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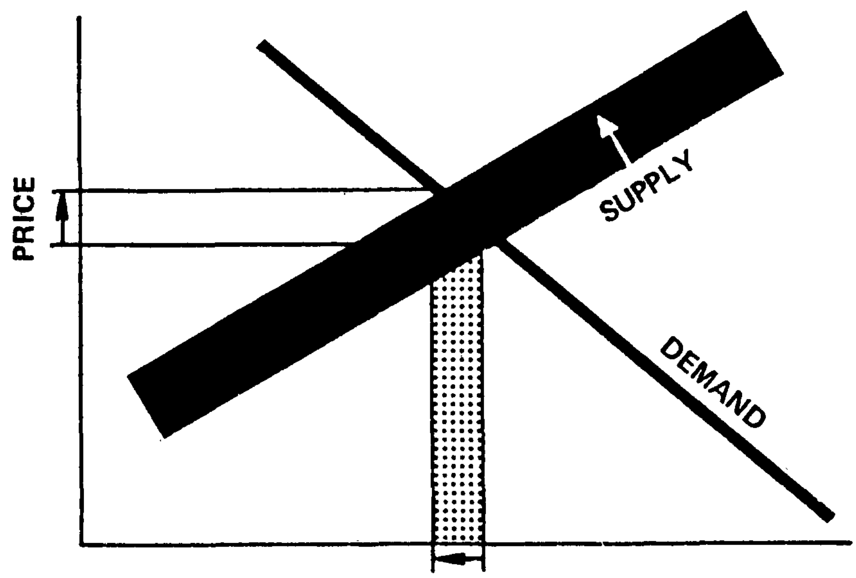
Economic Impact Analysis of Effluent Limitations and Standards for the Battery Manufacturing Industry



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

Submitted to:

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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), BAT (best available technology economically achievable), PSES (pretreatment standards existing sources), NSPS (new source performance standards), and PSNS (pretreatment standards new sources), that have been promulgated 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 no longer in production, are of little commercial significance, or are experimental (e.g., nickel-zinc and fuel cells).

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. 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 regulations. Supplementary 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 are 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 three 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 regulations. These include the determinants of demand (e.g., demand elasticities), market structure, the degree of intraindustry competition, and financial performance. These basic characteristics are described in Chapters 3, 4, and 5 of the report.

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

BATTERY PRODUCT GROUPS	TECHNICAL SUBCATEGORY
Mercury-Cadmium Nickel-Cadmium Silver Oxide-Cadmium	Cadmium Anode
Calcium	Calcium[1]
Lead Acid	Lead
Carbon Zinc and Related Types	Leclanche
Lithium	Lithium Anode[2]
Magnesium Carbon Magnesium Reserve Thermal	Magnesium Anode[2]
Alkaline Manganese Carbon Zinc-Air Mercury-Ruben Mercury Cadmium-Zinc Nickel-Zinc Silver Oxide-Zinc	Zinc Anode, Alkaline Electrolyte

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

[2]Does not include thermal.

Step 2: Industry Supply and Demand Analysis

The second step in the analysis is a determination of likely changes in market prices and industry production levels for each battery product group and for each regulatory option. The price/output model assumes that to the extent industry structure and market strength will allow, firms will adjust price and output levels to maintain precompliance return on investment. Some firms will be able to pass all of their compliance costs on to their customers in the form of higher prices, while other firms will have to absorb all or part of their compliance costs in the form of reduced profit margins. The estimates of post-compliance price and output levels are used in the plant level analyses (Steps 4, 5, 6, and 7) to determine postcompliance revenue and profit levels for specific plants in each product group.

Step 3: Analysis of Cost of Compliance

Investment and annual compliance costs for 233 production facilities (includes 64 zero dischargers) were estimated in a separate study 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 "Level 0," "Level 1," "Level 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 a basic profit/operational parameter to separate those plants with obviously small impacts from those with potentially significant impacts. The primary variable is the degree of gross profit margin reduction (change in return on sales). In general, if return on sales (ROS) falls by less than 1 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 Profitability Analysis

Two basic measures of profitability are used so that one may serve as a check on the other--return on investment (ROI) and internal rate of return (IRR). Plants with after-compliance ROI below a threshold value of 6 percent and/or with after-compliance IRR below 13 percent are considered likely plant closures. The baseline ROI is 12 percent and the baseline IRR is 23 percent. The use of these approaches is 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 industrywide parameters obtained from various published sources and companywide data from corporate annual reports, representative values are developed for each of the key parameters (e.g., return on investment) and applied to the specific plants.

Step 6: Plant-Level Capital Requirements Analysis

In addition to analyzing the potential for plant closures from a profitability perspective, it is also necessary to assess the ability of firms to make the initial capital investment needed to construct and install the required treatment systems. Capital requirements of the regulation are evaluated in terms of the amount of the initial compliance capital investment in relation to normal annual plant and equipment expenditures and in relation to plant fixed assets. Although these ratios indicate the magnitude of the investment burden, no single critical value is used for these measures.

Step 7: Assessment of Plant Closure Potential

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

Step 8: Assessment of Other Impacts

"Other impacts" which result from the basic plant closure, price, and quantity changes include impacts on employment, industry structure, the special case of small entities, and imports and exports. These impacts are assessed through the use of industrywide and firmwide ratios calculated from public data sources (e.g., value of shipments per employee) and other supplementary analyses that are described where the results are reported in the appropriate sections of the report.

Step 9: Small Business Analysis

The Regulatory Flexibility Act 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, BAT, 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 sources (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 a comparison of the foregoing cost estimates and by analogy of 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 intraindustry shifts in competitiveness.

Limitations

In performing these analyses a number of assumptions, empirical estimates, and judgments 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 judgments 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 regulatory options.

OVERVIEW OF INDUSTRY CHARACTERISTICS

The 1977 domestic production of both primary and secondary batteries amounted to $2.6 billion.[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 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 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.

[1] 1977 Census of Manufactures; the figure for 1980 is $3.5 billion.

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.

The EPA data base used in the economic impact analysis identified 170 firms and 240 battery "production facilities." A production facility, in this context, is defined differently than that of "establishment" used by the Census of Manufacturers. A production facility is a specific battery product line as defined by cathodeanode pair. The primary data base upon which the plant-by-plant impact analysis is based is the 240 production facilities identified by EPA (referred to as "plants" in this report).

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 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, and the impacts on small entities.

Compliance Cost

Table S-2 shows the estimated investment and total annual compliance cost in 1983 dollars by technical subcategory for the selected regulatory alternatives

TABLE S-2. BATTERY INDUSTRY COMPLIANCE COSTS FOR EXISTING SOURCES AT SELECTED OPTIONS (1983 Dollars)

SUBCATEGORY	SELECTED LEVEL	CAPITAL COST	ANNUAL COST
Cadmium			
Direct	Level 1	179,233	54,861
Indirect	Level 1	464,703	159,410
Subtotal		643,936	214,271
Calcium			
Direct	None	0	0
Indirect	None	0	0
Subtotal		0	0
Lead			
Direct	Level 1	818,501	509,777
Indirect	Level 1	7,113,711	4,068,506
Subtotal		7,932,212	4,578,283
Leclanche			
Direct	None	0	0
Indirect	Level 0	62,554	31,540
Subtotal		62,554	31,540
Lithium			
Direct	None	0	0
Indirect	None	0	0
Subtotal		0	0
Magnesium			
Direct	None	0	0
Indirect	a	54,562	29,545
Subtotal		54,562	29,545
Zinc			
Direct	Level 1	131,419	34,920
Indirect	Level 1	506,127	146,288
Subtotal		637,546	181,208
Total			
Direct		1,129,153	599,558
Indirect		8,201,657	4,435,289
Subtotal		9,330,810	5,034,847

[a]The selected option is a combination of Level 2 and Level 0.

SOURCE: Table S-3.

Descriptions of the technical characteristics of these options appear in Chapter 6 of this report and in the Development Document. The regulations would add $5.0 million to the annual costs of battery manufacturing. This represents 0.22 percent of the value of shipments of plants incurring costs. Associated investment costs would be $9.3 million, representing 1.6 percent of fixed assets of plants incurring costs. Table S-3 shows the compliance costs for the other regulatory options that were considered but not selected.

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 (less than 1 percent) and the demand for battery products is not very sensitive to changes in relative prices.

In general, the market factors for these products are strong, so that the bulk of the impacts will result from the intraindustry distribution of compliance costs and the subsequent change in the competitiveness among the various plants. All plants are estimated to have a low potential for closure at the selected option, since their profitability measures are adequate and their capital investment requirements relative to fixed assets and annual capital expenditures are not prohibitive. Estimated regulation-induced changes in prices, output, and profit margin are all less than 1 percent and there are no employment, industry structure, or foreign trade impacts due to the regulation. Under the Level-4 scenario which is not being promulgated, two nickel-cadmium plants and four lead-acid plants are estimated to be likely closures. Although the nickel-cadmium plants are small, they account for a noticeable market share in certain product lines (i.e., sealed nickel-cadmium batteries), and the loss of their combined capacity would increase concentration and, possibly, alter the pricing behavior of sealed nickel-cadmium batteries. The lead plants are small relative to market size.

TABLE S-3. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS EXISTING SOURCES
(1983 Dollars)

SUBCATEGORY	LEVEL 0 CAPITAL COST $	LEVEL 0 ANNUAL COST $	LEVEL 1 CAPITAL COST $	LEVEL 1 ANNUAL COST $	LEVEL 2 CAPITAL COST $	LEVEL 2 ANNUAL COST $	LEVEL 3 CAPITAL COST $	LEVEL 3 ANNUAL COST $	LEVEL 4 CAPITAL COST $	LEVEL 4 ANNUAL COST $
Cadmium										
Direct Dischargers	88,289	33,675	179,233	54,861	214,229	70,920	NA	NA	911,463	195,119
Indirect Dischargers	481,931	110,413	464,703	159,410	607,718	204,882	NA	NA	2,192,308	716,501
Subcategory Total	570,220	144,088	643,936	214,271	821,947	275,802	NA	NA	3,103,771	911,620
Calcium										
Direct Dischargers	a	a	a	a	a	a	NA	NA	NA	NA
Indirect Dischargers	6,442	4,850	6,442	4,850	6,442	4,850	NA	NA	NA	NA
Subcategory Total	6,442	4,850	6,442	4,850	6,422	4,850	NA	NA	NA	NA
Lead										
Direct Dischargers	762,761	485,756	818,501	509,777	968,117	580,628	890,668	690,947	1,457,984	870,594
Indirect Dischargers	6,914,867	3,962,238	7,113,711	4,068,506	8,382,220	4,718,750	7,711,642	5,615,313	12,623,623	7,075,294
Subcategory Total	7,677,628	4,447,994	7,932,212	4,578,283	9,350,337	5,299,378	8,602,310	6,306,260	14,081,607	7,945,888
Leclanche										
Direct Dischargers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indirect Dischargers	62,554	31,540	62,554	31,540	62,554	31,540	NA	NA	NA	NA
Subcategory Total	62,554	31,540	62,554	31,540	62,554	31,540	NA	NA	NA	NA
Lithium										
Direct Dischargers	00	721	0	721	0	721	NA	NA	NA	NA
Indirect Dischargers	0	8,877	0	8,877	0	8,877	NA	NA	NA	NA
Subcategory Total	0	9,598	0	9,598	0	9,598	NA	NA	NA	NA
Magnesium										
Direct Dischargers	30,526	11,876	0	20,776	0	20,776	NA	NA	NA	NA
Indirect Dischargers	41,277	21,274	54,562	29,545	54,562	29,545	NA	NA	NA	NA
Subcategory Total	71,803	33,150	54,562	50,321	54,562	50,321	NA	NA	NA	NA
Zinc										
Direct Dischargers	73,429	26,600	131,419	34,920	149,148	55,753	149,148	55,753	159,181	80,579
Indirect Dischargers	377,372	128,835	506,127	146,288	592,211	232,590	592,211	232,590	799,185	368,307
Subcategory Total	450,801	155,435	637,546	181,208	741,359	288,343	741,359	288,343	958,366	448,886
TOTAL INDUSTRY										
Direct Dischargers	955,005	558,628	1,129,153	621,055	1,331,494	728,798	1,039,816	746,700	2,528,628	1,146,292
Indirect Dischargers	7,884,443	4,268,027	8,208,099	4,449,016	9,705,707	5,231,034	8,303,853	5,847,903	15,615,116	8,160,102
Industry Total	8,839,448	4,826,655	9,337,252	5,070,071	11,037,181	5,959,832	9,343,669	6,594,603	18,143,744	9,306,394

[a]No direct dischargers reported.
NA - Not applicable.

SOURCE: EPA.

TABLE S-4. BATTERY INDUSTRY SUMMARY OF IMPACTS FOR SELECTED OPTION

IMPACT MEASURE	IMPACT
Investment Compliance Cost (thousands of 1983 $)	9,330.8
Annual Compliance Cost (thousands of 1983 $)	5,034.8
Annual Compliance Cost/Revenues for Plant Incurring Costs (%)[a]	0.22
Price Change (%)	0.21
Production Change (%)	0.06
Plant Closures	0
Other Impacts	0

[a]176 plants incur costs.

SOURCE: Chapter 7.

Table S-5 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 5, 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 S-5 as having a high potential for closure under Level 4.

Impacts on Small Entities

The 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 is greater than that for larger ones. However, these costs will cause no plant closures at the selected options and six plant closures at Level 4. The effect of the OSHA Lead Standards on these conclusions are assessed in Appendix B of this report. Specifically, it is concluded that the OSHA standards will not alter the conclusion that the impacts of the effluent guidelines are mild.

All 6 projected plants expected to close as a result of the Level 4 technology are small. Two of the 6 (the nickel-cadmium plants) belong to large corporations. The other 4 are small independent lead-acid plants. A regulatory flexibility analysis appears in Chapter 8 and provides a description of the impacts on small entities.

Industry Structure Effects

Since there will be no plant closures at the selected option, there will be no immediate readily observed industry structure effects. However, the

TABLE S-5. SUMMARY OF POTENTIAL PLANT CLOSURES BEFORE CONSIDERATION OF BASELINE CLOSURES

BATTERY PRODUCT GROUP	NUMBER OF PRODUCTION FACILITIES	REGULATORY OPTION[a]	NUMBER OF PROBABLE CLOSURES
Lead-Acid	167	Levels 0-3	0
		Level 4	4
Nickel-Cadmium	9	Level 4	2
Other	64	All Levels	0
Total	240	Level 4	6

[a]There are no closures estimated for levels 0 through 3.

SOURCE: Table 7-7.

compliance cost per unit is larger for smaller plants than for larger plants. Moreover, there is a trend in the industry toward increasing industry concentration and closing of small plants. The combined effects of these developments will be a deterioration in the competitive position of small plants relative to large plants. The deterioration of the relative competitiveness of small plants is especially noteworthy in the lead-acid product group. The increase in industry concentration is not likely to affect the price-determining behavior of the industry, since the market position of the 8 largest lead-acid battery firms relative to each other will not change significantly.

General Impacts

As summarized in Table S-4, the estimated impacts of the selected options on prices, production levels, and foreign trade are small. The projected 6 plant closures under Level 4 involve between 250 and 400 jobs. However, these numbers 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 approximately 3 to 5 percent annually, quantity reductions of fractions of a percent will not be noticeable.

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. New source investment costs are estimated to average 0.14 percent of plant assets and new source annual costs are estimated to be 0.04 percent of revenues of new sources. The new source selected option cost will total \$0.7 million in annual costs and \$1.2 million in investment costs to 1990. 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

1.1 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), BAT (best available technology economically achievable), NSPS (new source performance standards), and PSES and PSNS (pretreatment standards for existing sources and new sources) that are being promulgated 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 addressed in the analysis are 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 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
cathode-anode 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--according to the basic anode material used; whether the batteries are of the primary or secondary types; and according to the cathode-anode 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
Mercury-Cadmium Nickel-Cadmium Silver Oxide-Cadmium	Cadmium Anode
Calcium	Calcium[1]
Lead-Acid	Lead
Carbon-Zinc and Related Types	Leclanche
Lithium	Lithium Anode[2]
Magnesium-Carbon Magnesium Reserve Thermal	Magnesium Anode[2]
Alkaline Manganese Carbon Zinc-Air Mercury-Ruben Mercury Cadmium-Zinc Nickel-Zinc Silver Oxide-Zinc	Zinc Anode, Alkaline Electrolyte

[1]Includes magnesium, lithium, calcium anode, and other thermal batteries.
[2]Does not include thermal.

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 its cathode-anode pair is the primary segmentation scheme used in the economic study. Table 1-1 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 starting, lighting, and ignition (SLI) 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, they may also be classified as 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 are 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 eight 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 offers some of the future critical parameters for a better 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 Development Document for Effluent Limitations Guidelines and Standards for the Battery Manufacturing Point Source Category, prepared by EPA's Effluent Guidelines Division in February 1984. 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

2.1 OVERVIEW

An overview of the analytical approach used to assess the economic impacts likely to occur as a result of the costs of each regulatory option is illustrated in Figure 2-1. For three industry segments five alternative regulatory options are considered in the economic study; each option represents increasing levels of compliance costs and, generally, pollution abatement. For the other four industry segments, three regulatory options are considered. The basic approach used in this study is to (1) develop a model of the price and output behavior of the battery manufacturing industry and (2) assess the likely plant-specific responses resulting from the compliance costs estimated for each regulatory option described in Chapter 6. This model explicitly considers, for each regulatory option, the changes in output caused by reductions in quantity demanded due to higher prices as well as changes in supply due to plant closings.

The model of price and output behavior of the industry is used, in conjunction with compliance cost estimates supplied by EPA, to determine post-compliance industry price and production levels for each major battery product group and for each regulatory option. Individual plant data are 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 change significantly more than their estimated revenue will change are subjected to a financial analysis that uses capital budgeting techniques to determine likely plant closures. The industry model is then reviewed for each regulatory option to incorporate the reduced supply into the analysis. Finally, other effects that flow from the basic price, production, and industry structure changes are determined. These

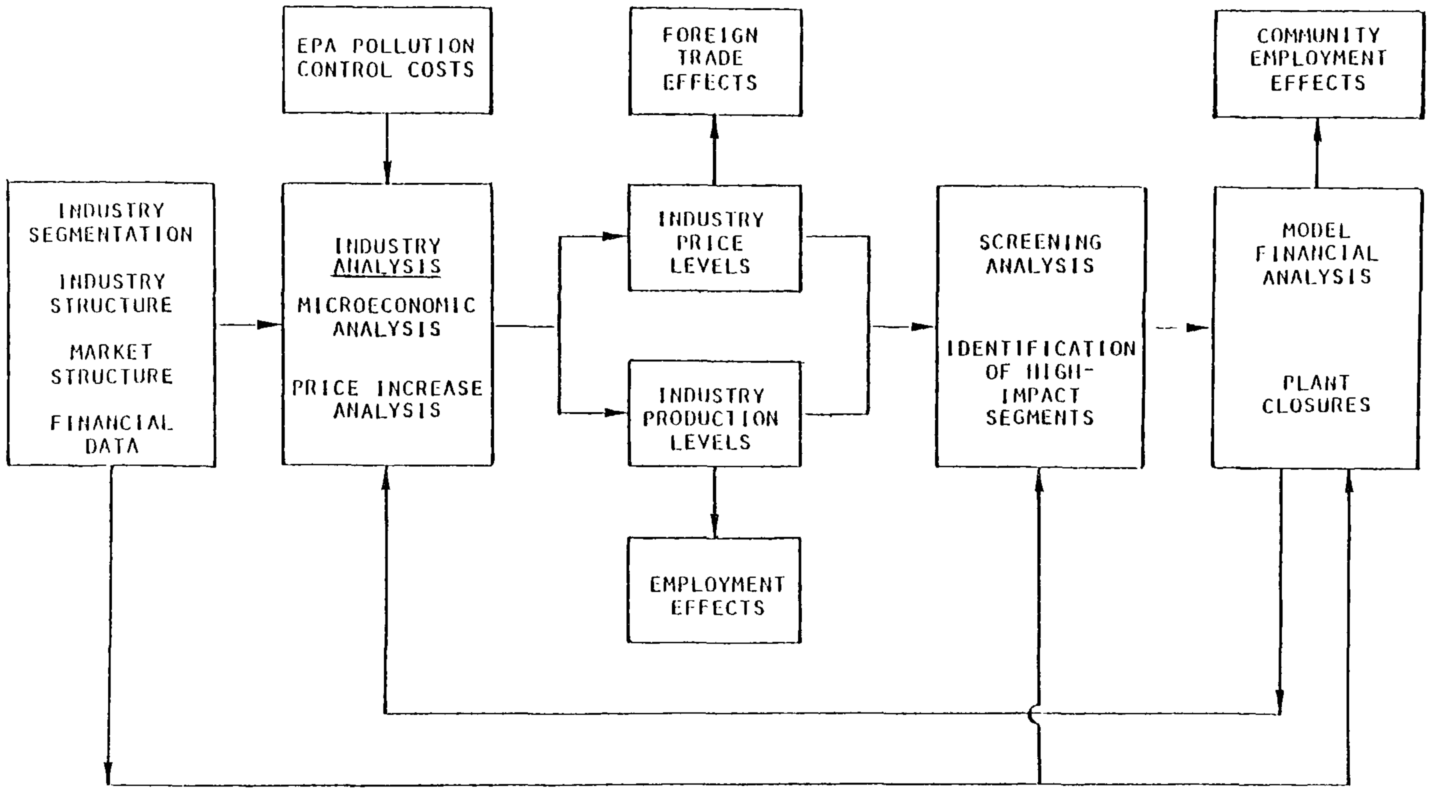

FIGURE 2-1. ECONOMIC ANALYSIS STUDY OVERVIEW

include employment, community, and foreign trade impacts. Specifically, the study proceeded in the following ten steps:

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. Small business analysis
10. Assessment of new source impacts.

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

2.2 STEP 1: DESCRIPTION OF INDUSTRY CHARACTERISTICS

The first step in the analysis is to develop a description of the basic industry characteristics that would enable estimation of the impacts of the regulation. These characteristics, which include the determinants of demand (e.g., demand elasticities), market structure, the degree of intraindustry 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 were:

- 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 not to 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 are 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 is a need for analytical methods that would account for these interplant and interfirm 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 postcompliance price and output levels are used in the plant-level analysis to determine postcompliance 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 intraindustry competition, the firms may attempt to maintain their financial status by closing higher cost and/or less efficient plants. A separate supply-demand analysis is developed for each of the 16 product groups and the results for each product group is reported in Chapter 7. These analyses were conducted according to the assumptions and analytical techniques described in the following subsections.

2.3.1 Basic Assumptions

Short-run price behavior can be inferred from the interaction of the supply and demand curves. However, lacking the necessary data to estimate supply curves for the various battery product groups, pricing behavior was inferred from the price elasticities developed in Chapter 4 and market structure information described in Chapter 3. In addition, the following basic assumptions were employed:

- Each battery product is a homogeneous good with a separate market mechanism of its own. (The substitution possibilities between battery types are 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.

The equilibrium assumption reflects the intent of the analysis to represent pricing behavior in a "normal" period. That is, a period during which quantities supplied and demanded are in relative balance. If the analysis was conducted under an assumption of excess demand as in a strong cyclical expansion, or under an assumption of excess supply, the baseline financial performance and price changes might be misstated for normal periods.

The third assumption is reflected in the following algorithm:

(1)
$$P_1 = P_0 + \frac{CC}{Q_0} + ROI\ (Icc)$$

$$Q_1 = Q_0 + \left(\frac{P_1 - P_0}{P_0}\right) \varepsilon\, Q_0$$

(2)
$$P_2 = \frac{P_1 Q_1 + (Q_0 - Q_1)(P_1)(AFC)}{Q_1}$$

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

where

P_0 = initial precompliance price (from Chapter 4)

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

CC = total annualized compliance cost (from EPA cost estimation)

Q_0 = initial precompliance quantity (from 308 Survey)

ROI = return on net assets (from Appendix A)

Icc = investment compliance costs per unit of output (from EPA cost estimation)

ε = demand elasticity (from Chapter 4)

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

AFC = average fixed costs = ratio of fixed cost to revenues (from industry sources).

Equations (1) and (2) are iterated to solve for successive price/quantity adjustments until it converges. This algorithm solves for the price and quantity that will approach the precompliance return on net assets. The application of the algorithm differs from one battery product group to another, to reflect differing market structures among the product groups. The following paragraphs describe the market structure conditions used.

2.3.2 Market Structure Conditions

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. For the perfectly competitive market the compliance costs used in the algorithm above is the mean for all plants in the product group. Product groups treated in this manner include vented nickel-cadmium, silver-cadmium, calcium, Leclanche, magnesium reserve, mercury-Ruben, nickel-zinc, mercury cadmium-zinc, and silver oxide-zinc.

The second market structure involves market in which each seller has 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 precompliance 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 or assets. 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 (i.e., an individual firm faces a perfectly elastic demand curve). 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. The product groups falling into this category include lithium, magnesium thermal, and alkaline manganese.

Because of the high concentration ratios for some of the product groups, oligopolistic pricing behavior might be expected. For this market structure, the algorithm above is applied to one or the average of a few firms 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 that exhibit characteristics of oligopoly markets, such as:

- 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 that 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 that 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 previously mentioned points are indicators of difficulty of entry. Product groups treated as if there were price leadership by a few producers include lead-acid, and sealed nickel-cadmium. Product groups containing only one firm were also considered in this group.

2.3.3 Projections of Industry Conditions

It is necessary to determine if the key industry structure parameters would change significantly by the mid-1980s. 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 is also made of the factors which might affect the real cost of manufacturing batteries (i.e., relative to the cost of other manufactured goods). No reason is found to expect the real price of battery products to increase between now and 1985.

It is 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 are used to develop the pricing algorithms.

2.3.4 Data Sources and Limitations

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, is available to the study team. In place of this data, industrywide averages are used. For example, 12 percent return on assets is used for the lead battery subcategory. These averages are 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. Appendix A details the estimating procedure used. Compliance cost data, on the other hand, are available for specific plants and an examination of them shows wide variation in unit compliance cost from one plant to another within each subcategory. For this reason, the economic impact analysis is conducted under the assumption of equal profit margins among plants, but with varying compliance costs.

The postcompliance 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 240 production facilities are estimated by EPA's Effluent Guidelines Division. Various sets of costs, corresponding to increasing levels of pollution control are considered. For purposes of this report the regulatory options are labeled "Level 1," "Level 2," etc., in order of increasing levels of pollution control. A description of the control and treatment technologies and the rationale behind these compliance cost estimates appear in Chapter 6 and in Sections V, IX, X, XI, and XII of the Development Document.

2.5 STEP 4: PLANT-LEVEL SCREENING ANALYSIS

The screening analysis uses a basic operational/profit ratio to separate those plants with obviously small impacts from those with potentially significant impacts. The criterion is the degree of gross profit margin (return on sales) reductions.

In general, if a plant's ROS is estimated to fall by less than 1 percent, that plant is not considered to be a candidate for closure. Although some of these plants will probably experience some drop in their profitabilities, these changes would be small. Estimates of profitability changes for these plants are recorded, but they are not subject to a detailed financial analysis. Plants that have changes in ROS estimated to be greater than 1 percent are 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 are 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 involves a comparison of the measures with critical values which are described below.

2.6.1 Return on Investment (ROI) Analysis

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. Because of a lack of data on individual plant profits and lack of evidence on the difference in profit rates among product groups, a common baseline return on assets is assumed for all plants. This common return on assets value was developed using aggregate industry and model plant data. The procedure used to estimate baseline profit rates is described in Appendix A.

The ROI impact is assessed by calculating the after-compliance ROI for each plant and comparing it to average values experienced by major manufacturing industries. Plants with after-compliance ROIs below those experienced by the industry averages are considered potential plant closures. The underlying assumption is that plants cannot continue to operate as viable concerns if they are unable to generate a minimum return on investment at least equal to that of other manufacturing activities. The precompliance ROI used is the same for all plants in the industry and the postcompliance ROIs differ from one plant to another because they reflect variations in plant-specific compliance costs.

The threshold value for ROI is set at a range of 6 to 8 percent. A range is used because it is difficult to explicitly specify a single value below which all plants will close. This difficulty arises from the observation that the threshold value for a given firm will depend upon a number of factors that vary significantly within and between industries. The most important of these factors include capital structure (debt/total assets), tax rates, and salvage value. The range of 6 to 8 percent is based upon a review of ROIs for the 33 major industry groups for which aggregate financial data are published by the Federal Trade Commission (FTC). During the time period for which most of the plant data base was developed (1977-1978), the range of ROIs for these 33 major manufacturing industries was 6 to 18 percent. It is assumed that, all other things being equal, if other industries remained in operation within this range, then a battery manufacturing firm operating within this range could not significantly increase its profitability by liquidating its assets and investing in another manufacturing business. That is, its opportunity cost is zero or negative. If a battery manufacturing operation's ROI falls below this range, there would be a positive opportunity cost of staying in the battery industry and, consequently, there would be a plant closure. Thus, if ROI for a plant falls into the 6 to 8 percent range or below, it is considered a potential plant closure. The baseline ROI for the industry is estimated to be 12 percent. This estimate is based on an evaluation of data in corporate annual reports, previous government reports, Federal Trade Commission and Census of Manufactures data, and communications with industry personnel. These sources are described in Appendix A.

The after-compliance ROI (ROI_{2i}) is estimated for each plant using the following algorithm:

$$ROI_{2i} = \frac{PROFIT_{1i} + DPROFIT_i}{A_i + CCI_i}$$

where

$PROFIT_{1i}$ = Precompliance profit of plant i
$DPROFIT_i$ = Change in profit of plant i
A_i = Precompliance assets value of plant i
CCI_i = Compliance capital investment for plant i

These variables are further defined in Appendix A.

2.6.2 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 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 (NPV) method. Both techniques will provide the same plant closure decisions in this application. This analysis uses the IRR technique. The following paragraphs describe the application of this approach.

The IRR for an investment is the discount rate that equates the present value of the expected stream of annual cash flows (A_T) with the initial investment (A_0). It is represented by that rate r, such that

$$\sum_{T=1}^{n} A_T (1 + r)^{-T} = A_0 \tag{3}$$

where A_0 is the initial investment, A_T is the annual 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 annual cash flow A_T is a constant series (A), then Equation 3 can be transformed to:

$$A_0/A = \sum_{T=1}^{n} (1 + r)^{-T}. \tag{4}$$

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.

2.6.3 Data Sources and Assumptions

Most of the data used in this analysis were estimated from a combination of publicly available information and the technical 308 Survey. The details of these estimation techniques and data sources are provided in Appendix A. The following are the most important variables:

- Precompliance plant revenues = P_1Q_1, where P_1 is average sales price reported by industry sources (described in Chapter 4) and Q_1 (production in pounds) is reported in the 308 Survey.

- Postcompliance revenues = P_2Q_2, where P_2 is defined in the microeconomic supply-demand analysis (Step 2 above) 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. Since proposal of this regulation in November 1982, only the lead anode subcategory has been recosted and reanalyzed thoroughly. In all other subcategories, with the exception of one Leclanche plant, no changes have been made.

- Baseline profits are estimated from industry sources and average factors from company annual reports. Baseline profit margin = 6 percent, return on assets = 12 percent, and IRR = 23 percent as explained in Appendix A.

- Depreciation charges are assumed to be a straight line over 10 years.

- Assets are determined as a percentage of revenues. Averages for the appropriate 4-digit SIC codes (1977 Census of Manufactures) and the FTC's Quarterly Financial Reports are used.

- Initial cash outlay, A_0, is defined as the liquidation value of plant assets. The liquidation value of plant assets are assumed to equal 100 percent of current assets + 30 percent of fixed assets (assumption based on industry sources).

- Income tax rates are assumed to be 30 percent, however, a sensitivity analysis using a 40 percent rate indicated no additional plant closures.

- The critical value of IRR is assumed to be 13 percent. The rationale for this value is presented in Appendix A.

- Annual cash flows, A_t (baseline and after compliance) are constant and defined as

$$A_t = \text{After Tax Profit} + DEP_t$$

where:

- PROFIT = 6 percent

- DEP = Annual depreciation charges assumed to be 2.5 percent of revenues.

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 important 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:

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

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

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 precompliance average annual capital expenditures of the plant. The latter ratio reflects, to some extent, the practice of viewing the level of normal precompliance 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 normal 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 that is already highly leveraged (as indicated by a high debt/equity ratio) and a firm that 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 in the profit analysis above, from industrywide 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 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 but are of lesser importance in the final plant closure estimates.

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 and is presented in Chapter 7. This matrix provides a format that facilitates the evaluation of the combined effects of the key variables.

2.9 STEP 8: ASSESSMENT OF OTHER IMPACTS

"Other impacts" include economic impacts that 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:

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

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 countywide 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 are 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: 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 that 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 criteria for defining "small" battery manufacturing plants were selected for examination and the impacts on small plants under each criteria 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.

Finally, the Small Business Administration provided EPA with data regarding the financial condition of battery manufacturing firms. The data are grouped by size of firm. Analysis of this data has been performed and is discussed in Chapter 8.

2.11 STEP 10: 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.

2.12 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, they are not discussed in detail 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 (e.g., return on investment, profit margin, asset turnover ratios), 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. The major assumptions made in estimating and extrapolating these data are discussed in Chapter 9.

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 multiplant 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 consists of 175 firms which operated 276 manufacturing establishments. The EPA Technical Survey (completed in 1979) identifies 240 production facilities and

132 firms that account for most of industry production. Firms that 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 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 independents and using them as component suppliers and/or distributors of finished batteries.

As shown in Table 3-1, production of primary batteries is highly concentrated with 4-firm and 8-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. 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 are further explained in Chapter 5 (Baseline Projections of Industry Conditions).

TABLE 3-1. 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 producers of storage and primary batteries appear to dominate the field.

Storage Batteries

- ESB, Inc. (subsidiary of Inco, Ltd.)
- Globe-Union, Inc.
- Delco-Remy (division of General Motors Corporation)
- Eltra, Inc. (subsidiary of Allied Corporation)
- 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. that has recently been divested)
- 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 primarily 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, a medium-sized firm, 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 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 have been obtained on the 13 battery companies whose financial statements are publicly available. Of the 13 firms, 3 are primarily engaged in battery manufacturing, while the other 10 are more diversified. The nature of the business lines of most of these firms are discussed in Section 3.2. Table 3-2 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 13 companies had better ROEs than the U.S. all-manufacturing average. Among the less profitable companies are the 2 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.

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 assemblers of

TABLE 3-2. FINANCIAL CHARACTERISTICS OF SELECTED BATTERY MANUFACTURERS

	1977 Company Sales ($ Millions)		1977 Long-Term Debt/Equity	Before-Tax 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 of Allied Corp.	922.1	N/A	25.9	21.6	22.7*	21.6*	23.2	23.7*
FDI, Inc.**	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.

†Not available.

**Has closed battery manufacturing operations or merged into another firm.

SOURCES: Company annual reports and Quarterly Financial Report on Manufacturing, Mining and Trade, FTC.

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

Other industry sources report that the profitability of small firms are not significantly different from that of larger firms. To examine this question, data on financial ratios of a number of firms grouped by firm size were obtained from SBA's FINSTAT data base. The small firms in this data base show better financial performance than those firms shown in Table 3-2. It was concluded that although the representativeness of this data base could not be precisely determined, the data do not support the hypothesis that small battery manufacturing firms have generally lower profit rates than larger battery manufacturing firms. The analysis of the FINSTAT data base is further described in the Small Business Analysis.

3.4 PLANT CHARACTERISTICS

The EPA has identified 179 active production facilities that manufacture storage batteries and 61 plants that manufacture primary batteries.[1] Table 3-3 lists the number of firms and production facilities identified by EPA by type of battery. Table 3-4 presents the 1977 distribution of the battery establishments identified by the Department of Commerce and their value of shipments by employment size. Table 3-5 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 3-4, the storage battery industry segment consists of many small plants existing alongside a number of large ones. However, these

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[1]According to the Census of Manufactures, there were 218 storage battery establishments and 58 primary battery establishments in operation in 1977. The census definition of "establishment" and the EPA definition of a "facility" are inconsistent. Therefore, the numbers do not match precisely.

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

BATTERY TYPE	# OF FIRMS	NUMBER OF PLANTS			
		ZERO DISCHARGE	DIRECT DISCHARGE	INDIRECT DISCHARGE	TOTAL
Primarily Storage					
Lead-Acid	114	56	8	103	167
Nickel-Cadmium	9	2	3	4	9
Silver Oxide-Cadmium	1	-	1	-	1
Nickel-Zinc	1	-	1	-	1
Mercury-Cadmium	1	1	-	-	1
Subtotal	126	59	13	107	179
Primarily Primary					
Leclanche	9	-	12	7	19
Carbon Zinc-Air	2	2	-	-	2
Alkaline Manganese	5	-	1	7	8
Mercury-Ruben (Zinc)	3	-	-	4	4
Mercury Cadmium-Zinc	1	-	-	1	1
Silver Oxide-Zinc	6	-	2	7	9
Magnesium-Carbon	3	3	-	-	3
Magnesium Reserve	4	2	1	1	4
Lithium	7	2	1	4	7
Thermal (Magnesium)	1	-	-	1	1
Calcium	3	1	-	2	3
Subtotal	44	10	17	34	61
Total	170	69	30	141	240

[1]Note: Because of the existence of multiproduct plants and firms, the actual number of establishments and firms is lower than the number of production facilities in the table.

SOURCE: EPA Technical Survey.

TABLE 3-4. DISTRIBUTION OF BATTERY MANUFACTURING ESTABLISHMENTS BY EMPLOYMENT SIZE, L977

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	100	1,982.5	100
SIC 3691 - 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	666.2	100
Total of SICs 3691 and 3692	276		2,648.7	

NOTES: 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 anlaysis (in Chapter 7) refer to production "facilities." Production facilities are individual product lines as defined by cathode-anode pair. Percentages may not total 100 due to rounding

SOURCE: 1977 Census of Manufactures.

TABLE 3-5. GEOGRAPHIC DISTRIBUTION OF BATTERY PLANTS

DIVISION	ALL ESTABLISHMENTS TOTAL	%	≥ 20 EMPLOYEES	≤ 20 EMPLOYEES	VALUE OF SHIPMENTS* ($ 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	7	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	33	5	14	**	
United States Total	58	100	33	25	666.1	100

*Columns do not add to totals to avoid confidential disclosures.

**Not disclosed to avoid individual company disclosures.

NOTE: Percentages may not total 100 due to rounding.

SOURCE: 1977 Census of Manufactures.

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.

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 9 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 3-4). 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 3-6. 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 3-4, and the number of firms producing each battery type is shown in Table 3-3.

TABLE 3-6. COMPARISON OF SINGLE- AND MULTIPRODUCT NON-LEAD-ACID BATTERY PLANTS

PRODUCT GROUP	TECHNICAL SUBCATEGORY	TOTAL NUMBER OF PRODUCT LINES IN SUBCATEGORY	NUMBER OF SINGLE PRODUCT PLANTS	NUMBER OF MULTIPRODUCT PLANTS	ONE OTHER BATTERY PRODUCT	TWO OTHER BATTERY PRODUCTS	THREE OTHER BATTERY PRODUCTS
Alkaline Manganese	Zinc	8	4	4	1	2	1
Carbon-Zinc	Leclanche	19	13	6	3	2	1
Silver Oxide-Zinc	Zinc	9	2	7	3	2	2
Mercury-Ruben	Zinc	4	0	4	0	2	2
Mercury Cadmium-Zinc	Cadmium	1	0	1	0	0	1
Carbon Zinc-Air	Zinc	2	1	1	0	1	0
Calcium	Calcium	3	0	3	3	0	0
Magnesium Reserve	Magnesium	4	3	1	1	0	0
Magnesium-Carbon	Magnesium	3	2	1	0	1	0
Lithium	Lithium	7	6	1	1	0	0
Nickel-Cadmium	Cadmium	9	4	5	2	3	0
Other		4	4	0	0	0	0
Total		73	39	34	14	13	7

SOURCE: EPA Technical Survey.

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 regulations.

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 appliances.

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	58
	409	69	758	72	1,372	73
Industrial						
Standby 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	31	110	32	183	30
Electronic equipment	77	23	82	24	152	25
Toys and games	45	13	59	17	104	17
	228	67	251	73	439	72
Industrial	31	9	44	13	85	14
Government	69	20	50	14	85	14
TOTAL PRIMARY BATTERIES	338	100	345	100	609	100

NOTE: Percentages may not total 100 due to rounding.

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

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. Thus, in addition to an overall industry analysis, a separate treatment of each battery type is included. Price elasticities for the various battery types are not available directly. However, they can be inferred from demand-related factors. The following discussion presents a development of price elasticity estimates based on an examination of the nature of the end-use markets, availability of substitute products, and the strength of consumer demand. Table 4-2 serves as a summary for this discussion.

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 "primary versus storage" classification. The "dry cell" group can be thought of as smaller, lighter batteries primarily for portable use, such as in flashlights, calculators, and hand-held tools, 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 forklifts, mining equipment, and railroad equipment. Few economically feasible substitutes exist for these uses, although in the short term, delaying the

TABLE 4-2. 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[2]	RELATIVE SUBSTITUT-ABILITY	ESTIMATED ELASTICITY
Cadmium Anode							
Mercury-Cadmium	Dry	Specialized Military & Industrial Applications (extreme temperatures & long shelf life)	NA	None	NA	low	-03 to -0.6
Nickel-Cadmium	Dry and Wet	Calculators, Walkie Talkies, Portable Tools, & Appliances	1 to 50	Alkaline Silver-Oxide	lower higher	moderate	-0.6 to -0.8
Silver Oxide-Cadmium	Dry	Space, Appliances, Tools, T.V. Sets	1 to 20	Ni-Cad Silver Oxide-Zinc	lower lower	moderate	-0.6 to -0.8
Calcium Anode							
Calcium	Special	Military, Aerospace, & Nuclear	NA	Magnesium Anode Thermal	lower	low	-0.3 to -0.6
Lead Anode							
Lead-Acid	Primarily Wet	Autos Industrial	0.2 to 0.7	Rebuilt & used batteries, public transportation	NA	very low	-0.3
Lead-Acid Reserve	Wet	Military	1 to 10	None	NA	NA	-0.3 to -0.6

[1]Includes only the purchase value, not total life-cycle cost.
[2]Includes lead-acid reserve.
NA = Not applicable.
SOURCE: JRB estimates.

TABLE 4-2. MAJOR END-USE MARKETS, SUBSTITUTES, AND PRICE ELASTICITIES FOR BATTERY SUBCATEGORIES (Continued)

BATTERY TYPE		MAJOR MARKETS	PERCENT OF PRODUCT VALUE[1]	SUBSTITUTES	RELATIVE PRICE OF SUBSTITUTE[2]	RELATIVE SUBSTITUT-ABILITY	ESTIMATED ELASTICITY
Leclanche							
Carbon-Zinc	Dry	Flashlights, Radios, Photographic Equipment Toys, Industrial	1 to 50	Alkaline Manganese Nickel-Cadmium Silver-Oxide	higher higher higher	high	-0.8 to -1.2
Lithium Anode							
Lithium	Dry	Electric Watches	1 to 25	Mercury-Ruben Silver Oxide-Zinc	lower higher	moderate	-0.6 to -0.8
Magnesium Anode							
Magnesium-Carbon	Dry	Military, Aircraft, Marine, Mining	1 to 20	Alkaline Manganese	lower	low	-0.3 to -0.6
Magnesium Reserve	Special	Emergency Lighting & Radio Systems, Marine Applications	NA	None	NA	NA	-0.3 to -0.6
Magnesium Thermal		Military, Aerospace, Alarm & Sensing Applications	NA	Calcium Anode	higher	low	-0.3 to -0.6

[1]Includes only the purchase value, not total life-cycle cost.
[2]Includes lead-acid reserve.
NA = Not applicable.
SOURCE: JRB estimates.

TABLE 4-2. MAJOR END-USE MARKETS, SUBSTITUTES, AND PRICE ELASTICITIES FOR BATTERY SUBCATEGORIES (Continued)

BATTERY TYPE		MAJOR MARKETS	PERCENT OF PRODUCT VALUE[1]	SUBSTITUTES	RELATIVE PRICE OF SUBSTITUTE[2]	RELATIVE SUBSTITUT-ABILITY	ESTIMATED ELASTICITY
<u>Zinc Anode, Alkaline Electrolyte</u>							
Alkaline Manganese	Dry	Flashlights, Radios, Photographic Equipment, Watches	1 to 75	Carbon-Zinc Silver-Oxide Nickel-Cadmium	lower higher higher	moderate	-0.6 to -.08
Carbon Zinc-Air	Dry	Lighting & Signaling Systems, Portable Transceivers, Night-Vision Devices, Satellite Communications	1 to 50	Aklaline Manganese	higher	low	-0.3 to -0.6
Mercury-Ruben	Dry	Hearing Aids, Watches, Cameras, Electronic Instruments	1 to 20	Silver-Oxide Alkaline Manganese	higher lower	moderate	-0.6 to -0.8
Nickel-Zinc							
Silver Oxide-Zinc	Dry	Defense, Space, Watches, Hearing Aids, Cameras	1 to 20	Mercury-Cadmium Alkaline Manganese	lower lower	moderate	-0.6 to -0.8

[1]Includes only the purchase value, not total life-cycle cost.
[2]Includes lead-acid reserve.
NA = Not applicable.
SOURCE: JRB estimates.

purchase of new batteries by rebuilding or repairing used ones could occur. In short, the demand for lead 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.

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), requiring 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). For these reasons, the estimated price elasticities are lower than those of carbon-zinc.

As mentioned above, these elasticity estimates, along with the major contributing factors, are summarized in Table 4-2. A more detailed discussion of each battery product group is provided below.

4.2.1 Cadmium Anode Batteries

The cadmium anode subcategory includes mercury-cadmium, nickel-cadmium, and silver oxide-cadmium batteries, each of which is discussed separately below.

Mercury-Cadmium

Mercury-cadmium batteries are manufactured in small quantities for special military and industrial applications. Their principal advantages are long shelf life (up to five years in temperate conditions) and the ability to operate over a wide range of temperatures (-40° to +75°C). Because they are heavier and bulkier than other primary batteries, they are used primarily in applications requiring the desired shelf life and operating temperature ranges. For most of these applications, few substitutes are available.

Nickel-Cadmium

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 2 percent per month as compared to 1 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-Cadmium

Silver oxide-cadmium cells are composed of a silver-oxide cathode cell and a cadmium anode. The principal advantage of silver oxide-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 oxide-cadmium cells are two to three times that of nickel-cadmium cells. Silver oxide-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 oxide-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 oxide-cadmium cells to satellites and other space applications. Recently, however, this cell has been used commercially in appliances, tools, and portable television sets.

4.2.2 Calcium Anode Batteries

All calcium anode batteries currently produced are thermal batteries. 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.

Calcium anode thermal batteries are produced at three plants in limited quantities. While total production volume is not known, employment at the three plants is estimated at 240. Virtually all production is used for military, aerospace, and nuclear applications.

Calcium thermal batteries are preferred in applications involving minimum battery weight and volume, short life, and high discharge rate.

4.2.3 Lead Anode Batteries

The lead anode subcategory includes lead-acid and lead-acid reserve batteries, each of which is discussed separately below.

Lead-Acid

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 used primarily 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).

The other 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., forklifts), mining vehicles, yard locomotives, and for standby 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]

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.

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[1]The literature contains a number of studies that 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.

4.2.4 Leclanche (Carbon-Zinc) Cells

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 make carbon-zinc batteries very popular in a wide range of applications such as flashlights, radios, clocks, and tape recorders.

4.2.5 Lithium Anode Batteries

Lithium is the earth's lightest solid element. While weighing only about one-thirtieth the weight of lead, lithium can generate 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.

4.2.6. Magnesium Anode Batteries

The magnesium anode subcategory contains magnesium carbon, magnesium reserve and thermal cells, each of which is described separately in the following paragraphs.

Magnesium-Carbon Batteries

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.

Magnesium Reserve Batteries

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.

Magnesium Thermal Batteries

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, no required maintenance, compactness, mechanical ruggedness, and operability over a wide ambient temperature range. They are used for military and aerospace systems and for alarm and sensing applications.

In comparison with calcium batteries, magnesium thermal batteries are heavier, bulkier, and have a lower discharge rate. On the other hand, they are less expensive, more stable, and have a longer life.

4.2.7 Zinc Anode Batteries

The zinc anode subcategory includes aklaline manganese, carbon zinc-air, mercury-Ruben, nickel-zinc, and silver oxide-zinc, each of which is described separately below.

Alkaline Manganese

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, toys, radios, tape recorders. 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 storage batteries.

Carbon Zinc-Air Batteries

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 system offers a unique combination of high energy density and high power density at relatively low cost. Carbon zinc-air cells are used in portable transceivers, semaphore devices, highway flashing systems, lighthouses, railway signals, night-vision devices, and satellite communications.

Mercury-Ruben Batteries

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 resistance 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 Batteries

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). Silver-zinc cells are available in both storage and primary configurations. Storage silver-zinc cells have shorter life, in terms of the number of possible charge/discharge cycles, than nickel-cadmium and silver-cadmium cells. Because of its high cost, the silver-zinc storage cell is mainly used in military and aerospace applications where cost is of lesser importance than performance. The primary silver oxide-zinc battery has been the fastest growing primary battery in recent years, with an average annual growth rate of 67 percent between 1973 and 1977. Sales reached $54 million in 1977 (see Table 4-3).

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-temperature capacity (silver-zinc cells remain operative at -50° Fahrenheit while mercury-zinc capacity drops considerably around 40° Fahrenheit and becomes virtually inert around the freezing point).

4.2.8 Miscellaneous Battery Types

There are a number of battery types that were considered for inclusion in this study, but were omitted during the course of the research because they are not made in commercial quantities. Examples of these are nuclear batteries, advanced lead-acid batteries, lithium storage batteries, and nickel-iron batteries.

The first three of these battery types are experimental or made to order for special applications. Nickel-iron batteries were once used in applications such as material handling, railway lighting, and telephone exchange system equipment. They are now produced only in limited quantities primarily for experimental purposes. Substitution by lead-acid and nickel-cadmium batteries

TABLE 4-3. PRIMARY BATTERY PRODUCTION,1973-1977
(Current Dollars)

TYPE	1973		1975		1977		COMPOUNDED AVERAGE ANNUAL GROWTH (%)
	$ MILLION	% OF TOTAL	$ MILLION	% OF TOTAL	$ MILLION	% OF TOTAL	
Carbon-Zinc	208	60	263	59	317	52	11.1
Alkaline Manganese	57	16	80	18	111	18	18.1
Mercury-Zinc	32	9	43	10	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

NOTE: Percentages may not total 100 due to rounding.

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

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.

4.3 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 4-4). 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 both storage and primary batteries 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 percent).

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, these prices peaked in 1979 and dropped about 40 percent by 1983. There are several reasons for the rapid price increases during the 1970s. 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 bloc countries, and OSHA regulations, which are estimated to add between zero to about one cent to a pound of lead.[1] According to industry sources, this price escalation

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[1]Occupational Safety and Health Administration, Economic and Environmental Analysis of the Current OSHA Lead Standard, CRA Project No. 536.6, prepared by Charles River Associates, 1982.

TABLE 4-4. 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 1967-1977 (%)
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	[a]	[a]	[a]	NA	6.8[b]
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	[a]	[a]	[a]	NA	4.8[b]
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)	1008.0	1052.0	1079.0	1086.0	1108.0	1186.0	1255.0	1246.0	1234.0	1300.0	1372.0	1433.0	1483.0	1481.0	1510.0	3.0

[a] Price index of storage batteries unreported for years beyond 1977.

[b] Based on years 1967 to 1977.

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

is not expected to continue at such high levels. Moreover, as the data in Table 4-4 show, the price of lead has dropped significantly from its 1979 high and it is expected that there will be a lead surplus throughout the 1980s. For these reasons, it is expected that lead prices will remain low. Therefore, as a conservative estimate, 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 percent of the domestic consumption of storage batteries has been 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 1970s and early 1980s, 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.

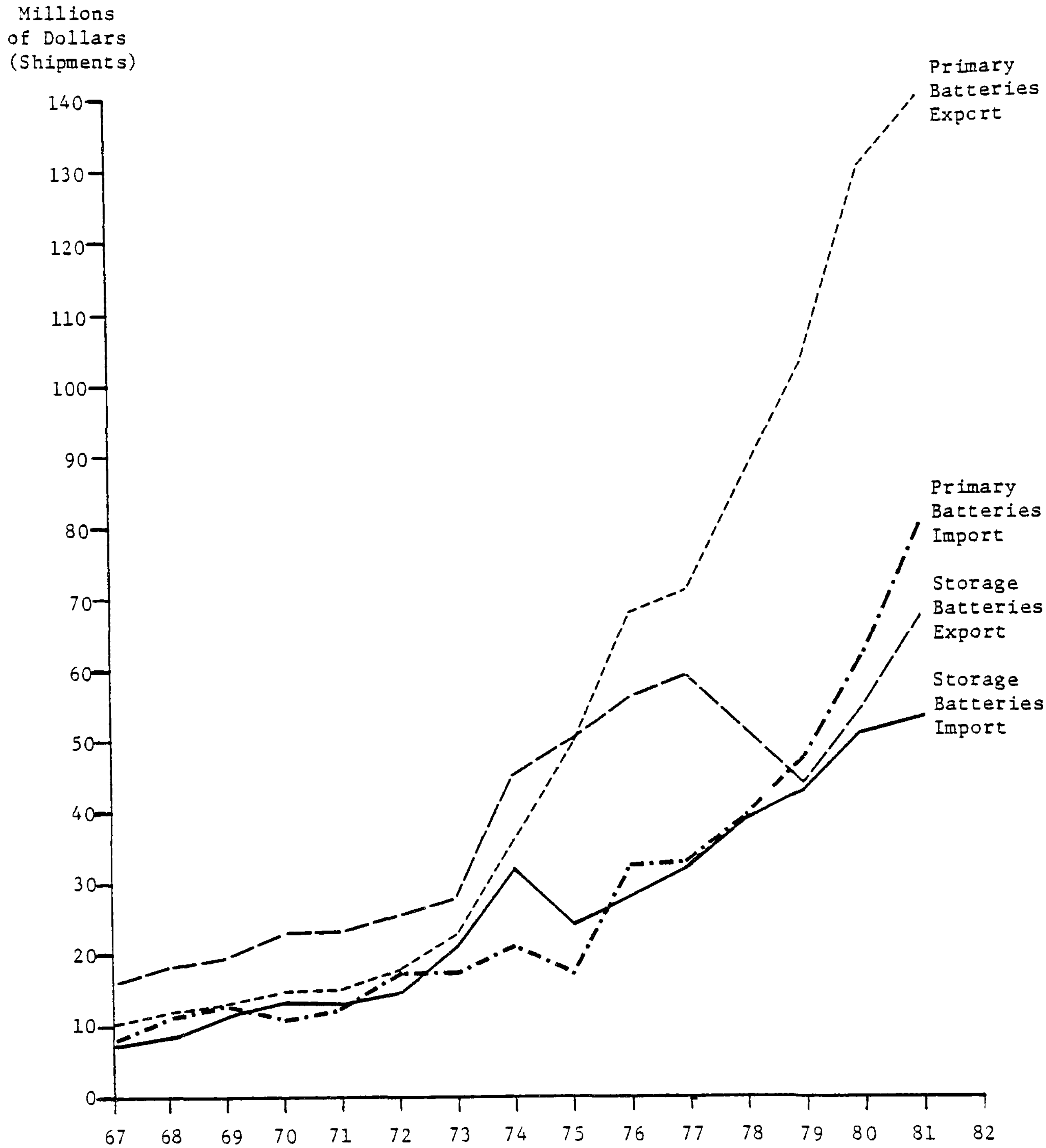
The SLI battery has also been imported to the United States indirectly via imported motorcycles. Recently, however, two of the major exporters of motorcycles, namely Taiwan and Japan, have found it advantageous to manufacture motorcycle batteries in the United States--a factor which may influence this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

Exports of American-made storage batteries account for about 2 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 flashlight and transistor radio battery market. 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 preclude a comprehensive assessment by product group. However, as the figure shows, aggregate industry data indicate 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 4-5 and shown graphically in Figure 4-1. These figures do not account for batteries included as an integral part of end-use products such as automobiles.

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. EPA's Effluent Guidelines Division, which conducts the technical analysis, reports production in the form of weight of product produced. They also reported 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. For some battery types the production weight



SOURCES: 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. These data exclude batteries that are components of end-use products.

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

TABLE 4-5. BATTERY INDUSTRY IMPORTS AND EXPORTS, 1967-1977
(Millions of Dollars)

YEAR	IMPORTS				EXPORTS			
	STORAGE	PERCENTAGE OF DOMESTIC CONSUMPTION*	PRIMARY	PERCENTAGE OF DOMESTIC CONSUMPTION**	STORAGE	PERCENTAGE OF DOMESTIC CONSUMPTION	PRIMARY	PERCENTAGE 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 include battery parts but do not include batteries imported as components of end-use products.

NA = Not available.

SOURCES: 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.

and value of shipments for 1972 and 1973 are 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.[2] For other battery types, price lists from such sources as the General Services Administration, retail store catalogs, and battery manufacturers are used. For the wet cell lead-acid batteries, a value of $0.60 per pound was used based on extrapolation from a 1978 figure of $0.50 per pound. The resulting estimates of battery value per pound for each battery type are shown in Table 4-6. The analyses for the lead-acid battery product group are done using 1983 dollars. However, since the analyses for the other product groups are done useing 1978 dollars, the values for these products shown in the table are in 1978 dollars.

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 that can be passed through depends upon the market acceptance of price increases as measured by price elasticity of demand and the pricing behavior and power in the industry. Price elasticity estimates for the various product groups are presented in Section 4.2.

If large firms set prices, smaller firms may be forced to accept their lead. As indicated in Chapter 6, since unit compliance costs are usually lower for larger or newer plants, firms operating 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.

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[2] EPA, "Assessment of Hazardous Waste Practices: Storage and Primary Batteries," Final Report (SW-120c), prepared by Versar, Inc., Springfield, Virginia, for the Office of Solid Waste, 1975.

TABLE 4-6. AVERAGE VALUE PER POUND OF PRODUCTION

BATTERY TYPE	AVERAGE $ VALUE PER POUND[a]
Cadmium Anode	
Mercury-Cadmium	-
Nickel-Cadmium Vented	31.70
Nickel-Cadmium Sealed	8.03
Silver Oxide-Cadmium	160.00
Calcium Anode	
Calcium	250.00
Lead Anode	
Lead-Acid, Wet	.60
Lead-Acid, Gel	5.59
Lead-Acid Reserve	-
Leclanche	
Carbon-Zinc and	-
Related Types	1.39
Lithium Anode	
Lithium	16.00
Magnesium Anode	
Magnesium-Carbon	4.08
Magnesium Reserve	26.27
Thermal	26.27
Zinc Anode	
Alkaline Manganese	3.39
Miniature Alkaline Manganese	4.00
Carbon Zinc-Air	-
Mercury-Ruben	10.36
Nickel-Zinc	-
Silver Oxide-Zinc	26.27

[a]Lead-acid batteries are in 1983 dollars; all other figures are in 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; and 1977 Census of Manufactures.

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 immediately pass along 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 each specialty market situation. Where this is known to be a specific factor it is indicated in the economic impact estimates in Chapter 7.

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, which, as shown in Table 4-2, is estimated to have low to moderate demand elasticities.

The information in this chapter is used in Chapter 5 to project market conditions in the industry and in Chapter 7 to estimate variables such as plant revenues and price and production impacts of the regulation.

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 are 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 from the effluent guidelines.

The primary variables of interest are divided into two broad categories for consideration in this report--demand-related factors and supply-related factors. Demand-related factors include the value of battery products shipped, the type of battery products shipped, and price elasticity. The supply factors considered are cost of producing batteries, employment, number of baseline closures, and number of new plants.

The basic approach followed in developing the projections begins with demand forecasts under the assumption that the economy will grow fairly steadily and battery prices will remain constant relative to general price levels. Using the results of the demand forecasts, industry supply factors are assessed to determine if there would be any significant changes in the relative costs or profitability of producing batteries over the next decade.

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 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 (2) the battery industry is a very small proportion of the total economic activity in the U.S. and is, therefore, more likely to react to general trends, rather than influence them.

Demand forecasting is an inexact discipline, with considerable dependence on individual judgment. 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 statistical techniques are examined. These include time series analysis and regression analysis. To augment these techniques, information and estimates provided by other authors are also reviewed.

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. Table 5-1 summarizes the industry's growth pattern over the historical period.

TABLE 5-1. ANNUAL GROWTH RATES FOR
REAL STORAGE AND PRIMARY BATTERIES SHIPMENTS

YEARS	GROWTH RATES		TOTAL INDUSTRIAL PRODUCTION
	STORAGE	PRIMARY	
1949 - 1960	1.5%	5.0%	4.9%
1960 - 1970	4.8%	5.7%	5.0%
1970 - 1980	3.5%	5.6%	3.2%
1975 - 1980	5.3%	11.5%	4.5%
1949 - 1980	3.8%	5.2%	4.2%

SOURCE: JRB Associates estimates.

Storage Batteries

During the 1950s, the value of storage battery shipments in constant dollars showed no growth at all. During the 1960s and 1970s, industry growth, more or less, paralleled that of total economic activity as measured by the Federal Reserve Board Index of Total Industrial Production. The compounded average annual growth rate from 1960 to 1970 was 4.8 percent compared to 5.0 percent for total industrial production and from 1970 to 1980 the figures were 3.5 and 3.2 percent, respectively. The growth rate for the 1949-1980 period was 3.8 percent compared to 4.2 percent for industrial production.

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 is the switch from 6-volt to 12-volt storage, lighting, and ignition (SLI) batteries during the 1950s. 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 in automobiles (such as air conditioning and power windows). The third development is the general trend toward increased number of miles driven per year by motorists through the 1950-1980 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.

Primary Batteries

Unlike the storage batteries, primary batteries experienced significant growth in shipments during the 1950s. Average annual growth in the value of shipments (constant dollars) during the 1950s was approximately 5.0 percent. During the 1960s the average annual growth rate increased to 5.7 percent, and in the 1970s it averaged around 5.6 percent annually. These rates appear to parallel general economic activity.

The recent growth in the primary battery industry is due mainly to innovations in the battery and battery-using industries. In the primary battery industry, innovations include 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), 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 the falling share of the market of the older products.

5.1.2 Regression Analysis

Regression analysis is a statistical technique that can be used to summarize the relationship between the fluctuations in the value of a variable (i.e., the dependent variable) and variables that are believed to cause these fluctuations (i.e., the independent variables). In demand analysis, it is used to explicitly relate changes in quantities of a product demanded to the level of economic activity in industries or sectors that use the product, and to the prices of the product, its substitutes, and its complements.

Specifically, the demand for batteries can be expressed in equation form:

$$D_a = b_1 y_a + b_2 p_a + b_3 p_s + b_4 t + b_0 + e$$

where

D_a = Demand for batteries in market a

y_a = an appropriate activity variable in market a

p_a = prices of product a, appropriately deflated

p_s = the prices of substitutes, appropriately deflated

b_0, b_1, b_2, b_3, and b_4 = the parameters of the relationship to be estimated

t = a measure of technological change

e = stochastic error term.

After testing a variety of functional forms, the demand model specification shown in Table 5-2 was finally selected for use in the forecast. The independent variables in the primary batteries equation are the total GNP in constant dollars and a price variable for primary battery products. The independent variables in the storage batteries equation are the GNP in constant dollars and the price variable for storage batteries. Total GNP is used as the activity variable because of the pervasive use of batteries by the consumer and the commercial and industrial sectors of the economy. The price variables for primary and storage batteries are constructed by deflating the appropriate Federal Reserve Board (FRB) producer price index for batteries by the FRB index for total manufacturing. These price variables represent the relative prices of batteries compared to other manufactured products. These indices are appropriate for this analysis because (a) long time series for the prices of the various battery products are not readily available and (b) these price indices are constructed as an aggregation of the changes in the price of the various types of battery products in the market.

Table 5-2 also summarizes the results of the demand equations for primary and storage batteries. The high R^2's ($R^2 = 1$ represents a perfect fit) suggest that a significant portion of the movement in the dependent variables is explained by the movement in the independent variables. Additionally, both the activity and price variables in each equation are significant at the 95 percentile level.

TABLE 5-2. SUMMARY OF REGRESSION MODEL RESULTS

Demand Model: $\log D_a = \alpha_0 + \alpha_1 \log P_a + \alpha_2 \log Y_a + \varepsilon$

EXPLANATORY VARIABLES	PRIMARY BATTERIES[a,b]	STORAGE BATTERIES[a,b]
Intercept	-3.9866 (-3.829)	.6592 (-.996)
Price	-.5253 (-2.331)	-.778 (-2.626)
GNP ($1972)	1.3832 (9.099)	1.0384 (10.558)
R^2 Sample Time Period	.8706 1949-1980	.8781 1957-1980

[a]Corrected for autocorrelation.

[b]The t-statistics are in parentheses.

The regression equations in Table 5-2 together with exogenously prepared forecasts of the explanatory variables (GNP and relative battery prices) are used to project value of battery shipments in constant dollars over the 1983-1990 period. An evaluation of the trend of the prices for batteries indicates no reason to expect that they would increase at a faster rate than other goods in the economy. Therefore, the real prices for primary and storage batteries are assumed to be constant over the forecast period. The forecasts for the activity variables (i.e., GNP) were developed by the consulting firm Data Resources Inc.[1] This source projects a compounded annual average growth rate of 3.5 percent through 1990 for real GNP.

5.1.3 Summary of Forecasts

Table 5-3 presents the forecasts developed from the time trend analysis and the regression model for primary and storage batteries for the 1981-1990 period. The predictions for the explanatory variables are also shown in this table. The time trend technique provides a check on the regression model. Forecasts based on both the regression models and the time trend analyses indicate that there will be significant growth in battery shipments during the 1980s. Shipments of primary batteries are expected to grow at a faster rate than those of storage batteries.

For the storage battery segment, the forecasts based on the regression model are in general agreement with those based on the trend analysis. For 1985 both forecasts call for shipments of $1.4 billion in 1967 dollars ($3.2 billion in 1981 dollars). For 1990, the forecast based on the regression model is somewhat lower than that based upon the trend analysis ($1.65 billion versus $1.69 billion in 1967 dollars). The compounded annual growth rates from 1980 to 1990 is 3.6 percent based upon the regression model and 3.8 percent based upon the trend analysis.

[1]Data Resources, Inc., Long-Term Review, Winter, 1982-1983.

TABLE 5-3. BASELINE DEMAND PROJECTIONS FOR THE BATTERY PRODUCT SEGMENTS
(In 1967 Dollars)

	TIME TREND ($000)		DEMAND MODEL[a] ($000)		RELATIVE PRICE[b]		GNP[c] (billions of 1972 dollars)
YEARS	PRIMARY BATTERIES	STORAGE BATTERIES	PRIMARY BATTERIES	STORAGE BATTERIES	PRIMARY	STORAGE	
1983	629	1,304	562	1,288	.67	.75	1509.2
1984	661	1,353	604	1,346	.67	.75	1575.6
1985	696	1,405	639	1,405	.67	.75	1641.7
1986	732	1,458	672	1,459	.67	.75	1702.6
1987	770	1,514	707	1,516	.67	.75	1765.9
1988	810	1,572	739	1,567	.67	.75	1823.8
1989	852	1,631	769	1,614	.67	.75	1876.0
1990	896	1,693	794	1,653	.67	.75	1919.6
ANNUAL RATE 1980-1990	5.2%	3.8%	3.9%	3.6%	0	0	3.5%

[a]From equations in Table 5.2.

[b]Federal Reserve Board Producer Price Index for batteries deflated by the producer price index for total manufactured goods; 1967 = 1.0.

[c]Data Resources, Inc., Long-Term Review, Winter, 1982-1983.

For primary batteries, the forecasts based on the regression model are significantly lower than those based upon the trend analysis. 1990 shipments are expected to be $794 billion (1967 dollars) based on the regression model and $896 billion based on the trend analysis. The compounded average annual growth rate is 3.9 percent based on the regression model and 5.2 percent based on the trend anlaysis.

Other sources including the American Metal Market, Chemical Week, government reports, and interviews with a number of industry personnel contacted during the course of the study indicate that the market for battery products is likely to expand fairly rapidly during the 1980s. From these sources, a number of trends and potential technological developments could affect the validity of the estimates above. These are:

- Maintenance-free batteries may 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 compared to the theoretical potential of some other systems (e.g., lithium batteries).

- The recent trend of making smaller SLI batteries is expected to continue. This trend is increasing especially in the automobile industry, which is improving its fuel economy by reducing the size and weight of batteries in cars and trucks. The demand for these smaller batteries will increase because of the expected shorter average useful battery life of the smaller-sized 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 development of a practical electric vehicle holds the promise of revolutionizing this industry. Although there are a number of test electric vehicles on the road today, none appear to be able to replace completely the internal combustion engine at this time. Assuming that an electric automobile using a fairly conventional lead-acid technology 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.

- A trend toward diesel engines would increase demand for SLI batteries, since diesel engines require two batteries.

These factors could affect the demand for batteries. However, because of the uncertainty inherent in predicting technological breakthroughs and world energy prices most of these factors are not incorporated in the demand forecast.

5.2 SUPPLY FACTORS

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

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 of shipments increased almost steadily from $32 to $45 thousand (in 1967 dollars) or 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 changes in product mix. Thus, the growth in production was largely the result of increased labor productivity. Since there is little evidence indicating significant changes in these productivity trends, value of shipments per employee is expected to continue to grow at the historic rate of 2.5 percent per year and thus reach $54.8 thousand in 1985 (1967 dollars) and $62 thousand in 1990. Using the above demand forecast, 1990 storage battery employment is projected to be 26.7 thousand, about 9 percent higher than 1977. Likewise, 1985 employment is projected to be 25.1 thousand, about 3 percent above the 1977 level.

Primary battery employment increased from 8.5 thousand in 1963 to 10.7 thousand in 1977, representing a compounded average growth rate of 1.8 percent per year. During this period, the real value of shipments per employee increased from $26.8 thousand to $38.6 thousand (1967 dollars), which represents an average growth of about 2.6 percent per year. Extrapolating this growth rate to 1990 and 1985 results in estimates of $54.1 thousand and $47.5 thousand per employee, respectively. Given the above demand forecast ($794 million in 1990 and $639 million in 1985), this would mean 14.7 thousand primary battery employees in 1990, about 37 percent higher than in 1977; and 13.4 thousand employees in 1985, about 26 percent higher than 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 throughout the 1980s. 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 the use of 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 reduction in size of the SLI battery and some possible new battery configurations to accommodate 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. Moreover, additional OSHA requirements (150 $\mu g/m^3$ permissible exposure limit for lead) became effective in June 1983 and a more stringent requirement (50 $\mu g/m^3$ PEL) will become effective in 1986. OSHA has estimated that compliance with these new regulations are quite costly and may cause a significant number of closures of small and medium-sized plants and alter the structure of the lead-acid subcategory. Because it is too soon to observe the actual impacts of these regulations and because of the drastic alterations these regulations might have on the industry, two different forecasts of baseline plant closures are presented.

The first scenario uses trend extrapolation to project that plants will continue to close at the same rate as during the 1963 to 1977 time period (about 1.5 - 2.5 per year). Thus, between 1977 and 1990, there would be an additional 20 to 33 plant closures in the lead-acid battery industry. This scenario is used as the baseline against which the impacts presented in Chapter 7 are estimated.

The second scenario uses OSHA compliance cost estimates for the OSHA 50 $\mu g/m^3$ permissible exposure limit to estimate the impacts of the OSHA regulations on the lead-acid plants in EPA's data base. This analysis indicates that 44 small plants would close as a result of the OSHA rules. (The OSHA Economic Impact Analysis, using a somewhat different methodology, reports estimates of 42 small and 5 medium-sized plant closures.)[2] The economic impacts of the effluent guidelines under this scenario (i.e., post-OSHA 50 $\mu g/m^3$ permissible exposure limit for lead) are also estimated. These estimates are included in Appendix B.

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 consolida-

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[2]OSHA, op. cit.

tions 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.

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 1990 estimate of $794 million in 1967 dollars) could be met with 26-40 new plants if output at existing plants remained unchanged. An additional 1 or 2 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 or the capacity utilization rates increase, the number of new plants would be fewer. Industry sources report that the latter scenario is more likely. Thus it is doubtful that, at the given demand projections, there would be more than 4 or 6 new lead-acid plants built during the 1980s.

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 25 to 50 new plants to meet the projected demand increase of $254 million (1976 dollars) if there is 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. Thus, it is doubtful that there would be more than 10 new primary battery plants built during the 1980s.

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 for the total electrical equipment industry. During the late 1970s, however, there has been an unusual jump in some prices, because of raw material and energy cost increases. However, the prices during the 1980-1983 period were significantly lower. It has become clear that the unusual fluctuations around the late 1970s and early 1980s were cyclical phenomena and not indicative of long-run trends. For these reasons, it is expected that the prices of batteries will increase at approximately the same rate as the general economic price levels.[3]

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 5-4. Between now and 1990, shipments will increase at an annual rate close to that of the long-term GNP trend. However, because of increasing labor economies of 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 a number of 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

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[3]See page 4-19.

TABLE 5-4. SUMMARY OF BASELINE PROJECTIONS

	STORAGE BATTERIES				PRIMARY BATTERIES			
	1977	1980	1985	1990	1977	1980	1985	1990
Value of Shipments								
(Billions of 1967 Dollars)	1.2	1.2	1.4	1.7	0.4	0.5	0.6	0.8
(Billions of 1981 Dollars)	2.7	2.7	3.2	3.9	0.7	0.9	1.1	1.5
(Annual rate -%)			3.6%	3.6%			3.9%	3.9%
No. of Employees (000)[a]	24.5	NA	25.1	26.7	10.7	NA	13.4	14.7
No. of Plants[a]	215	209	195-202	182-195	57	57	57-62	57-67
No. of Firms	112-132	NA	NA	NA	17	17	NA	NA
Price Level (1967 = 100)	162[b]	221[b]	c	c	161[d]	176.5[d]	c	c
Return on Sales (%)[e] (Before Taxes)	.06-.14	.06-.14	.06-.14	.06-.14	.06-.14	.06-.14	.06-.14	.06-.14
Industry Competition	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

[a]Under the second scenario (47 baseline plant closures due to OSHA regulations using OSHA's plant closure estimates), there would be 162 plants in 1985 and 1990, and employment will be somewhat lower.

[b]Bureau of Labor Statistics Producer Price Index for Storage Batteries (1967 = 100).

[c]Price increases are projected to be equal to those of the general price levels. However, under the second scenario (OSHA price impacts of about 6 percent), the prices would be somewhat higher.

[d]Bureau of Labor Statistics Producer Price Index for Primary Batteries (1967 = 100).

[e]Under the second scenario (47 baseline plant closures due to OSHA regulations using OSHA's plant closure estimates), return on sales may be higher for the plants remaining in the industry, due to a higher capacity utilization at the reamining plants.

NA = Not available.

SOURCE: JRB Associates estimates.

increased industry concentration is expected in the lead-acid battery industry (because of the projected exits of small firms and possible consolidations of larger firms), the information available does 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 types that are still in the research and development stage such as nickel-zinc) has made it difficult to project trends in consolidation of these products.

Except for a one-time increase of 3 to 6 percent due to OSHA regulations, 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 are 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 as well as the uncertainties in predicting fluctuations in interest rates, cost of capital and energy prices. Because of this shortcoming the economic analysis is performed under the assumption that profit rates remain at current levels.

Economic impacts of OSHA regulations that became effective in June 1983 could significantly change the structure of the industry. The implications for these industry structure changes on the economic impact estimates is considered in a sensitivity analysis described in Chapter 9 (Limitations).

Although insufficient information is 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:

Battery Type	Growth Rate
Cadmium Anode	
Mercury-Cadmium	Lower
Nickel-Cadmium	Higher
Silver Oxide-Cadmium	Average
Calcium Anode	
Calcium	Average
Lead Anode	
Lead-Acid	Average
Lead-Acid Reserve	Lower
Leclanche	
Carbon-Zinc and Related Types	Lower
Lithium Anode	
Lithium	Higher
Magnesium Anode	
Magnesium-Carbon	Average
Magnesium Reserve	Average
Thermal	Higher
Zinc Anode	
Alkaline Manganese	Higher
Carbon Zinc-Air	Lower
Mercury-Ruben	Higher
Nickel-Zinc	Lower*
Silver Oxide-Zinc	Higher

*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

6.1 OVERVIEW

The recommended water treatment control systems, costs, and effluent limitations for the battery manufacturing industry are 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 wastewater; and the constituents of wastewater. Using those 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 Development Document also identifies and assesses 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. 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 of the Development Document, and the selected techniques are enumerated and described in Sections VII and VIII of that 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. 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.

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 had to be made by EPA. These are described in the Development Document and summarized below:

- All costs are estimated in first-quarter 1982 dollars and adjusted to June 1983 dollars for the economic impact analysis using the EPA Sewage Treatment Plant Construction Cost Index.

- Capital costs include equipment costs (i.e., equipment purchase price, delivery charges, and installation costs) and system cost (i.e., contingency, engineering, and contractor's fees).

- Capital costs are amortized over 10 years at a 12 percent interest rate.

- Annual labor cost (including supervision, fringe benefits, and overhead) is $21 per hour of direct labor (1982 dollars) based on a base labor rate of $9 per person-hour for skilled labor (Bureau of Labor Statistics 1982 national wage rate for skilled labor) plus $12 for supervision and plant overhead.

- The cost of electrical energy is $0.0483 per kilowatt-hour, which is based on the electricity charge rate for March 1982 reported in the Department of Energy's Monthly Energy Review.

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.

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.

6.5 CONTROL AND TREATMENT TECHNOLOGY FOR EXISTING AND NEW SOURCE DISCHARGERS

The treatment systems considered vary from one subcategory to another. Five regulatory alternatives were considered for the lead, cadmium, and zinc subcategories; three alternatives were considered for the calcium, lithium, and magnesium subcategories; and one alternative was considered for the Leclanche subcategory. Generally, these alternatives are arranged in order of increasing cost and, generally, pollution abatement. The treatment technologies are described in detail in Sections IX, X, XI, and XII of the Development Document. Listed below is a brief summary of the treatment technologies considered for each subcategory:

<u>Cadmium, Lead, and Zinc</u>

Level 0	Lime Settle (LS)
Level 1	LS, Flow Reduction (FR)
Level 2	Lime Settle Filter (LSF), FR
Level 3	Sulfide Settle Filter (SSF), FR (zinc subcategory only)
Level 4	LSF or SSF, reverse osmosis (lead and zinc subcategories) LSF, ion exchange (cadmium subcategory)

<u>Calcium, Lithium, Magnesium</u>

Level 0	Lime Settle
Level 1	Lime Settle Filter (LSF)
Level 2	Complete Recycle/Zero Discharge

<u>Leclanche</u>

Level 0	Complete Recycle/Zero Discharge

The considered options for new sources to achieve NSPS or PSNS are identical to options considered for existing sources in each subcategory. The selected options and costs for new sources are reported in Section 7.8 along with the estimates of economic impacts on new sources.

6.6 INDUSTRY COMPLIANCE COSTS

Table 6-2 shows the estimated investment and total annual compliance costs by battery type and industry technical subcategory in 1983 dollars. These costs were developed by arraying the technological options for each plant in order of increasing total annual costs. The cost estimates are based on the regulatory flows and take into account treatment in place. Since the BPT/Level 0 regulatory flow is on the whole larger than the BAT/Level 1 flow, and the in-process controls tend to be relatively inexpensive, the cost of Level 1 was less than Level 0 for a number of plants. Thus, for the purpose of evaluating the economic impacts, it was assumed that the plants would install the least expensive treatment to meet the requirements of Level 0. Hence, in those cases where the cost of Level 1 was less than Level 0, it was assumed that the lower Level 1 costs would be incurred to meet the Level 0 limits and no incremental cost would be incurred in meeting the Level 1 limits. This rearraying 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 Table 6-2 shows, the most costly control option (Level 4) would add $9.3 million to the annual cost of manufacturing batteries in the United States (1983 dollars). Direct dischargers would incur $1.1 million and indirect dischargers would incur $8.2 million of this figure. Associated investment costs are $2.5 million for direct dischargers, $15.6 million for indirect dischargers, and $18.1 million for the entire industry. As shown in the table the costs for most other options are significantly lower. For example, Level 1 would incur a total industry annual cost of $5.1 million and an investment cost of $9.3 million. It should also be noted that the lead-acid battery product group accounts for 90 percent of total industry annual costs and 85 percent of industry investment costs (for example, at the Level 1 option). Average

TABLE 6-2. BATTERY INDUSTRY TOTAL COMPLIANCE COSTS FOR EXISTING SOURCES
(1983 Dollars)

SUBCATEGORY	LEVEL 0 CAPITAL COST $	LEVEL 0 ANNUAL COST $	LEVEL 1 CAPITAL COST $	LEVEL 1 ANNUAL COST $	LEVEL 2 CAPITAL COST $	LEVEL 2 ANNUAL COST $	LEVEL 3 CAPITAL COST $	LEVEL 3 ANNUAL COST $	LEVEL 4 CAPITAL COST $	LEVEL 4 ANNUAL COST $
Cadmium										
Direct Dischargers	88,289	33,675	179,233	54,861	214,229	70,920	NA	NA	911,463	195,119
Indirect Dischargers	481,931	110,413	464,703	159,410	607,718	204,882	NA	NA	2,192,308	716,501
Subcategory Total	570,220	144,088	643,936	214,271	821,947	275,802	NA	NA	3,103,771	911,620
Calcium										
Direct Dischargers	a	a	a	a	a	a	NA	NA	NA	NA
Indirect Dischargers	6,442	4,850	6,442	4,850	6,442	4,850	NA	NA	NA	NA
Subcategory Total	6,442	4,850	6,442	4,850	6,422	4,850	NA	NA	NA	NA
Lead										
Direct Dischargers	762,761	485,756	818,501	509,777	968,117	580,628	890,668	690,947	1,457,984	870,594
Indirect Dischargers	6,914,867	3,962,238	7,113,711	4,068,506	8,382,220	4,718,750	7,711,642	5,615,313	12,623,623	7,075,294
Subcategory Total	7,677,628	4,447,994	7,932,212	4,578,283	9,350,337	5,299,378	8,602,310	6,306,260	14,081,607	7,945,888
Leclanche										
Direct Dischargers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indirect Dischargers	62,554	31,540	62,554	31,540	62,554	31,540	NA	NA	NA	NA
Subcategory Total	62,554	31,540	62,554	31,540	62,554	31,540	NA	NA	NA	NA
Lithium										
Direct Dischargers	00	721	0	721	0	721	NA	NA	NA	NA
Indirect Dischargers	0	8,877	0	8,877	0	8,877	NA	NA	NA	NA
Subcategory Total	0	9,598	0	9,598	0	9,598	NA	NA	NA	NA
Magnesium										
Direct Dischargers	30,526	11,876	0	20,776	0	20,776	NA	NA	NA	NA
Indirect Dischargers	41,277	21,274	54,562	29,545	54,562	29,545	NA	NA	NA	NA
Subcategory Total	71,803	33,150	54,562	50,321	54,562	50,321	NA	NA	NA	NA
Zinc										
Direct Dischargers	73,429	26,600	131,419	34,920	149,148	55,753	149,148	55,753	159,181	80,579
Indirect Dischargers	377,372	128,835	506,127	146,288	592,211	232,590	592,211	232,590	799,185	368,307
Subcategory Total	450,801	155,435	637,546	181,208	741,359	288,343	741,359	288,343	958,366	448,886
TOTAL INDUSTRY										
Direct Dischargers	955,005	558,628	1,129,153	621,055	1,331,494	728,798	1,039,816	746,700	2,528,628	1,146,292
Indirect Dischargers	7,884,443	4,268,027	8,208,099	4,449,016	9,705,707	5,231,034	8,303,853	5,847,903	15,615,116	8,160,102
Industry Total	8,839,448	4,826,655	9,337,252	5,070,071	11,037,201	5,959,832	9,343,669	6,594,603	18,143,744	9,306,394

[a]No direct dischargers reported.
NA = Not applicable.

SOURCE: EPA.

unit compliance costs and the distributions of compliance costs among plants in the industry is discussed further in Chapter 7 of this report.

The costs for the selected options are shown in Table 6-3. The total industry capital and annual costs are $9.3 million and $5.0 million, respectively.

TABLE 6-3. BATTERY INDUSTRY COMPLIANCE COSTS FOR EXISTING SOURCES AT SELECTED OPTIONS (1983 Dollars)

SUBCATEGORY	SELECTED LEVEL	CAPITAL COST	ANNUAL COST
Cadmium			
Direct	Level 1	179,233	54,861
Indirect	Level 1	464,703	159,410
Subtotal		643,936	214,271
Calcium			
Direct	None	0	0
Indirect	None	0	0
Subtotal		0	0
Lead			
Direct	Level 1	818,501	509,777
Indirect	Level 1	7,113,711	4,068,506
Subtotal		7,932,212	4,578,283
Leclanche			
Direct	None	0	0
Indirect	Level 0	62,554	31,540
Subtotal		62,554	31,540
Lithium			
Direct	None	0	0
Indirect	None	0	0
Subtotal		0	0
Magnesium			
Direct	None	0	0
Indirect	Level 2	54,562	29,545
Subtotal		54,562	29,545
Zinc			
Direct	Level 1	131,419	34,920
Indirect	Level 1	506,127	146,288
Subtotal		637,546	181,208
Total			
Direct		1,129,153	599,558
Indirect		8,201,657	4,435,289
Subtotal		9,330,810	5,034,847

SOURCE: Table 6-2.

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 240 battery manufacturing facilities of various sizes and configurations and the analytical methodology described in Chapter 2. These plants represent 93 percent of the estimated industry production facilities and at least 98 percent of the industry's production capacity. The primary variables considered 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 industrywide price and production change for each compliance option estimated from the pricing strategy model described in Chapter 2. For most product groups price changes are small, exceeding 0.5 percent of before-compliance prices for only two product groups for the most costly option considered (Levels 0 through 2 for lithium and Level 4 for cadmium silver-oxide batteries). The price increases for the selected options for existing sources range from a low of zero for several products to a high of 0.5 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 4-3. The resulting quantity reductions for the selected option range from zero for several subcategories to 0.3 percent for magnesium reserve batteries.

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

TABLE 7-1. ESTIMATED PRICE AND PRODUCTION CHANGES

	LEVEL 0		LEVEL 1		LEVEL 2		LEVEL 3		LEVEL 4	
	dP	dQ	dP	dQ	dP	dQ	dP	dQ	dP	dQ
Cadmium										
Cadmium Silver-Oxide	.04	.03	.09	.07	.13	.10	.36	.29	.88	.71
Mercury-Cadmium	0	0	0	0	0	0	0	0	0	0
Nickel-Cadmium	.03	.03	.04	.03	.05	.04	.07	.06	.12	.10
Calcium										
Calcium	.03	.02	.03	.02	.03	.02	NA	NA	NA	NA
Lead										
Lead-Acid	.26	.08	.27	.08	.31	.07	.37	.11	.46	.14
Leclanche										
Carbon-Zinc & Related Types	.01	.01	.01	.01	.01	.01	NA	NA	NA	NA
Lithium										
Lithium	.91	.73	.91	.73	.91	.73	NA	NA	NA	NA
Magnesium										
Magnesium-Carbon	0	0	0	0	0	0	NA	NA	NA	NA
Magnesium Reserve	.40	.24	.50	.30	.50	.30	NA	NA	NA	NA
Thermal (Magnesium)	.13	.08	.13	.08	.13	.08	NA	NA	NA	NA
Zinc										
Alkaline Manganese	.03	.02	.03	.02	.06	.05	.06	.05	.09	.07
Carbon Zinc-Air	0	0	0	0	0	0	0	0	0	0
Mercury Cadmium-Zinc	.09	.07	.11	.09	.13	.11	.23	.19	.23	.19
Mercury (Ruben)	.07	.06	.08	.06	.11	.09	.11	.09	.22	.18
Nickel-Zinc	e	e	e	e	e	e	e	e	e	e
Silver Oxide-Zinc	.04	.03	.06	.05	.12	.10	.12	.10	.17	.14

dP = Percentage change in price.
dQ = Percentage change in quantity.
NA = Not applicable.
e = Experimental.

SOURCE: JRB Associates estimates.

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) and probably will leave the industry. An assessment of the ability of individual plants to earn a profit at these estimated postcompliance price levels is presented in Sections 7.3 through 7.5.

7.2 MAGNITUDE OF PLANT-SPECIFIC COMPLIANCE COSTS

As described in Chapter 2, the ratio of total annualized compliance cost to annual plant revenues was calculated for each of the 214 facilities for which compliance cost and other data were 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 4-6, page 4-25). The distribution of the compliance cost to revenue ratios are shown in Table 7-2. For the selected options, 14 production facilities had ratios of costs to revenues in excess of the threshold value of 1 percent. The number of facilities with ratios greater than 1 percent varies from one alternative to another. For example, for Level 4, 32 facilities exceed the threshold value. All facilities with compliance cost/revenue ratios of less than 1 percent are considered to have a low probability for plant closure.

7.3 SCREENING ANALYSIS

The screening analysis involves 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, 11 plants are expected to experience profit declines of more than 1 percent of sales

TABLE 7-2. DISTRIBUTION OF PLANTS BY ANNUAL COMPLIANCE COST TO REVENUES RATIOS[1] (Number of Plants)

PRODUCT GROUP	NUMBER OF FACILITIES SAMPLED	COMPLIANCE COST AS A PERCENTAGE OF REVENUES[1]: LEVEL 0			LEVEL 1			LEVEL 2			LEVEL 3			LEVEL 4			
		<1%	1-2%	2-4%	<1%	1-2%	2-4%	<1%	1-2%	2-4%	<1%	1-2%	2-4%	<1%	1-2%	2-4%	>4%
Cadmium																	
Cadmium Silver-Oxide	1	1			1			1			1			1			
Mercury-Cadmium	1	1			1			1			1			1			
Nickel-Cadmium	9	9			9			9			8	1		5	2	2	
Calcium																	
Calcium	3	3			3			3			NA			NA			
Lead																	
Lead-Acid	141	129	6	6	128	6	7	126	7	8	122	9	10	118	11	8	4
Leclanche																	
Leclanche	19	19			19			19			NA			NA			
Lithium																	
Lithium	7	7			7			7			NA			NA			
Magnesium																	
Magnesium-Carbon	3	3			3			3			NA			NA			
Magnesium Reserve	4	4			4			4			NA			NA			
Thermal (Magnesium)	1	1			1			1			NA			NA			
Zinc																	
Alkaline Manganese	8	8			8			8			8			5	3		
Carbon Zinc-Air	2	2			2			2			2			2			
Mercury Cadmium-Zinc	1	1			1			1			1			1			
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	
TOTAL	214	201	6	7	200	6	8	198	7	9	193	10	11	182	17	11	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.

NA = Not Applicable.

SOURCE: JRB Associates estimates.

TABLE 7-3. DISTRIBUTION OF PLANTS BY ESTIMATED CHANGE IN RETURN ON SALES[1]
(Number of Plants)

PRODUCT GROUP	NUMBER OF FACILITIES SAMPLED	LEVEL 0			LEVEL 1			LEVEL 2			LEVEL 3			LEVEL 4		
		≤1%	1-2%	2-4%	≤1%	1-2%	2-4%	≤1%	1-2%	2-4%	≤1%	1-2%	2-4%	≤1%	1-2%	2-4%
<u>Cadmium</u>																
Cadmium Silver-Oxide	1	1			1			1			1			1		
Mercury-Cadmium	1	1			1			1			1			1		
Nickel-Cadmium	9	9			9			9			8	1		6	1	2
<u>Calcium</u>																
Calcium	3	3			3			3			NA			NA		
<u>Lead</u>																
Lead-Acid	141	132	3	6	131	3	7	129	5	7	158	5	7	126	5	10
<u>Leclanche</u>																
Leclanche	19	19			19			19			NA			NA		
<u>Lithium</u>																
Lithium	7	7			7			7			NA			NA		
<u>Magnesium</u>																
Magnesium-Carbon	3	3			3			3			NA			NA		
Magnesium Reserve	4	4			4			4			NA			NA		
Thermal (Magnesium)	1	1			1			1			NA			NA		
<u>Zinc</u>																
Alkaline Manganese	8	8			8			8			8			5	3	
Carbon Zinc-Air	2	2			2			2			2			2		
Mercury Cadmium-Zinc	1	1			1			1			1			1		
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
TOTAL	214	204	4	6	203	4	7	201	5	8	200	6	8	195	10	13

1Alterantives 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.

NA = Not applicable.
SOURCE: JRB Associates estimates.

under Level 1, the most predominant selected scenario. Of these, 10 are lead-acid battery plants and one is a silver oxide-zinc plant. Under the Level 4 option, 23 plants would experience profit margin declines of more than 1 percent. The likelihood of closures for these plants as a result of the regulation is described in Section 7.6.

In summary, 11 plants at the selected options and 23 plants at the most costly options will experience impacts greater than the ROS threshold values. The following two sections present a more detailed financial analysis for these 23 plants.

7.4 PLANT-LEVEL PROFITABILITY ANALYSIS

Two different measures of financial performance are 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 involves a comparison of the measures with critical values. As described in Section 2.6.1, a critical value of 6 percent is used for the ROI analysis; and a critical value of 13 percent is used for the IRR analysis.

Table 7-4 shows the estimated ROIs before and after compliance with the regulations for each of the 23 plants that are potentially affected at the highest option. For the selected options, all plants are above the threshold value of 6 percent. These estimates indicate that there would be a significant decline in the profitabilities of these plants, although the decline will not be enough to cause any plant shutdowns.

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 postcompliance IRRs are shown in Table 7-5. For the selected alternatives only the silver-oxide plant would have an IRR below the critical value of 13 percent. All other facilities would be profitable by this

TABLE 7-4. POSTCOMPLIANCE RETURNS ON INVESTMENT (ROI)
(Percentages)

Product Group	Plant I.D.	ROI Before Compliance	ROI After Compliance LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Alkaline Manganese-Zinc	1	12	12	12	10	10	09
	2		12	12	10	10	09
	3		12	12	10	10	09
Silver Oxide-Zinc	4	12	08	07	07	07	08
	5		11	11	10	10	09
Nickel-Cadmium	6	12	10	10	10	09	08
	7		10	10	10	09	05
	8		11	11	11	09	04
Lead-Acid	9	12	08	08	07	06	06
	10		08	08	07	07	07
	11		09	08	07	07	07
	12		08	08	07	07	07
	13		08	08	08	07	07
	14		08	08	09	08	08
	15		09	09	08	08	08
	16		10	10	09	09	08
	17		10	10	09	09	09
	18		08	10	09	09	09
	19		10	10	09	09	09
	20		10	10	10	09	09
	21		10	10	10	10	09
	22		10	10	10	10	09
	23		10	10	10	10	10

SOURCE: JRB Associates estimates.

TABLE 7-5. POSTCOMPLIANCE INTERNAL RATES OF RETURNS (IRRs)
(Percentages)

Product Group	Plant I.D.	IRR After Compliance				
		LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Alkaline Manganese-Zinc	1	23	23	20	20	17
	2	23	23	20	20	17
	3	23	23	18	18	17
Silver Oxide-Zinc	4	16	14	12	12	15
	5	21	20	19	19	17
Nickel-Cadmium	6	20	20	20	18	14
	7	18	18	18	17	8
	8	21	20	20	18	6
Lead-Acid	9	16	16	13	13	10
	10	16	16	15	14	11
	11	18	17	15	14	12
	12	16	16	15	14	12
	13	17	17	16	16	13
	14	18	18	18	17	15
	15	18	18	17	17	15
	16	20	19	19	18	16
	17	20	20	19	19	17
	18	20	20	19	19	17
	19	20	20	19	19	17
	20	20	20	20	19	18
	21	21	21	20	20	18
	22	21	21	20	20	19
	23	20	21	21	21	20

SOURCE: JRB Associates estimates.

measure. The IRR values for the 23 affected plants will be used in Section 7.5, together with other information, to assess the plant closure potential for the industry.

7.5 CAPITAL 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 precompliance average annual capital expenditures of the plant.

These ratios were calculated for each of the 23 plants. Since complete plant-level financial data were unavailable, the precompliance 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 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.

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

	Plant	COMPLIANCE CAPITAL COST AS A PERCENTAGE OF FIXED ASSETS					COMPLIANCE CAPITAL COSTS AS A PERCENTAGE OF ANNUAL CAPITAL EXPENDITURES				
Product Group	I.D.	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Zinc Anode											
Alkaline											
Manganese-	1	0	0	6	6	12	0	0	29	29	56
Zinc	2	0	0	4	4	8	0	0	18	18	41
	3	0	0	5	5	7	0	0	24	24	36
Silver Oxide-	4	22	33	35	35	0	106	159	169	169	0
Zinc	5	7	10	10	10	15	33	47	47	47	72
Cadmium Anode											
Nickel-Cadmium	6	4	6	6	12	31	17	31	31	60	150
	7	10	11	12	17	46	50	54	60	82	222
	8	7	6	6	14	35	32	29	29	66	167
Lead Anode											
Lead-Acid	9	15	17	20	18	30	60	68	80	72	120
	10	20	20	22	20	33	80	80	88	80	132
	11	14	15	20	18	29	56	60	80	72	116
	12	17	17	20	18	29	68	68	80	72	116
	13	13	16	18	16	27	26	64	72	64	108
	14	04	08	08	08	25	08	32	32	32	100
	15	15	15	16	15	13	60	60	64	60	52
	16	09	10	12	11	17	36	40	48	44	68
	17	07	07	08	08	13	28	28	32	32	52
	18	08	08	10	09	15	32	32	40	36	60
	19	09	10	11	10	17	36	40	44	40	68
	20	09	09	10	09	15	36	36	40	36	60
	21	08	09	11	11	17	32	36	44	44	68
	22	08	08	10	09	14	32	32	40	36	56
	23	12	08	09	09	14	48	32	36	36	56

SOURCE: JRB Associates estimates.

For the selected options, the ratio ranges from zero to 33 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 example, the plant with the highest compliance investment costs would have to increase its fixed assets by about one-third. These estimates do not, by themselves, indicate whether or not a plant closure will occur. They are evaluated, simultaneously with other financial and non-financial variables, to determine the potential for closure (see Section 7.5).

Compliance investment costs are large in comparison to normal annual capital expenditures in the industry. Selected option investment costs for 1 of the 23 plants are greater than their estimated precompliance annual capital expenditures. For 8 plants they amount to more than half of annual precompliance capital investment expenditures. 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 precompliance "normal" investments for a period of one to two years. "Normal" investments are those used to sustain and improve the plants' operations.

7.6 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, intraindustry 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 23 plants shown in Tables 7-4, 7-5, and 7-6. The information in Table 7-7 was drawn from earlier sections of this report. The last column contains the study team's evaluation of the potential for

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 OPTION	ACC ÷ REV. (%)	Δ ROS (%)	ROI ($)	IRR (%)	ICC ÷ FA (%)	ICC ÷ NPE	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Zinc:														
Alkaline Manganese-Zinc	1	Small	High	Moderate	.6 - .8	Low	0	0	0	12	23	0	0	Low
							1	0	0	12	23	0	0	Low
							2	0.4	0.36	10	20	6	29	Low
							3	0.4	0.36	10	20	6	29	Low
							4	1.2	1.15	9	17	12	56	Low
	2	Small	High	Moderate	.6 - .8	Low	0	0	0	12	23	0	0	Low
							1	0	0	12	23	0	0	Low
							2	0.4	0.33	10	20	4	18	Low
							3	0.4	0.33	10	20	4	18	Low
							4	1.3	1.21	9	17	8	41	Low
	3	Small	High	Moderate	.6 - .8	Low	0	0	0	12	23	0	0	Low
							1	0	0	12	23	0	0	Low
							2	0.7	0.68	10	18	5	24	Low
							3	0.7	0.68	10	18	5	24	Low
							4	1.3	1.17	9	17	7	36	Low
Silver Oxide-Zinc	4	Small	High	Moderate	.6 - .8	Medium	0	1.4	1.3	8	16	22	106	Low
							1	1.9	1.7	7	14	33	159	Low
							2	2.7	2.0	7	12	35	169	Medium
							3	2.8	2.0	7	12	35	169	Medium
							4	2.8	2.0	8	15	0	0	Low
	5	Small	High	Moderate	.6 - .8	Medium	0	0.4	0.27	11	21	7	33	Low
							1	0.6	0.45	11	20	10	47	Low
							2	0.8	0.65	10	19	10	47	Low
							3	1.5	0.65	10	19	10	47	Low
							4	1.5	1.21	9	17	15	72	Low

ACC/Rev. = Ratio of annual compliance cost to revenues in percentages.
ΔROS = Estimated change in return on sales in percentages.
ROI = Estimated postcompliance return on net assets in percentages (critical value is 6 percent).
IRR = Estimated postcompliance internal rate of return in percentages (critical value is 13 percent).
ICC ÷ FA = Ratio of compliance investment cost to plant fixed assets in percentages.
ICC ÷ NPE = Ratio of compliance investment cost to typical annual plant and equipment expenditures.

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 OPTION	ACC ÷ REV. (%)	Δ ROS (%)	ROI ($)	IRR (%)	ICC ÷ FA (%)	ICC ÷ NPE	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Cadmium:														
Nickel-Cadmium	6	Small	Medium	Low	0 - .3	Low	0	0.6	0.36	10	20	4	17	Low
							1	0.6	0.54	10	20	6	31	Low
							2	0.6	0.54	10	20	6	31	Low
							3	1.0	0.88	9	18	12	60	Low
							4	1.7	1.61	8	14	31	150	Low
	7	Small	High	Moderate	.6 - .8	Low	0	0.7	0.66	10	18	10	50	Low
							1	0.8	0.78	10	18	11	54	Low
							2	0.8	0.82	10	18	12	60	Low
							3	1.1	1.10	9	17	17	82	Low
							4	3.1	3.10	5	8	46	222	High
	8	Small	High	Moderate	.6 - .8	Low	0	0.5	0.22	11	21	7	32	Low
							1	0.6	0.57	11	20	6	29	Low
							2	0.6	0.57	11	20	6	29	Low
							3	1.0	0.98	9	18	14	66	Low
							4	3.7	3.67	4	6	35	167	High
Lead:														
Lead-Acid	9	Insig.	Medium	Low	0 - .3	Low	0	2.4	2.1	8	16	15	60	Low
							1	2.8	2.4	8	16	17	68	Low
							2	3.3	2.9	7	13	20	80	Low
							3	3.9	3.4	6	13	18	72	Low
							4	4.9	4.3	6	10	30	120	High
	10	Insig.	Medium	Low	0 - .3	Low	0	2.6	2.3	8	16	20	80	Low
							1	2.6	2.3	8	16	20	80	Low
							2	3.0	2.6	7	15	22	88	Low
							3	3.5	3.1	7	14	20	80	Low
							4	4.5	3.9	7	11	33	132	High

ACC/Rev. = Ratio of annual compliance cost to revenues in percentages.
ΔROS = Estimated change in return on sales in percentages.
ROI = Estimated postcompliance return on net assets in percentages (critical value is 6 percent).
IRR = Estimated postcompliance internal rate of return in percentages (critical value is 13 percent).
ICC ÷ FA = Ratio of compliance investment cost to plant fixed assets in percentages.
ICC ÷ NPE = Ratio of compliance investment cost to typical annual plant and equipment expenditures.

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 SUBSTITU-TION	PRICE ELASTICITY	EXISTENCE OF SPECIALTY MARKETS	REGULA-TORY OPTION	ACC ÷ REV. (%)	Δ ROS (%)	ROI ($)	IRR (%)	ICC ÷ FA (%)	ICC ÷ NPE	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	11	Insig.	Medium	Moderate	0 - .3	N/A	0	1.9	1.6	9	18	14	56	Low
							1	2.5	2.1	8	17	15	60	Low
							2	2.9	2.5	7	15	20	80	Low
							3	3.5	3.0	7	14	18	72	Low
							4	4.4	3.8	7	12	29	116	High
Lead-Acid	12	Small	Medium	Moderate	0 - .3	Low	0	2.5	2.1	8	16	17	68	Low
							1	2.5	2.1	8	16	17	68	Low
							2	2.9	2.5	7	15	20	80	Low
							3	3.4	3.0	7	14	18	82	Low
							4	4.3	3.7	7	12	29	116	High
Lead-Acid	13	Small	Medium	Moderate	0 - .3	Low	0	3.1	2.8	8	17	13	26	Low
							1	3.1	2.8	8	17	16	64	Low
							2	3.6	3.2	8	16	18	72	Low
							3	4.3	3.9	7	16	16	64	Low
							4	5.5	4.9	7	13	27	108	Low
Lead-Acid	14	Small	Medium	Moderate	0 - .3	Medium	0	3.3	3.0	8	18	4	8	Low
							1	3.3	3.0	8	18	8	32	Low
							2	3.3	2.9	9	18	8	32	Low
							3	4.0	3.5	8	17	8	32	Low
							4	5.0	4.4	8	15	25	100	Low
Lead-Acid	15	Moderate	Medium	Moderate	0 - .3	Some	0	1.7	1.4	9	18	15	60	Low
							1	1.7	1.4	9	18	14	60	Low
							2	2.0	1.6	8	17	16	64	Low
							3	2.4	1.9	8	17	15	60	Low
							4	3.0	2.4	8	15	13	52	Low

ACC/Rev. = Ratio of annual compliance cost to revenues in percentages.
ΔROS = Estimated change in return on sales in percentages.
ROI = Estimated postcompliance return on net assets in percentages (critical value is 6 percent).
IRR = Estimated postcompliance internal rate of return in percentages (critical value is 13 percent).
ICC ÷ FA = Ratio of compliance investment cost to plant fixed assets in percentages.
ICC ÷ NPE = Ratio of compliance investment cost to typical annual plant and equipment expenditures.

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 OPTION	ACC ÷ REV. (%)	Δ ROS (%)	ROI ($)	IRR (%)	ICC ÷ FA (%)	ICC ÷ NPE	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	16	Small	Medium	Moderate	0 - .3		0	1.3	1.0	10	20	9	36	Low
							1	1.5	1.2	10	19	10	40	Low
							2	1.8	1.4	9	19	12	48	Low
							3	2.1	1.6	9	18	11	44	Low
							4	2.7	2.1	8	16	17	68	Low
Lead-Acid	17	Insig.	Medium	Low	0 - .3	Some	0	1.4	1.1	10	20	7	28	Low
							1	1.4	1.1	10	20	7	28	Low
							2	1.8	1.4	9	19	8	32	Low
							3	2.1	1.6	9	19	8	32	Low
							4	2.6	2.0	9	17	13	52	Low
Lead-Acid	18	Insig.	Medium	Low	0 - .3	Sig.	0	1.3	1.0	8	20	8	32	Low
							1	1.3	1.0	10	20	8	32	Low
							2	1.6	1.2	9	19	10	40	Low
							3	1.9	1.5	9	19	9	36	Low
							4	2.4	1.9	9	17	15	60	Low
Lead-Acid	19	Insig.	Medium	Low	0 - .3	Small	0	2.8	2.5	10	20	9	36	Low
							1	2.8	2.5	10	20	10	40	Low
							2	3.3	2.9	9	19	11	44	Low
							3	3.9	3.4	9	19	10	40	Low
							4	4.9	4.3	9	17	17	68	Low
Lead-Acid	20	Insig.	Medium	Low	0 - .3	Small	0	0.5	0.1	10	20	9	36	Low
							1	0.5	0.1	10	20	9	36	Low
							2	0.5	0.1	10	20	10	40	Low
							3	0.6	0.2	9	19	9	36	Low
							4	0.8	0.2	9	18	15	60	Low

ACC/Rev. = Ratio of annual compliance cost to revenues in percentages.
ΔROS = Estimated change in return on sales in percentages.
ROI = Estimated postcompliance return on net assets in percentages (critical value is 6 percent).
IRR = Estimated postcompliance internal rate of return in percentages (critical value is 13 percent).
ICC ÷ FA = Ratio of compliance investment cost to plant fixed assets in percentages.
ICC ÷ NPE = Ratio of compliance investment cost to typical annual plant and equipment expenditures.

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 OPTION	ACC REV. (%)	ROS (%)	ROI ($)	IRR (%)	ICC FA (%)	ICC NPE	POTENTIAL FOR CLOSURE BECAUSE OF REGULATORY COST
Lead-Acid	21	Insig.	Medium	Low	0 - .3	Low	0	0.8	0.5	10	21	8	32	Low
							1	0.9	0.5	10	21	9	36	Low
							2	1.2	0.8	10	20	11	44	Low
							3	1.4	0.9	10	20	11	44	Low
							4	1.8	1.2	9	18	17	68	Low
Lead-Acid	22	Insig.	Medium	Low	0 - .3	Low	0	0.9	0.6	10	21	8	32	Low
							1	1.1	0.7	10	21	8	32	Low
							2	1.2	0.8	10	20	10	40	Low
							3	1.4	1.0	10	20	9	36	Low
							4	1.8	1.2	9	19	14	56	Low
Lead-Acid	23	Insig.	Medium	Low	0 - .3	Low	0	0.9	0.5	10	20	12	48	Low
							1	0.9	0.5	10	21	8	32	Low
							2	1.0	0.6	10	21	9	36	Low
							3	1.2	0.7	10	21	9	36	Low
							4	1.5	0.9	10	20	14	56	Low

ACC/Rev. = Ratio of annual compliance cost to revenues in percentages.
ROS = Estimated change in return on sales in percentages.
ROI = Estimated postcompliance return on net assets in percentages (critical value is 6 percent).
IRR = Estimated postcompliance internal rate of return in percentages (critical value is 13 percent).
ICC FA = Ratio of compliance investment cost to plant fixed assets in percentages.
ICC NPE = Ratio of compliance investment cost to typical annual plant and equipment expenditures.

plant closures, based on a review of the combined effects of the other columns in the table.

In general, the market factors for these products are strong, so that the bulk of the impacts will result from the intraindustry distribution of compliance costs and the subsequent change in the competitiveness among the various plants. All plants are believed to have a low potential for closure at the selected option, since their profitability measures are adequate and their capital investment requirements relative to fixed assets and annual capital expenditures are not prohibitive. Under the Level-4 scenario, 2 nickel-cadmium plants and 4 lead-acid plants are estimated to be likely closures. Although the nickel-cadmium plants are small, they account for a noticeable market share in certain product lines (i.e., sealed nickel-cadmium batteries) and the loss of their combined capacity would increase concentration and, possibly, alter the pricing behavior of sealed nickel-cadmium batteries. The lead plants are small relative to market size.

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 5, 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.

As described in Appendix B, EPA has estimated that the implementation of the OSHA 50 $\mu g/m^3$ Permissible Exposure Limit (PEL) for lead will cause about 44 small plant closures in the lead-acid product group. These 44 plants include all of the lead-acid battery plants shown in Tables 7-4 through 7-7. The lead-acid plants remaining after OSHA compliance will experience mild impacts (less than a 1 percent change in return on sales) and, consequently, will pass the screening analysis (Step 5 of the study approach).

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

BATTERY PRODUCT GROUP	NUMBER OF PRODUCTION FACILITIES	REGULATORY OPTION[a]	NUMBER OF PROBABLE CLOSURES
Lead-Acid	167	Levels 0-3	0
		Level 4	4
Nickel-Cadmium	9	Level 4	2
Other	64	All Levels	0
Total	240	Level 4	6

[a]There are no closures estimated for Levels 0 through 3.

SOURCE: Table 7-7.

7.7 OTHER IMPACTS

7.7.1 Employment, Community, and Regional Effects

As shown in Table 7-9, the 6 plants estimated to have a high potential for closure under Level 4 employ between 250 and 400 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.

7.7.2 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.

7.7.3 Industry Structure Effects

The potentially high-impacted plants (the 23 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 is significantly higher than that 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 with other Federal regulations are also higher for small plants than those for large plants. The combined effect of these developments will be a deterioration in the competitive position of small plants relative to large plants.

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
Nickel-Cadmium	9	1 - 2	Level 4	2	220 - 320
Lead	167	24 - 25	Level 4	4	30 - 80
Other	64	9 - 11	All	0	0
Total	240	37	Level 4	6	250 - 400

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

Of particular importance in this regard is the cost of meeting the new OSHA lead-air standards. A 150 μg permissible exposure limit (PEL) became effective in June 1983, and a 50 μg PEL will become effective in 1986. An EPA analysis of the impacts of meeting the OSHA lead-air standards indicates that the OSHA requirement alone could cause the closing of 40 small lead-acid plants. An OSHA analysis of the same regulations using a different analytical approach concludes that 42 small and 5 medium-sized plants will close, thereby eliminating 13 percent of industry capacity. Among these closings will be the "high compliance cost" lead-acid plants listed above.

The deterioration in the relative competitiveness of small plants 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 could remain in the industry over the long run. Specialty markets, in this context, may be a specific type of battery with very narrowly defined specifications meant for a particular use, the volume of which would 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 could 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 Level 4 option, which is not being promulgated. Of the 9 nickel-cadmium plants there are only 6 that manufacture <u>sealed</u> nickel-cadmium batteries in the U.S. These plants belong to large firms. One of these 6 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 2 plants whose compliance costs will be substantial (Level 4 annual costs amount to over 3 percent of annual revenues). These 2 plants are estimated to be likely closures under the Level 4 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 is considered likely or borderline closure candidates, because the technologies are considerably less expensive.

If these 2 plants closed, industry capacity would drop substantially (15 to 20 percent). To the extent that this void would be filled by the industry's largest producer (the firm with 60 to 65 percent of the market), this industry sector would become significantly more concentrated. The long-run impact of increased concentration could be a reduction in price competition within this industry segment.

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 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.

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 are insufficient to reliably forecast the number of plant modifications and the proportion

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

SUBCATEGORY	SELECTED EXISTING SOURCE LEVEL	SELECTED NEW SOURCE LEVEL	INCREMENTAL[a] COSTS ÷ ASSETS (Percentage)	ANNUAL COSTS[a] ÷ REVENUES (Percentage)
Cadmium				
Direct	1	2	0.06	0.03
Indirect	1	2	0.12	0.06
Calcium				
Direct	None	2	0.08	0.04
Indirect	None	2	0.08	0.04
Lead				
Direct	1	2	0.13	0.03
Indirect	1	2	0.16	0.04
Leclanche				
Direct	None	0	0.00	0.00
Indirect	0	0	0.00	0.00
Lithium				
Direct	None	1	0.00	0.15
Indirect	None	1	0.00	1.8
Magnesium				
Direct	None	2	0.00	1.18
Indirect	b	2	0.00	0.00
Zinc				
Direct	1	2	0.06	0.03
Indirect	1	2	0.10	0.05
TOTAL	-	-	0.14	0.040

[a]The costs used for this ratio represents the difference between the new source alternatives and the existing source selected alternatives.

[b]The selected option is a combination of Level 2 and Level 0.

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 three assumptions were employed in estimating new source compliance costs:

- Compliance costs for the lead-acid battery product group are based upon a normal plant analysis.
- For the non-lead-acid product groups, the compliance cost per unit of output (pound of batteries) for new sources is 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 percentages, 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 second 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 of 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 team to quantify the bias. However, it is believed that the estimates shown are reasonable approximations for use in an industrywide assesment of impacts. To the extent that existing plants have the new source technology in place, costs may be underestimated for a green-field site.

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 Level 2 minus that of Level 1. 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 percentage of revenues and investment compliance cost as a percentage of plant assets. New sources will, on average, incur annual costs equal to 0.04 percent of revenues and investment costs equal to 0.14 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 0.06 percent of revenues for indirect discharger cadmium battery manufacturers. Similarly, capital costs range from zero to 0.16 percent of plant assets. These averages are based upon the product mix of existing sources.

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 intraindustry shifts in competitiveness.

As Sections 7-1 through 7-6 demonstrate, the impacts of regulatory alternatives 0 through 3 will cause no plant closures and will generally involve price increase and profit reduction of less than 1 percent. Thus, the new source alternatives will cause no general economic impact for these subcategories. The cost ratios shown in Table 7-10 indicate differences in cost of production of significantly less than 1 percent of revenues. Moreover, the new source requirements will add only a fraction of a percent to the asset value of a plant. 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.

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 the value of industry output over 1980 is taken from the base-case demand forecast in Chapter 5 ($1.2 billion for storage batteries and $600 million for primary batteries in 1983 dollars).
- The amount of industry output subject to new sources standards is assumed to be equal to the forecated growth in industry output above.
- The annual compliance cost per unit of output and the investment compliance cost as a percentage of plant assets are assumed to be equal to those 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 estimates could be overestimated.)

Using this approach, the new source selected option will cost the industry $1.2 million in investment costs and $0.7 million in annual costs by 1990, in 1983 dollars.

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 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 approach used for this analysis 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 precompliance industry conditions at the time the regulations are expected to become effective (mid-1980s). 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 were on a plant basis, the individual production facility, rather than firm, was used as the basis for the analysis.

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. Five alternative criteria for determining "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. 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 5, between 20 and 30 closures of small lead-acid plants are expected between 1980 and 1990, even without these regulations. Moreover, implementation of the OSHA lead-air standard alone, which became effective in 1983, is expected to cause about 40 to 47 closures. Any new lead-acid plants to be built 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.

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

TABLE 8-1. COMPLIANCE COSTS OF LEAD-ACID BATTERY MANUFACTURING FACILITIES BY SIZE OF FACILITY
(In 1983 Dollars)

			LEVEL 0			LEVEL 1			LEVEL 2		
FACILITY SIZE (By Value of Production)	NUMBER OF FACILITIES IN SAMPLE	VALUE OF PRODUCTION ($ Millions)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COST	ANNUAL COMPLIANCE COST AS A PERCENT OF REVENUE (Percentage)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COST	ANNUAL COMPLIANCE COST AS A PERCENT OF REVENUE (Percentage)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COST	ANNUAL COMPLIANCE COST AS A PERCENT OF REVENUE (Percentage)
<$1 Million (% of Total)	9 (10.6)	4.914 (0.3)	182,890 (2.2)	107,886 (2.1)	2.20	182,684 (2.3)	106,767 (2.4)	2.17	210,203 (2.3)	124,308 (2.4)	2.53
$1-2.5 Million (% of Total)	8 (9.4)	12.480 (0.7)	261,096 (3.1)	187,697 (3.7)	1.50	244,890 (3.1)	141,595 (3.1)	1.13	284,568 (2.7)	167,910 (3.2)	1.35
$2.5-5 Million (% of Total)	5 (5.9)	18.989 (1.1)	225,894 (2.7)	112,004 (2.2)	0.59	203,682 (2.6)	94,924 (2.1)	0.50	250,200 (2.7)	117,745 (2.3)	0.62
$5-10 Million (% of Total)	13 (15.3)	90.118 (5.3)	648,345 (7.7)	467,357 (9.2)	0.52	613,000 (7.8)	378,680 (8.4)	0.42	783,433 (8.5)	463,992 (8.9)	0.51
>$10 Million (% of Total)	50 (58.9)	1,572.592 (92.6)	7,148,809 (84.4)	4,185,368 (82.7)	0.27	6,573,223 (84.1)	3,786,617 (84.0)	0.24	7,691,221 (83.8)	4,344,389 (83.3)	0.28
TOTAL INDUSTRY (% OF TOTAL)	85 (100)	1,699.093 (100)	8,467,034 (100)	5,060,312 (100)	0.30	7,817,479 (100)	4,508,583 (100)	0.27	9,219,625 (100)	5,218,344 (100)	0.31

NOTES: The industry totals differ from those reported in Chapter 6, because of differences in sample size. Percentages may not total 100 due to rounding.

SOURCE: EPA and JRB Associates estimates

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

			LEVEL 0			LEVEL 1			LEVEL 2		
FACILITY SIZE (By Value of Production)	NUMBER OF FACILITIES IN SAMPLE	VALUE OF PRODUCTION ($ Million)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COSTS	ANNUAL COMPLIANCE COSTS AS A PERCENT OF REVENUES (Percentage)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COSTS	ANNUAL COMPLIANCE COSTS AS A PERCENT OF REVENUES (Percentage)	INVESTMENT COMPLIANCE COST	ANNUAL COMPLIANCE COSTS	ANNUAL COMPLIANCE COSTS AS A PERCENT OF REVENUES (Percentage)
< $1 Million (% of Total)	21 (32.3)	5.2 (0.6)	77,944 (8.3)	28,771 (8.7)	0.56	84,505 (8.1)	29,600 (7.2)	0.37	87,374 (8.0)	30,335 (7.3)	0.59
$1-2.5 Million (% of Total)	8 (12.3)	13.6 (1.7)	126,383 (13.4)	40,256 (12.2)	0.30	114,968 (11.0)	54,276 (13.2)	0.40	115,943 (10.6)	54,497 (13.0)	0.40
$2.5-5 Million (% of Total)	8 (12.3)	28.8 (3.6)	132,129 (14.0)	50,600 (15.3)	0.18	168,860 (16.2)	61,292 (14.9)	0.21	169,495 (15.5)	61,580 (14.7)	0.21
$5-10 Million (% of Total)	6 (9.2)	42.2% (5.2)	169,689 (18.0)	52,391 (15.9)	0.14	170,088 (16.3)	62,834 (15.3)	0.14	181,738 (16.6)	64,564 (15.4)	0.15
$10-20 Million (% of Total)	8 (12.3)	121.3 (15.0)	189,493 (20.1)	55,326 (16.8)	0.05	194,897 (18.7)	83,057 (20.2)	0.07	194,897 (17.8)	83,057 (19.9)	0.07
> $20 Million (% of Total)	14 (21.5)	596.9 (73.9)	248,043 (26.3)	102,550 (31.1)	0.02	307,371 (29.5)	119,538 (29.1)	0.02	346,087 (31.6)	124,317 (29.7)	0.02
TOTAL INDUSTRY (% of Total)	65 (100)	808.0 (100)	943,681 (100)	329,894.5 (100)	0.04	1,040,689 (100)	410,597 (100)	0.05	1,095,534 (100)	418,350 (100)	0.05

[1]*Data for 8 of the 73 production facilities were not adequate for inclusion in this table.*

NOTE: Percentages may not total 100 due to rounding.
SOURCE: EPA and JRB estimates.

small plants counted in Table 8-1 will still be in operation when the regulations become effective. 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 these data preclude estimation of plant-specific activities. Consequently, the assessment of impacts on small business was developed primarily with the data base of existing plants from the EPA 308 Survey and industry trade sources. However, an examination was made of small firm financial data available in the SBA FINSTAT data base to determine if the current financial performance of small battery firms are different from that of larger battery firms.[1] The FINSTAT data showed wide variations in financial ratios from one firm to another. In addition, the baseline financial ratios used in impact analyses in Chapter 7 are more conservative than those computed from small firms in the FINSTAT data (i.e., those in FINSTAT indicate better baseline profit rates), although the averages are consistent with the figures used in the impact anlaysis. For example, the average sales-to-asset ratio calculated from FINSTAT data is 2.6, compared to 2.0 used in Chapter 7. Net profit/sales of small firms in the FINSTAT data base average 10.8 percent compared to 6 percent in Chapter 7. The FINSTAT data also show an ROI of 15.6 percent for small firms compared to 12 percent used in the analysis above. In view of these findings and in view of a number of ambiguities and inconsistencies found in the FINSTAT data, it is concluded from this examination that the data do not support the hypothesis that the baseline financial performance of small firms is significantly different from that of larger ones. Thus, although there is qualitative evidence that small-firm financial performance is poorer than that of larger ones, the financial data available do not support that hypothesis.

[1]Memorandum from JRB Associates to EPA, August 16, 1983.

8.4 COMPLIANCE COSTS

This section describes the compliance costs that will be incurred by small firms. The economic impacts that result from the 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 size categories 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 used in Chapter 6 (Cost of Compliance). The proportion of total lead-acid battery output and industry sector compliance costs attributed to both small and large plants are also provided in Table 8-1. For example, 10.6 percent (9 plants) of the lead-acid plants in the sample produce less than $1 million annually. Plants in this size group produce 0.3 percent ($4.9 million) of the value of industry output and will incur 2.4 percent ($106,767) of the industry's annual compliance cost and 2.3 percent ($182,684) of the industry's investment cost under Level 1, the selected option. The annual Level 1 compliance costs for these 9 plants would be 2.17 percent of their combined revenues.

In contrast to these very small plants, 58.9 percent (50 plants) of the plants have annual production values in excess of $10 million. These 50 plants produce 92.6 percent ($1.6 billion) of the value of lead-acid battery production in the sample and account for 82.7 percent ($4.2 million) of the industry sector's annual cost and 84.4 percent ($7.1 million) of the industry sector's investment cost under Level 1. The annual compliance cost for these 50 plants would be 0.28 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 regulations will reduce the profitabilities of small plants more than it will for large plants.

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 Chapter 2, the costs of the regulation will foster a drop in the returns on sales (ROS) of many small plants. It is estimated that at the selected pollution control option (Level 1) there will be 11 plants whose ROSs will fall by more than 1 percent. The drop in ROS will not be enough to cause any plant shutdowns.

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 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. For example, under regulatory Level 1 (the selected option), $107,000 of annual cost and $183,000 of investment cost would be avoided in the lead-acid sector if the plants with production values of under $1 million were exempted. In addition, 9 very small plants would incur no additional costs. If an exemption were set for plants with production values of under $10 million, 16 percent ($721,967) of the lead-acid sector's annual costs and 16 percent ($1.2 million) of the lead sector's investment cost would be avoided at Level 1 option. Moreover, 41 percent of the plants in the sample would be exempt from the regulation; there would be no plant closures and price, production, and profit impacts would be small. Similarly, the implications of the other definitions for "small entities" can be seen in Tables 8-1 and 8-2. It should be noted that these results are influenced by the fact the production and compliance cost data on 56 zero-discharging lead-acid plants and 19 discharging lead-acid plants are not included in the analysis. It does not appear that the inclusion of these omitted data would significantly change the overall findings of this study.

9. LIMITATIONS OF THE ANALYSIS

This section outlines the major limitations of the economic impact analysis. It focuses on the limitations of the data, methodology, assumptions, and estimations made in the analyses performed to assess the economic impacts of the compliance costs.

9.1 DATA LIMITATIONS

The accuracy of the conclusions of this report depends largely on the accuracy of the data used in the analyses, especially those of the estimated compliance costs, and plant financial and economic characteristics.

The assumptions relating to the estimation of plant-specific compliance costs are outlined in Chapter 6 of this report and described in detail in the technical Development Document.

In the absence of a detailed financial survey for the battery manufacturing industry, a financial profile of the industry was developed based on extensive review of trade literature and published financial reports. This financial profile is subject to the following major assumptions and limitations:

- Lacking plant-specific operating ratios such as profit margin, assets value, fixed and variable costs of production, salvage value, and tax rates, industry average estimates were applied to the plants. The methodology for estimating these financial variables is explained in Appendix A. An examination of a limited data base of small business financial data indicated that the baseline financial performances of small firms are not significantly different from those of larger ones.

- Lacking plant-specific revenues data, plant revenues were estimated by multiplying production of each plant (in pounds) reported in the technical 308 Survey by an average industry price per pound of production. 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 at a specific plant so that adjustments were made as required.

- The cost of capital used for the cost analysis 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.

- Only a single year's plant production data were collected in the EPA survey. For most plants these data were for either 1976, 1977, or 1978. For several plants, these data were for 1982. Multiple years' production data would have enabled a more in-depth analysis encompassing the cyclical nature of the industry. However, these were neither peak nor trough periods for the industry or the general economy and are, therefore, considered to be representative of average conditions in the industry over the long run.

- To stress the conservative nature of the study effort, all quantity changes were calculated at the higher end of the elasticity estimate range and the lower end of the 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 taken. That is, judgments were made that would more likely result in overstating the economic impacts than understating them.

9.2 METHODOLOGY LIMITATIONS

In addition to the data limitations described above, this study is also subject to limitations of the methodology used. These limitations are related to critical assumptions on price increase, profit impact, and capital availability.

9.2.1 Price Increase Assumptions

It is assumed that the industry's pricing behavior follows a scenario that will cause the baseline return on assets for the dominant firms in the industry to be maintained. This assumption generally results in a price change that is insufficient for all plants in the industry to recover all compliance costs and maintain profitability, since average unit compliance costs vary among the plants. This price increase assumption is justified by observations made regarding the demand and industry structure characteristics. That is, the price elasticities of demand for most battery products are inelastic and the industry exhibits some characteristics of noncompetitive market behavior.

9.2.2 Profit Impact Assumptions

The basic measures of profit impact used in this study are the after-compliance internal rate of return and return on net assets. Due to the difficulty and uncertainties of forecasting the fluctuation in annual cash flows, it is assumed that annual cash flows remain constant over the period of the analysis. The rationale for this assumption is that while cash flows vary from year to year, they would tend to average around a normal level over a period of time. The assumption of constant cash flow is believed to have little effect on the accuracy of the analysis.

Another limitation relates to the ability of the profit impact methodology to assess the combined effects of the business cycle and the timing of the effective date of the regulation. As previously mentioned, portions of the study rely on inferences from only one year or a few years of data. Where this occurred, care was taken to insure that any point estimate was not taken for an extreme year, such as a trough of a recession or a peak of an expansion. The time periods used were indicative of neither a peak nor a trough for the industry or the general economy; and are, therefore, considered to be representative of average conditions in the industry over a long period of time.

9.2.3 Capital Availability Assumptions

The impacts of the capital investment requirements were assessed through an evaluation of the investment costs in comparison to typical annual capital expenditures in the industry and to plant fixed assets. Although this technique does not provide a precise conclusion on a firm's ability to make the investment, it does provide a good indication of the relative burden of the requirement.

9.2.4 Establishment Definitions

For the purpose of this study, the focus of the analysis is on the impacts of the regulations on the battery manufacturing operations of a plant. As a result, when a plant includes manufacturing activities other than battery manufacturing, only the battery manufacturing operations are evaluated. That is, the economic impact analysis is focused on the compliance costs and revenues of the battery manufacturing operations of the plant.

9.2.5 OSHA Requirements

The assessment of the impacts of the OSHA requirements on the baseline conditions of the battery manufacturing industry may be hindered by the lack of knowledge regarding the current state of compliance with the OSHA lead standard. The cost estimates used were taken directly from the OSHA report and are sensitive primarily to variation in plant size, while they lack sensitivity to technology in place. Nevertheless, the plant closure estimates (44 small plants) reported in Appendix B are in general agreement with those estimated by OSHA (42 small and 5 medium-sized plants).

9.3 SUMMARY OF LIMITATIONS

Although the factors previously mentioned may affect the quantitative accuracy of the impact assessments on specific battery plants, it is believed that the results of this study represent a valid industrywide assessment of the economic impacts likely to be associated with effluent guideline control costs.

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

Three general approaches can be taken to analyze plant-level profitability for purposes of capital budgeting decisions: 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 return on investment (equity, assets) and return on sales. Of these, return on investment (ROI) is the most commonly used measure. The ROI 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 was 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 net present value method. Both techniques will generally provide the same profit impact and plant closure conclusions. This study uses the IRR approach as this technique provides a direct measure of the relative profitability of various projects. The remainder of this appendix describes the suggested implementation of the IRR 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 $A_0/A = \Sigma(1+r)^{-T}$. Since the values for r corresponding to various values of $\Sigma(1+r)^{-T}$ 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 that can then be used in conjunction with a present value table to look up the discount rate. Exhibit A (at the end of this Appendix) 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.

Estimation of Baseline Financial Ratios

Since no survey of industry financial and economic data was conducted, information from published sources or industrywide data and data on "model" or "typical" plants found in literature was used to estimate typical financial and operating ratios for the industry. 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 the development of a reasonable range of likely impacts that could result from the regulations. The following data sources were used in the analysis:

- Census of Manufactures, 1972 and 1977
- Company annual reports for Union Carbide Corp.; Eltra Corp.; ESB Inc.; Globe 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 1 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 these data were confirmed, to some extent (as the data permitted), by information gathered at plant visits. Separate calculations were done for "very small" (less than 1 million pounds per year) and small plants (between 1 and 10 million pounds per year). However, since the data on "small" plants conflict with data in corporate annual reports and site visit reports, only the ROI for the "very small" plants was actually used in the analysis. This decision favors a conservative approach to impact assessment since the ROI for the "very small" plants is lower than that for the small. Financial ratios from FTC and company annual reports were also compiled. However, these sources do not

TABLE A-1. ESTIMATED FINANCIAL DATA FOR SMALL LEAD-ACID BATTERY MANFUACTURING 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
Earning Rate Before Taxes	12.9%	13.4%
Taxes[3]	20,400	74,100
Earnings After Taxes	49,200	107,400
Earning Rate After Taxes	9.1%	8.0%

[1]For Wet and Wet/Dry Formation.

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

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

SOURCE: Lead-Acid Battery Manufacture--Background Information for Proposed Standards (DRAFT EIS). EPA-450/3-79-028a, 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 Thousands 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 0.25; process equipment at 0.66; OSHA, SIP at 0.133.

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

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

directly measure the financial parameters for any single battery product group, since they represent multiproduct entities. Therefore, an industrywide average for each parameter was applied to each product group. The variables, whose values were taken from published sources, include sales, total gross assets, net assets, total fixed assets, and net profit for corporations engaged in the manufacture of electrical and electronic equipment, the industry group to which battery manufacturing belongs. The data sources and values are indicated in Table A-3 and its footnotes. These variables were used to calculate baseline values for the following parameters: return on sales, sales to assets, profits to assets, cash flow, and internal rate of return. The variables are shown in the table. The last column of the table is a consensus of values for a typical battery manufacturing plant and represents the values used in the impact analyses presented in Chapter 7. It is important to note that many of the data sources relate to broader industry groups than just battery manufacturing. For example, the FTC data is dominated by nonbattery electrical and electronics equipment and most of the firms participate in many diverse activities and only consolidated financial data is available. For these reasons, greater weight was given to the model plant in determining some of the baseline parameters. 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 was promulgated.

Baseline Internal Rate of Return

Using the values in the table, the baseline IRR is calculated as follows:

(1) $$\frac{A_o}{VS} = \frac{SV}{VS} = \frac{SV}{A} \cdot \frac{A}{VS} = (0.65)\ (0.5) = 0.325$$

(2) $$\frac{A}{VS} = ROS + \frac{DEP}{VS} = .06\ (VS) + .025 = .085$$

(3) $$A_o/A = \Sigma\ (1 + r)^{-t} = .325/.085 = 3.82$$

if $A_0/A = 3.82$, then IRR = 23%

This is the baseline IRR used in the impact analysis.

TABLE A-3. DERIVATION OF BASELINE FINANCIAL RATIOS FOR THE BATTERY MANUFACTURING INDUSTRY

VARIABLE	UNITS	SOURCES					CONSENSUS[4]
		MODEL PLANT[1]	SITE VISITS	CENSUS	FTC[2]	CORPORATE ANNUAL REPORTS[3]	
1. Return on Sales	Percent	9	5	NA	6.1	4-8	6
2. Value of Shipments ÷ Total Assets (VS/A)	Ratio	2.1	NA	NA	1.7	1.2-2.1	2
3. Fixed Assets/Value of Shipments (FA/VS)	Ratio	0.25	NA	0.25	0.27	0.2-0.25	0.25
4. Current Assets/Value of Shipments (CA/VS)	Ratio	0.25	NA	NA	0.35	0.3-0.5	0.25
5. Fixed Assets/Total Assets (FA/TA)	Ratio	0.5	NA	NA	0.38	0.3-0.6	0.50
6. Baseline ROI	Percent	19	NA	NA	8.4	5-13	12
7. Tax Rate	Percent	29	NA	NA	30	33-50	30%[6]
8. Salvage Value (SV)	Percent	NA	X	NA	NA	NA	
Current Assets							100
Fixed Assets							30[5]
Average							65%
9. Annual Capital Exp./VS (CAP EXP/VS)	Percent	NA	NA	5.8	NA	5-6	5
10. Depreciation/Value Shipments (DEP/VS)	Percent	NA	NA	NA	2.5	2-4	2.5
11. Cost of Capital (COC)	Percent	NA	NA	NA	NA	NA	13

[1] Lead-Acid Battery Manufacture--Background Information for Proposed Standards, EPA 450/3-79-028a, EPA, Office of Air Quality Planning and Standards, November 1979.

[2] Federal Trade Commission, Quarterly Financial Reports for Electrical and Electronics Equipment, 1977-1978.

[3] For Eltra Corp.; ESB, Inc.; Globe Union, Inc.; Gould, Inc.; P.R. Mallory; Eagle Pitcher Industries, Inc.; Union Carbide Corp.; Northwest Industries; and General Electric Company.

[4] The consensus is used as the baseline value.

[5] Assumptions based on industry sources.

[6] A sensitivity analysis at 40 percent was also used.

X = Qualitative information provided.

NA = Not available or applicable.

Threshold Value for IRR Analysis

The threshold value for the IRR calculations is the cost of capital, which is defined as the weighted average of cost of equity and cost of debt, that is:

$$k = \frac{(i \times D) + (e \times E)}{D + E}$$

where:

k = Discount rate

i = Interest rate of debt capital

e = Cost of equity capital

D = Debt capital

E = Equity capital.

Interest rates on commercial loans are generally 1 to 2 percentage points above prime interest rates (i.e., interest rates that banks usually charge their best, most credit-worthy creditors). Data Resources, Inc. (DRI) forecastes that prime rates between 1985 and 1995 would average about 10.5 percent.[1] Assuming a premium of 1.5 percent, it is projected that interest rates on debt would average about 12 percent over that period of time.

For this study, cost of equity is defined as the rate of return on a risk-free investment such as the U.S. Treasury Bond plus a risk premium factor. The DRI forecasts show that 10-year U.S. Treasury Bond yields would average about 9 percent over the 1985-1995 time period.2 In the financial literature, the long-run normal risk premium on stock investment is estimated to be 5 percent.[3] As the result, the cost of equity is expected to average around 14 percent.

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[1]Data Resources, Inc., U.S. Long-Term Review, Winter 1982-1983.

[2]Ibid.

[3]Alfred Rappaport, "Strategic Analysis for More Profitable Acquisitions", Harvard Business Review, July-August 1979.

Finally, the Federal Trade Commission's Quarterly Financial Report indicates that book values of debt and equity in the electrical and electronic equipment industry each average approximately 50 percent of total capital during 1978-1982. As indicated in Table A-3, the salvage values of assets average approximately 65 percent of book value. Since debt is due in full at liquidation of the plant, it actually represents about 77 percent of the plant liquidation value (50 ÷ 65 = 0.77), and equity accounts for 23 percent. Thus, the cost of capital of the nonferrous metals forming industry is estimated to be 12.5 percent ([12 x 0.77] + [14 x 0.23]). This figure is rounded out to 13 percent to insure a conservative plant closure threshold value.

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:

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

n

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

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

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

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.

APPENDIX B

COMBINED IMPACTS OF OSHA 150 and 50 $\mu g/m^3$ PELS

This appendix presents an evaluation of the sensitivity of the economic impact estimates presented in Chapters 7 and 8 to the promulgation of the OSHA standards for the occupational exposure to lead.

BACKGROUND

In 1978 the Occupational Safety and Health Administration promulgated standards for occupational exposure to lead in the battery manufacturing and other industries. A 150 $\mu g/m^3$ permissible exposure limit (PEL) became effective in 1983 and a 50 $\mu g/m^3$ PEL is scheduled to become effective in 1986. OSHA estimated that these regulations will cause price increases of 3 to 5 percent and the shutdowns of 42 small and 5 medium-sized plants.[1] Because compliance with the OSHA regulations is quite costly and may cause a significant number of closures of small and medium-sized plants, the results of the EPA economic impact analysis described in Chapters 7 and 8 may require modification. To evaluate this possibility, the industry baseline analysis is modified to incorporate the impacts of the OSHA costs.

APPROACH

To assess the impact of the OSHA rules on the lead-acid plants in EPA's data base, cost of compliance with the OSHA rules was estimated for the plants in EPA's data base and the profit impact analysis methodology described in Chapter 2 is applied. The cost estimates are based on those in the OSHA economic impact analysis report and are shown in Table B-1. These estimates

[1]Occupational Safety and Health Administration, Economic and Environmental Analysis of the Current OSHA Lead Standard, CRA Project No. 536.60, submitted by Charles River Associates, 1982.

TABLE B-1. SUMMARY OF OSHA COMPLIANCE COSTS FOR LEAD-ACID BATTERY PLANTS (150 $\mu g/m^3$ plus 50 $\mu g/m^3$ PEL)

PLANT SIZE (Batteries/Day)	ANNUAL COST[a] ($ per Battery)			ANNAUL COST AS PERCENTAGE OF REVENUES[b] (%)
	150 PEL	50 PEL	TOTAL ANNUAL OSHA COSTS	
<300	7.45	0	7.45	31.0
301 - 500	2.58	0	2.58	10.7
500 - 1,200	2.01	0	2.01	8.4
1,200 - 3,000	1.52	0	1.52	6.3
>3,000	0.94	.24	1.18	4.9

[a]Unweighted averages for plants in the OSHA study inflated to 1983 dollars using Engineering News Record Construction Cost Index.

[b]This ratio uses a price of $24 per battery.

SOURCE: OSHA, Economic and Environmental Analysis of Current OSHA Lead Standard, CRA Project No. 536.60, submitted to OSHA by Charles River Associates, 1982.

are extrapolated to the EPA data base on the basis of plant size. Other information that may be pertinent to a plant-by-plant cost estimation, such as equipment in place or plant-specific financial data, is not available. For this reason, these estimates are considered an approximation of what OSHA costs might be for specific size groupings, rather than a precise set of plant-specific compliance costs.

RESULTS

Using the pricing algorithms presented in Chapter 2, the price increase expected to result from the combined 150 and 50 PELs is 5 percent. Given these price changes large plants (>3000 batteries per day) and intermediate-sized plants (1,201-3,000 batteries per day) will experience only small declines in profit margins (<1 percent). These profit declines are not enough to cause plant closures. Plants in the 501-1,200 batteries per day group will experience greater profit margin reductions. Although these profit changes are substantial (about 3 percent of revenues on average), most of these plants can remain in operation. However, the smaller plants (under 500 batteries per day) will not remain financially viable, according to the ROI and IRR tests. These plants experience annual compliance costs above 10 percent of revenues and will experience ROIs below the threshold value of 6 percent and IRRs below the 13 percent threshold. Forty-four of the 111 plants in EPA's data base fall into this size group. These plants account for about 2 percent of U.S. production of lead-acid batteries.

IMPLICATIONS FOR EPA ECONOMIC IMPACT ANALYSIS

The EPA economic impact analysis utilized a two-stage profit analysis test. First, in a "screening analysis," all lead-acid battery plants expected to experience profit margin declines of more than 1 percent of revenues are enumerated. Fifteen of the 111 plants are in this category. These plants are then subjected to a more detailed financial analysis using return on investment and internal rate of return ratios. All other plants will experience minimal economic impacts. Fourteen of the 15 plants screened out would close due to the OSHA rules, according to the above analysis of the impacts of the OSHA standards. Each of the remaining 96 plants in EPA's data base would experience extremely small compliance costs in comparison to their revenues and would not close due to the effluent guidelines. Moreover, the price impact of the effluent guidelines is also small relative to that of the OSHA rule (0.3 percent versus 5 percent). Thus, the incremental impacts of the effluent guidelines are minor.

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The U.S. EPA issued effluent guidelines and limitations for the Battery Manufacturing Point Source Category in March, 1984. This report estimates the economic impact of pollution control costs in terms of price changes, effects on profitability potential plant closures, unemployment, and other secondary effects. A plant by plant analysis of the 149 battery manufacturing facilities that are expected to incur costs as a result of this regulation was conducted.

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