DRAFT EIS). EPA-450/3-79-028e, Office of Air Quality Planning and Standards, November, 1979.

TABLE A-2

BASELINE ECONOMICS

CAPITAL INVESTMENT FOR EXISTING LEAD-ACID BATTERY PLANTS

WET AND DRY FORMATION

(In Thousand of Dollars)

	Manufacturing	
	100 BPD	250 BPD
Fixed Investment		
Casting	$ 15.0	$ 24.5
Pasting	6.7	10.0
3-P Process	10.0	11.6
Formation	12.5	17.5
Land	15.0	20.0
Building	68.6	101.8
Other Fixed Investment		
OSHA	23.3	26.0
SIP - particulates	35.0	35.0
Total Fixed Investment	$186.1	246.4
Accumulated Depreciation[1]	54.1	77.1
Fixed Investment After Depreciation	132.0	169.3
Current Assets[2]	132.0	169.3
Total Assets Before Control	$264.0	$338.6

[1]Building at .25 ; process equipment at .66; OSHA, SIP at .133.

[2]At 100% of fixed investment after depreciation.

TABLE A-3

ESTIMATED PROFITABILITY MEASURES FOR LEAD ACID BATTERY PLANTS

	Small	Very Small
ROI		
Low	.40	.12
Medium	.54	.18
High	.67	.24
IRR		
Low	.15	.17
Medium	.23	.22
High	.31	.32

Source: EPA, Office of Air Quality Planning and Standards, Lead Acid Battery Manufacture - Background Information for Proposed Standards (Draft), EPA 450/3-79-028a, November, 1979., Corporate Annual Reports, JRB Site Visits, and Census of Manufactures 1977.

$$\bullet \quad \frac{\text{Net Profit + Depreciation}}{\substack{\text{Assets} \\ \text{(Salvage Value)}}} = \sum_{T=1}^{n} (1 + r)^{-T}$$

The value of r was then looked up on a present value table. The result is a range of likely values for ROI and IRR appearing in Table A-4. The Table is divided into two broad sections to allow consideration of the sales to asset ratio the uncertainty of which is greater than that of most other variables. The first two columns are multiplied to get the third. The IRR value is determined from the above expression. Depreciation is estimated from industry and corporate averages and net assets are assumed to equal the salvage value of assets.

Some of the values in the table are quite low in comparison to the cost of capital of 10-11 percent. This results from the emphasis of the study team on arriving at extremely conservative results. However, the estimates corresponding to the lower return on sales figure were rejected, because they are in conflict with behavior in the industry, that is, these IRRs are so low that all firms would leave the industry, without compliance costs. Consequently, the analysis will focus on those conditions in which return on sales is at least 7 percent and in which sales to asset ratios are at least 3.

TABLE A-4

ESTIMATED PROFITABILITY MEASURES FOR NON-LEAD-ACID BATTERY PLANTS

Sales/Asset Ratio	Net Profit/Sales	Net Profit/Assets	IRR
(3.33)			
	.05	.13	<.10
	.07	.17	.13
	.10	.24	.21
	.12	.30	.25
(2.0)	.06	.12	.17
(1.71)			
	.05	.07	<.10
	.07	.09	<.10
	.10	.13	<.10
	.12	.16	<.10

Source: Census of Manufactures, Quarterly Financial Report For Manufacturing, Mining and Trade Corporation (FTC), Corporate Annual Reports.

EXHIBIT A

PRESENT VALUE OF AN EVEN CASH FLOW

This exhibit explains that if net cash flow is the same for each period, and the initial outlay occurs at time 0, the internal rate of return (r) may be calculated by dividing the initial outlay by the cash flow to obtain a factor which can be used in conjunction with a present value table to find r. In the relationships that follow:

A_0 = initial investment

$A_1 = A_2 = A_3 = \ldots \quad A_n$ = annual cash flow,

r = internal rate of return

n = number of years cash flows are expected

Calculation of r requires solving the following equation for r:

$$\sum_{T=0}^{n} A_T (1 + r)^{-t} = 0$$

$$\sum_{T=1}^{n} A_T (1 + r)^{-t} - A_0 = 0$$

$$A \sum_{T=1}^{n} (1 + r)^{-t} = A_0$$

$$\sum_{T=1}^{n} (1 + r)^{-t} = A_0/A$$

r can thus be calculated by simply looking up the discount rate corresponding to $\sum_{T=1}^{n} (1 + r)^{-t}$ on a present value table.