BACKGROUND REPORT

AP-42 SECTION 12.15

STORAGE BATTERY PRODUCTION

Prepared for

U.S. Environmental Protection Agency
OAQPS/TSD/EIB
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AP-42 Background Report

TECHNICAL SUPPORT DIVISION

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

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1.0 INTRODUCTION

The document "Compilation of Air Pollutant Emission Factors" (AP-42) has been published by the U.S. Environmental Protection Agency (EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by the EPA to respond to new emission factor needs of the EPA, state, and local air pollution control programs, and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

1. Estimates of area-wide emissions;
2. Emission estimates for a specific facility; and
3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information from process information obtained from industry comment and 50 test reports to support revision of emission factors for the storage battery production industry.

Including the introduction (Chapter 1), this report contains four chapters. Chapter 2 gives a description of the storage battery production industry. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from storage battery production industry.

Chapter 3 is a review of the emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Chapter 4 details criteria and noncriteria pollutant emission factor development. It includes the review of specific data sets and the results of data analysis.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL

The battery industry is divided into two main sectors: starting, lighting, and ignition (SLI) batteries and industrial/traction batteries. SLI batteries are primarily used in automobiles. Industrial batteries include those used for uninterruptible power supply and traction batteries are used to power electric vehicles such as forklifts. Lead consumption in the U.S. in 1991 was estimated to be 1.2 million megagrams (1.32 million tons); between 75 and 80 percent of this is attributable to the manufacture of lead acid storage batteries[8].

Lead acid storage battery plants range in production capacity from less than 500 batteries per day to about 20,000 batteries per day. Lead acid storage batteries are produced in many sizes, but the majority are produced for use in automobiles and fall into a standard size range. A standard automobile battery contains about 11.8 kilograms (26 lbs) of lead, of which about half is present in the lead grids and half in the lead oxide paste[9].

2.2 PROCESS DESCRIPTION

Lead acid storage batteries are produced from lead alloy ingots, sheet lead, and lead oxide. The lead oxide may be prepared by the battery manufacturer, as is the case for many larger battery manufacturing facilities, or may be purchased from a supplier. (See AP-42 Section 12.16.)

Battery grids are manufactured by either casting (SCC# 3-04-005-06) or stamping (SCC# 4-04-005-99) operations[10, 11]. In the casting operation, lead alloy ingots are charged to a melting pot, from which the molten lead flows into molds that form the battery grids. The stamping operation involves cutting or stamping the battery grids from lead sheets. The grids are often cast or stamped in doublets and split apart (slitting) after they have been pasted with either negative or positive paste and cured. The pastes used to make the battery grids are made in batch-type processes. In the paste mixing process (SCC# 3-04-005-07), a mixture of lead oxide powder, water, and sulfuric acid solution produces a positive paste, and the same ingredients in slightly different proportions with the addition of an extender (generally a mixture of barium sulfate, carbon black, and organics), make the negative paste. Pasting machines then force these pastes into the interstices of the grids, after which they are referred to as plates. At the completion of this process, the plates are flash dried, and then stacked and sent to curing ovens. These ovens most often operate under conditions of high humidity, but occasionally supply only dry heat, depending upon the desired plate characteristics.

After the plates are cured they are sent to the three-process operations (SCC# 3-04-005-09) of plate stacking, plate burning, and plate assembly into elements (Figure 2.2-1 illustrates schematically the lead acid battery manufacturing process[10]). In this process the doublet plates are first cut apart and stacked in an alternating positive and negative block formation, with insulators sandwiched between them. These insulators are made of materials such as wood, treated paper, plastic, or rubber. Many plants now insert the positive plates in envelopes, and then stack the plates rather than using separators. Leads are then welded to tabs on each plate, fastening the assembly (element) together. Then a positive and a negative terminal are welded to the element. This is the burning operation. An alternative to this operation is the cast-on strap process, in which molten lead is poured around the plate tabs to form the connection and terminals.

During formation (SCC# 3-04-005-12), the inactive lead oxide-sulfate paste is chemically converted into active electrodes. The battery plates/elements are immersed in a dilute sulfuric acid solution; the positive plates are connected to the positive pole of a direct current (DC) source and the negative plates connected to the negative pole of the DC source. In the wet formation process, the elements are assembled into the battery case before formation. After formation, in some instances the acid is dumped, fresh acid is added, and a boost charge is applied to complete the battery. In dry formation, the plates are formed in several ways. Some plates are individually formed in tanks of sulfuric acid solution before the three-process operation and then assembled into the battery cases and shipped dry. Most, however, are assembled into elements before formation, and the completed elements are then formed in large tanks of sulfuric acid solution. The formed elements are dried and placed in the battery cases, and the batteries are shipped dry. Other batteries shipped without acid electrolyte include damped-charged batteries (damp batteries). These batteries are assembled and charged in a similar procedure as wet batteries, then the acid is drained, and the batteries are shipped damped. Defective parts are either reclaimed (SCC# 3-04-005-10) at the battery plant or are sent to a secondary lead smelter (See AP-42 Section 12.11). Lead reclamation facilities at battery plants are generally small pot furnaces.

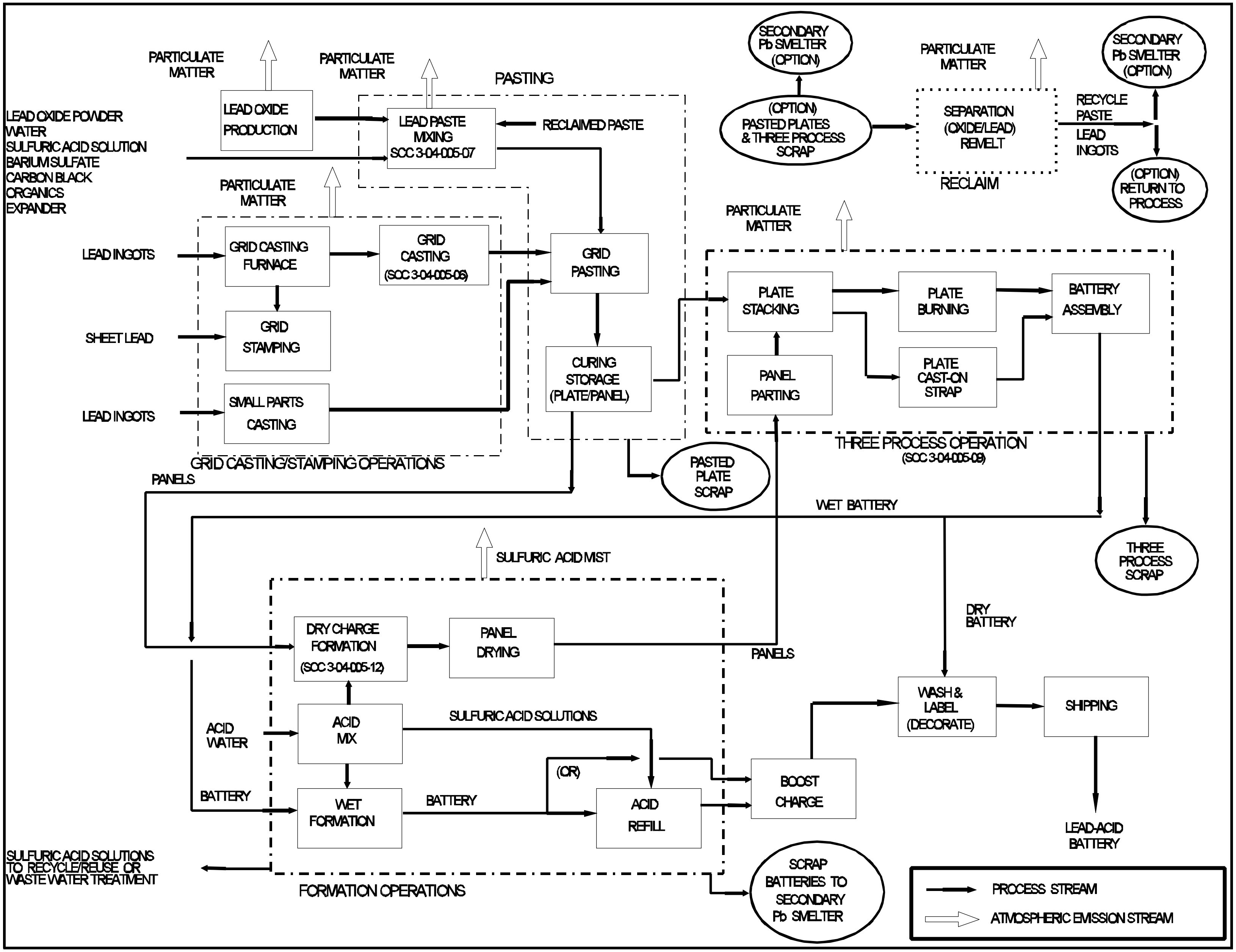

Figure 2.2-1 Process flow diagram for storage battery production

2.3 EMISSIONS AND CONTROLS

Lead oxide emissions result from the discharge of air used in the lead oxide production process. A fabric filter is generally used as part of the process/control equipment to capture particulate emissions from lead oxide facilities. Typical air-to-cloth ratios of fabric filters used for these facilities range from 2:1 to 4:1.

Emissions from grid casting are often uncontrolled. Some plants have used low-energy wet scrubbers and in some cases fabric filters to control these exhausts. Wet collectors (Type N-Roto-Clone) with a control efficiency of 90 percent is a common scrubbing device used for grid casting. Frequently, grid casting machines and furnaces are vented along with other operations, such as small parts casting and lead reclamation.

The paste mixing operation consists of two steps. The first, in which dry ingredients are charged to the mixer in a batch-type operation, can result in significant emissions of lead oxide. These emissions are usually collected and ducted through a baghouse or a Type N-Roto-Clone scrubber during mixing. During the second step, when moisture is present in the exhaust stream, emissions from the paste mixer are generally collected and ducted to a wet or dry collector. Type N-Roto-Clone with a collection efficiency of 90 percent is frequently used to control mixing operations. Also, bag filters with air-to-cloth ratios ranging from 4:1 to 8:1 can reduce lead emissions by 98 percent.

Fabric filters or scrubbers are used to control the three-process operations. Most plants vent the stacking, burning, and assembly operations into a common duct prior to cleaning. Other plants combine the three-process exhaust with other processes exhaust with a common control system. Fabric filters with an air-to-cloth ratio of 6:1 to 7:1 are used to control three-process operations. The resultant lead control efficiency is higher than 97 percent. Scrubbers with a lead removal efficiency of 90 percent are also used to control three-process emissions.

Sulfuric acid mist emissions are generated during the formation step. Acid mist emissions are significantly higher for dry formation processes than for wet formation processes because wet formation is conducted in battery cases (closed process), while dry formation is conducted in dilute acid-filled open tanks. Plants which do duct emissions from the work area use either foam, scrubber, mist eliminators, or combinations to control the acid mist emissions. Emission control practices include keeping the battery filter cap on the battery during formation, or using a dummy, reusable cover which helps in reducing emissions. Emissions of sulfuric acid mist from dry formation processes can be reduced up to 95 percent.

In conclusion, emission reductions of 97 percent and above can be obtained when fabric filtration is used to control slitting, paste mixing, and the three-process operation. Applications of scrubbers to paste mixing, grid casting, and lead reclamation facilities can result in emission reductions of 90 percent or better. New control techniques include cartridge dust collectors and High Efficiency Particulate Air Filters (HEPA Filters). The cartridge collectors are used as a primary control device and are similar to bag filters, except that they have cartridges instead if filters. Cartridges allow more filter area and easier/safer maintenance. HEPA Filters are most often used as a secondary control device following a bag filter or a cartridge[12].

Table 2.3-1 presents average controlled lead and particulate emission factors unless otherwise indicated. The data presented in Table 2.3-1 were developed from the 50 emission tests that Pacific Environmental Services (PES) received for the industry and from the previous AP-42 document (August/1982). The lead emission factors were all developed from the new emission tests received, except for the lead reclaim process. The particulate emission factors were obtained from the previous AP-42 section except for the grid casting process. The emission factors obtained from the previous AP-42 section were checked by reviewing References 1 through 7 which were the cited references in the previous AP-42 section. PES could not redevelop these emission factors from the cited references, because some of the references could not be obtained and others were illegible.

For the grid casting process, the controlled emission factor was higher than the uncontrolled emission factor. Note that the existing controlled process emission factor was developed from six source tests that represented the same plant; therefore, this condition could be representative of this plant only because of the product and/or the processes used. However, other operations performed on the grids after they are casted, such as grid shaping and cleaning, could also provide an explanation for this case if they are vented to the same baghouse. No information regarding this matter was given in the source tests that PES has investigated, and PES is uncertain if this is the common practice followed by industry. For this reason, both controlled and uncontrolled emission factors for the grid casting operation are presented. The lead emission factors presented in Table 2.3-1 represent emission of lead in elemental and compound form, while the particulate emissions include lead and its compounds. All particulate emission factors derived from the previous AP-42 section (August/1982) were converted to kg/Mg and lb/ton based on the assumption that there are 11.8 kg (26 lb) of lead in an automotive battery.

TABLE 2.3-1 (METRIC UNITS)
STORAGE BATTERY PRODUCTION EMISSION FACTORS

All Emission Factors are in kg/Mg Lead Produced
Ratings (A-E) Follow Each Factor

Process	Particulate Matter[k]	Rating	Lead[l]	Rating
Grid casting[a] (3-04-005-06)	0.115[b] 0.0328[c]	C C	0.00775[b] 0.00254[c]	C C
Paste process[d] (3-04-005-07)	0.166[i]	E	0.0365	B
Lead oxide production[e] (3-04-005-24)	0.0043[j]	E	0.00372	B
Three-process operation[f] (3-04-005-09)	3.56[i]	E	0.012	B
Lead reclaim furnace[g] (3-04-005-10)	0.257[i]	E	0.0530[i]	E
Dry formation (3-04-005-12)	1.25[i]	E	0.00011	D
Total production	(h)		(h)	

[a]Includes melting and casting operations.

[b]Controlled process, emission data obtained from 6 source for a single source.

[c]Uncontrolled process, emission data obtained from 6 source tests for three sources.

[d]Paste mixing consists of paste mixing, plate curing, and storing operations. Plate curing operation is uncontrolled.

[e]Includes emissions from the melting pot process, transfer system, and storage operation. Emissions from the melting pot are uncontrolled.

[f]Three-process operation consists of cast on strap line and central vacuum system.

[g]Based on the assumption that about 1 percent of the lead processed at a typical battery plant is processed by the reclaim operation.

[h]Totals should be calculated on a case-by-case basis to reflect the specific process operations employed at each individual facility.

[i]Uncontrolled emissions. Based on standard automotive batteries of 11.8 kg (26 lbs) of lead, of which half is present in the lead grids and half in the lead oxide paste.

[j]Baghouse outlet emissions. Based on standard automotive batteries of 11.8 kg (26 lbs) of lead, of which half is present in the lead grids and half in the lead oxide paste.

[k]Emission factors determined from References 1-7 except for the grid casting process.

[l]Emission factors determined from References 13, 15-21, 23-32, 34-37, 40, 42-57, & 62 listed in Section 4.5.

TABLE 2.3-1 (ENGLISH UNITS)
STORAGE BATTERY PRODUCTION EMISSION FACTORS
All Emission Factors in lb/ton Produced
Ratings (A-E) Follow Each Factor

Process	Particulate Matter[k]	Rating	Lead[l]	Rating
Grid casting[a] (3-04-005-06)	0.230 0.0655	C C	0.0155[b] 0.00507[c]	C C
Paste process[d] (3-04-005-07)	0.332[i]	E	0.073	B
Lead oxide production[e] (3-04-005-24)	0.0085[j]	E	0.00743	B
Three-process operation[f] (3-04-005-09)	12.12[i]	E	0.024	B
Lead reclaim furnace[g] (3-04-005-10)	0.514[i]	E	0.106[i]	E
Dry formation (3-04-005-12)	2.49[i]	E	0.00022	D
Total production	(h)		(h)	

[a]Includes melting and casting operations.
[b]Controlled process, emission data obtained from 6 source for a single source.
[c]Uncontrolled process, emission data obtained from 6 source tests for three sources.
[d]Paste mixing consists of paste mixing, plate curing, and storing operations. Plate curing operation is uncontrolled.
[e]Includes emissions from the melting pot process, transfer system, and storage operation. Emissions from the melting pot are uncontrolled.
[f]Three-process operation consists of cast on strap line and central vacuum system.
[g]Based on the assumption that about 1 percent of the lead processed at a typical battery plant is processed by the reclaim operation.
[h]Totals should be calculated on a case-by-case basis to reflect the specific process operations employed at each individual facility.
[i]Uncontrolled emissions. Based on standard automotive batteries of 11.8 kg (26 lbs) of lead, of which half is present in the lead grids and half in the lead oxide paste.
[j]Baghouse outlet emissions. Based on standard automotive batteries of 11.8 kg (26 lbs) of lead, of which half is present in the lead grids and half in the lead oxide paste.
[k]Emission factors determined from References 1-7 except for the grid casting process.
[l]Emission factors determined from References 13, 15-21, 23-32, 34-37, 40, 42-57, & 62 listed in Section 4.5.

2.4 REVIEW OF SPECIFIC DATA SETS

Pacific Environmental Services (PES) contacted the following sources to obtain the most up-to-date information on process descriptions and emissions for this industry:

1) Alabama Department of Environmental Management, Air Division, ADEM, Montgomery, AL.
2) Battery Council International (BCI), Washington, DC.
3) Florida Department of Environmental Regulation, Tallahassee, FL.
4) Georgia Department of Natural Resources, Atlanta, GA.
5) Jefferson County Air Pollution Control Bureau, Louisville, KY.
6) Johnson Controls, Jefferson City, FL.
7) Kansas Department of Health and Environment, Topeka, KS.
8) Lead Industries Association (LIA), New York, NY.
9) Michigan Department of Natural Resources, Lansing, MI.
10) Missouri Department of Natural Resources, Jefferson City, MI.
11) Pennsylvania Department of Environmental Resources, Harrisburg, PA.

Responses were received from two sources, contacts 2 and 5. The data received from contact 2, Battery Council International (BCI) (Reference 10) consisted of new process information and emission factors for the battery industry. PES has modified the process description and the process flow diagram of the AP-42 section to incorporate the new information received from BCI. The revised emission factors developed by BCI were not incorporated in the section revision, because PES could not obtain the primary sources (emission tests) that were the basis for these emission factors. The data received from contact 5, Jefferson County Air Pollution Control Bureau, consisted of two source tests that PES has used in developing the new lead emission factors for the section revision. PES received over 40 source tests from the Emission Standards Division, Office of Air Quality Planning and Standards, U.S. EPA (EPA/OAQPS/ESD). The data contained in the source tests received from ESD and contact 5 allowed PES to develop new emission factors for the industry. As a result, several emission factors were modified. The corresponding emission factors were listed earlier in Section 2.3, and a detailed analysis is presented in Chapter 4. For the remaining emission factors, References 1 through 7 were used for verification purposes. These were the cited references in the previous AP-42 section (August/1982). A discussion of the data obtained from References 1 through 7 is presented in Chapter 4.

A brief discussion of the references used in revising the AP-42 section is given below.

References 8 and 9

Reference 8, *Mineral Commodity Summaries*, 1992, was used in obtaining the estimated U.S. lead consumption in 1991, and the percentage that is attributed to the lead acid storage batteries. Reference 9, *Metals and Minerals*, included a more detailed description of the different types of batteries produced and provided the range of batteries produced per day in the U.S..

Reference 10

Reference 10 consisted of a letter from Mr. Jean Beaudoin of the Battery Council International (BCI). It included of a list of the current (1992) battery plants in the U.S., a description of the current processes and control techniques used in industry, and a revised version of the process flow diagram for storage battery production. It also included updated emission factors for the industry which BCI has developed. The revised process information and flow diagrams were incorporated in the AP-42 section revision. However, the emission factors developed by the BCI were not used, because PES did not obtain any emission tests that would verify the data. The emission factors developed by BCI are presented in Section 4.3 as background information.

Reference 11

General process information was discussed in Reference 11, *Guidance Manual for Battery Manufacturing Pretreatment Standards*. The process description gathered from this reference was in accordance with the methods illustrated by the BCI. As a result, PES added the stamping/cutting process for grid manufacturing in the section revision.

Reference 12

Detailed descriptions of each process in the battery industry were discussed in Reference 12, *Review of New Source Performance Standards for Lead-Acid Battery Manufacture*. PES has incorporated this information when applicable, along with the identification of the control devices used for each process, and their corresponding efficiencies when available. New control techniques for the industry were also obtained from this source.

2.5 REFERENCES FOR CHAPTER 2

1. Lead Acid Battery Manufacture—Background Information for Proposed Standards, EPA 450/3-79-028a, U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1979.

2. Source Test. EPA-74-BAT-1. U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1974.

3. Source Testing of a Lead Acid Battery Manufacturing Plant—Globe-Union, Inc., Canby, OR, EPA-76-BAT-4, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1976.

4. R.C. Fulton and C.W. Zolna. Report of Efficiency Testing Performed April 30, 1976, on American Air Filter Roto-Clone, Spotts, Stevens, and McCoy, Inc., Wyomissing, PA, June 1, 1976.

5. Source Testing at a Lead Acid Battery Manufacturing Company—ESB, Canada, Ltd., Mississauga, Ontario, EPA-76-3, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1976.

6. Emissions Study at a Lead Acid Battery Manufacturing Company—ESB, Inc., Buffalo, NY, EPA-76-BAT-2, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1976.

12. Test Report—Sulfuric Acid Emissions from ESB Battery Plant Forming Room, Allentown, PA, EPA-77-BAT-5. U.S. Environmental Protection Agency, Research Triangle Park, NC, 1977.

8. William D. Woodbury, Mineral Commodity Summaries, Lead, U.S. Department of the Interior Bureau of Mines, 1992.

9. Metals and Minerals, Minerals Yearbook, Volume 1, U.S. Department of the Interior, Bureau of Mines, 1989.

10. Letter from Jean M. Beaudoin and Mark T. Wright, Battery Council International, Washington, DC, to B. Richani, Pacific Environmental Services, July 1992.

11. Guideline Manual for Battery Manufacturing Pretreatment Standards, (Technical Report), Science Applications International Corporation, McLean, VA, August 1987.

12. Review of New Source Performance Standards for Lead-Acid Battery Manufacturing, U. S. Environmental Protection Agency, Research Triangle Park, NC, October 1989.

3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

The first step of this investigation involved a search of available literature relating to criteria and noncriteria pollutant emissions associated with the lead-acid battery manufacturing industry. This search included the following references:

AP-42 background files maintained by the Emission Factor and Methodologies Section. From these files, PES obtained all data necessary to verify emission factors in the 1982 version. The base process unit for battery manufacturing emission factor was changed from "number of batteries produced" to "weight of lead content in batteries produced" . Therefore, the emission factors were converted to kg/Mg and lb/ton instead of kg/1000 batteries and lbs/1000 batteries in order to be consistent with other AP-42 sections, and the transposed emission factors were downrated to "E" (refer to chapter 4 for more details). No other modifications were made to the emission factors that were transposed from the 1982 version.

Files maintained by the Emission Standards Division. PES obtained 48 source tests from this reference. These source tests are listed in Section 4.5, and were used in updating the emission factors for the battery production industry. The source tests covered most of the processes implemented in the industry, and the data developed resulted in the modification of several emission factors as listed earlier in Section 2.3. Details of the methods used in developing these emission factors are presented in Section 4.3.

"Locating and Estimating" reports (as applicable) published by the Emission Factor and Methodologies Section. No documents were received from the L&E reports for the battery production industry.

PM_{10} "gap filling" documents such as "PM_{10} Emission Factor Listing Developed by Technology Transfer" (EPA-450/4-89-022), "Gap Filling PM_{10} Emission Factors for Selected Open Area Dust Sources" (EPA-450/88-003), and "Generalized Particle Size Distributions for Use in Preparing Size Specific Particulate Emission Inventories" (EPA-450/4-86-013). PES found applicable emission factors which were developed on assumptions and not actual data (source tests). The accuracy of the assumed PM_{10} data is in doubt.

Information in the *Air Facility Subsystem* (AFS) of the EPA *Aerometric Information Retrieval System* (AIRS). PES compared data in the AIRS to the AP-42 section (August/1982). Three discrepancies were found that involved the particulate emissions for the grid casting, paste mixing, and the three-process operation. Note that the lead emissions for these process were in accordance with the 1982 AP-42 section. Upon review of the data in both the AP-42 section and the AIRS document, it is concluded that the particulate data in the AIRS are incorrect for the three specified processes. It appears that the AIRS data for these processes were developed by taking the metric AP-42 emission factor and multiplying it by a factor of 2. This would be correct if the emission factors in the AP-42 section were presented in kg/Mg units instead of kg/1000 batteries. Also, note that the emission factors presented for PM_{10} in the AIRS were obtained based on the assumption discussed in the earlier source; therefore, PES recommends that the particulate emission factors be corrected in the AIRS , and the PM_{10} emission factors for the industry be verified or deleted.

The EPA *Clearinghouse for Inventories and Emission Factors* (CHIEF) and *National Air Toxics Information Clearinghouse* (NATHIC), the *VOC/Particulate Matter* (PM) *Speciation Database Management System* (SPECIATE), and the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF). PES did not obtain any information from these sources for the battery industry.

To reduce the amount of literature collected to a final group of references pertinent to this report, the following general criteria were used:

1. Emissions data must be from a primary reference; i.e., the document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document.
2. The referenced study must contain test results based on more than one test run.
3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

If no primary data were found and the previous update utilized secondary data, these secondary data were still used and the emission factor rating lowered, if needed. A final set of reference materials was compiled after a thorough review of the pertinent reports, documents, and information according to these criteria. The final set of reference materials is discussed in Chapter 4.0.

3.2 EMISSION DATA QUALITY RATING SYSTEM

As part of Pacific Environmental Services' analysis of the emission data, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were always excluded from consideration.

1. Test series averages reported in units that cannot be converted to the selected reporting units;
2. Test series representing incompatible test methods (e.g., comparison of the EPA Method 5 front-half with the EPA Method 5 front- and back-half);
3. Test series of controlled emissions for which the control device is not specified;
4. Test series in which the source process is not clearly identified and described; and
5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Data sets that were not excluded were assigned a quality rating. The rating system used was that specified by the OAQPS for the preparation of AP-42 sections. The data were rated as follows:

A

Multiple tests performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in the EPA reference test methods, although these methods were certainly used as a guide for the methodology actually used.

B

Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

C

Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

D

Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.
2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent such alternative procedures could influence the test results.
3. Sampling and process data. Adequate sampling and process data are documented in the report. Many variations can occur unnoticed and without warning during testing. Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and were given a lower rating.
4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by the EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

3.3 EMISSION FACTOR QUALITY RATING SYSTEM

The quality of the emission factors developed from analysis of the test data was rated utilizing the following general criteria:

A (Excellent)

Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

B (Above average)

Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. As in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

C (Average) Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

D (Below average)

The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of the emission factor are noted in the emission factor table.

E (Poor)

The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

The use of these criteria is somewhat subjective and depends to an extent on the individual reviewer.

3.4 REFERENCES FOR CHAPTER 3

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections. U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1992. [Note: this document is currently being revised at the time of this printing.]

2. AP-42, Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, October 1986.

3. AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants, EPA 450/4-90-003, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1990.

4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT

4.1 CRITERIA POLLUTANT EMISSIONS DATA

Lead.

Lead is the main pollutant tested for in the battery production industry. The industry applies various control techniques including baghouses, low energy wet scrubbers, cartridge collectors, and secondary high efficiency particulate air filters. PES received 50 new source tests (References 13 through 62) for lead emissions from the battery industry. Ten source tests (References 14, 22, 33, 38, 39, 41, 58, 59, 60, and 61) did not include process data which is necessary to develop emission factors. Ten other source tests were excluded from the emission factors development. This is due to situations such as the methods practiced (e.g., venting more than one major process to the same control device), or the production units used in presenting the data without any information regarding the product weight (e.g., lbs/battery). These references are identified and discussed in the appropriate emission factor development sections.

Lead emission factors presented in Table 2.3-1 were developed from the applicable new source tests (30 tests) except for the lead reclaim process. Sufficient data were not available to justify a change in the present emission factor for the lead reclaim process. Note that for the lead reclaim process, the presented emission factor in the AP-42 section was developed based on the assumption that 1 percent of the lead processed at a typical battery plant is processed by the reclaim operation. PES recommends that this assumption be reviewed since battery plants are currently more efficient than in 1982. A single, total production emission factor was not presented, because this must be calculated on a case-by-case basis to reflect the specific processes employed at each plant.

This section presents the new data in support of the developed new lead emission factors presented in Table 2.3-1. It is divided into six parts to represent corresponding processes. Tables 4.1-1 through 4.1-9 illustrate the data gathered from each source test and the rating assigned to each test.

Grid Casting Process

The grid casting process includes the melting and casting operations. Twelve source tests (References 16, 24, 28, 36, 43, 44, 45, 46, 47, 48, 52, and 53) were used in developing the emission factor for this process. Both controlled and uncontrolled emission factors were developed. The controlled emission factors were developed from References 28, 44, 45, 46, 47, and 48. All six source tests were conducted for the same plant. Baghouse and Roto-Clone control devices were used. The controlled lead emission factor for this process was developed by averaging the results of the six tests:

EF_1 (Emission Factor, Grid Casting controlled)

$$= (0.0131 + 0.0118 + 0.00601 + 0.0171 + 0.0259 + 0.0192) \text{ lb/ton} / 6$$

$$= 0.0155 \text{ lb/ton.}$$

The uncontrolled emission factor was calculated from References 16, 24, 36, 43, 52, and 53. References 24, 43, 52, and 53 were tests conducted on the same plant, and Reference 16 included two tests for a different plant. The following calculation was used in developing the uncontrolled process emission factor:

EF_2 (Emission Factor, Grid Casting Uncontrolled)

$$= [(0.00750 + 0.00649 + 0.00376 + 0.00317) / 4 + (0.00110 + 0.000830) / 2 + 0.00902] \text{ lbs/ton} / 3$$

$$= 0.00507 \text{ lbs/ton.}$$

Note that the uncontrolled process reflects lower emissions than the controlled process. Since the controlled emission factor was developed from six sources tests conducted for the same plant, the emission factor developed could be as a result of operating procedures and processes at that plant, or it could be a result of other small operations such as grid cleaning, shaping, etc. which are performed on the grids and controlled using the same baghouse. PES did not obtain any information which could explain this situation, and the emission factor developed for this process is rated "C". The data for the grid casting process are presented in Tables 4.1-1 and 4.1-2. Reference 34 contained emission data for the uncontrolled grid casting operation. It was not included in the emission factor development because the process data for the grid casting operation were not provided.

TABLE 4.1-1 (METRIC UNITS)
LEAD: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
28	A	12	1	467.2	0.00490	0.0105
			2	467.2	0.00156	0.00335
			3	467.2	0.00273	0.00585
			Average	467.2	0.00306	0.00655
Control device: Baghouse						
44	B	12	1	631.4	0.00128	0.00203
			2	631.4	0.00413	0.00655
			3	631.4	0.00581	0.00920
			Average	631.4	0.00375	0.00593
Control device: Roto-Clone						
45	A	12	1	593.3	0.00177	0.00298
			2	593.3	0.00180	0.00303
			3	593.3	0.00178	0.00301
			Average	593.3	0.00178	0.00301
Control device: Roto-Clone						
46	A	12	1	610.1	0.00726	0.0119
			2	610.1	0.00485	0.00795
			3	610.1	0.00348	0.00570
			Average	610.1	0.00522	0.00855

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-1 (METRIC UNITS) (*concluded*)
LEAD: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Roto-Clone						
47	A	12	1	575.2	0.0135	0.0235
			2	575.2	0.00762	0.0132
			3	575.2	0.00122	0.00212
			Average	575.2	0.00744	0.0129
Control device: Baghouse						
48	A	12	1	631.4	0.00753	0.0119
			2	631.4	0.00342	0.00540
			3	631.4	0.00726	0.0115
			Average	631.4	0.00608	0.00960

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-1 (ENGLISH UNITS)
LEAD: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
28 Grid Casting	A	12	1	1030	0.0108	0.0210
			2	1030	0.00345	0.00670
			3	1030	0.00601	0.0117
			Average	1030	0.00675	0.0131
Control device: Baghouse						
44 Grid Casting	B	12	1	1392	0.00283	0.00407
			2	1392	0.00911	0.0131
			3	1392	0.0128	0.0184
			Average	1392	0.00826	0.0118
Control device: Roto-Clone						
45	A	12	1	1308	0.00391	0.00598
			2	1308	0.00396	0.00606
			3	1308	0.00393	0.00601
			Average	1308	0.00393	0.00601
Control device: Roto-Clone						
46	A	12	1	1345	0.0160	0.0238
			2	1345	0.0107	0.0159
			3	1345	0.00767	0.0114
			Average	1345	0.0115	0.0171

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-1 (ENGLISH UNITS) (*concluded*)
LEAD: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Roto-Clone						
47	A	12	1	1268	0.0297	0.0469
			2	1268	0.0168	0.0265
			3	1268	0.00268	0.00423
			Average	1268	0.0164	0.0259
Control device: Baghouse						
48	A	12	1	1392	0.0166	0.0238
			2	1392	0.00753	0.0108
			3	1392	0.0160	0.0230
			Average	1392	0.0134	0.0192

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-2 (METRIC UNITS)
LEAD: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
16a	B	12	1	319.2	0.00018	0.00055
			2	319.2	0.000060	0.000030
			3	319.2	0.00027	0.00014
			Average	319.2	0.00017	0.000090
Control device: None						
16b	B	12	1	418.7	0.00041	0.00098
			2	418.7	0.000068	0.00016
			3	418.7	0.000045	0.00011
			Average	418.7	0.00017	0.00042
Control device: None						
24	A	12	1	1551.3	0.00535	0.00345
			2	1551.3	0.00794	0.00510
			3	1551.3	0.00463	0.00298
			4	1551.3	0.00535	0.00345
			Average	1551.3	0.00582	0.00375
Control device: None						
36	A	12	1	383.7	0.000567	0.00148
			2	383.7	0.00422	0.0110
			3	383.7	0.000405	0.00106
			Average	383.7	0.00173	0.00451

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-2 (METRIC UNITS) (*concluded*)
LEAD: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
43	A	12	1	1551.3	0.00485	0.00313
			2	1551.3	0.00553	0.00357
			3	1551.3	0.00472	0.00304
			Average	1551.3	0.00504	0.00324
Control device: None						
52	B	12	1	323.9	0.000989	0.00306
			2	323.9	0.000369	0.00114
			3	323.9	0.000175	0.00054
			Average	323.9	0.000518	0.00159
Control device: None						
53	B	12	1	324.9	0.000576	0.00168
			2	324.9	0.000794	0.00232
			3	324.9	0.000562	0.00164
			Average	324.9	0.000644	0.00188

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-2 (ENGLISH UNITS)
LEAD: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
16a	B	12	1	703.7	0.00040	0.0011
			2	703.7	0.00013	0.00037
			3	703.7	0.00060	0.0017
			Average	703.7	0.00038	0.0011
Control device: None						
16b	B	12	1	923	0.00090	0.00195
			2	923	0.00015	0.00033
			3	923	0.00010	0.00022
			Average	923	0.00038	0.00083
Control device: None						
24	A	12	1	3420	0.0118	0.00690
			2	3420	0.0175	0.0102
			3	3420	0.0102	0.00596
			4	3420	0.0118	0.00690
			Average	3240	0.0128	0.00750
Control device: None						
36	A	12	1	846	0.00125	0.00296
			2	846	0.00930	0.0220
			3	846	0.000892	0.00211
			Average	846	0.00381	0.00902

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-2 (ENGLISH UNITS) (*concluded*)
LEAD: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
43	A	12	1	3420	0.0107	0.00626
			2	3420	0.0122	0.00713
			3	3420	0.0104	0.00608
			Average	3420	0.0111	0.00649
Control device: None						
52	B	12	1	714	0.00218	0.00611
			2	714	0.000814	0.00228
			3	714	0.000386	0.00108
			Average	714	0.00113	0.00317
Control device:						
53	B	12	1	756	0.00127	0.00336
			2	756	0.00175	0.00463
			3	756	0.00124	0.00328
			Average	756	0.00142	0.00376

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton

Pasting Process

The emission factor developed for the pasting process corresponds to the lead paste mixing, curing, and storing processes. Lead paste mixing process includes lead paste mixing, grid pasting, and grid parting operations. Plate curing is performed using OSI ovens to dry the lead grid plates after lead paste is applied. The storing process includes small clean-up operations. Five source tests (References 49, 50, 51, 54, and 55) were performed on the paste mixing process, four tests (References 20, 21, 27, 42) on the curing process, and one test (Reference 42) on the storing process. References 20, 21, and 27 were conducted on the same facility. Both the paste mixing and the storing processes were controlled by a Radco-Unit or a baghouse. The plate curing process was uncontrolled. The emission factors for each process and for the total pasting process were calculated as follows:

EF_3 (Emission Factor, Paste Mixing)

= (0.00958 + 0.0326 + 0.00819 + 0.0239 + 0.0645) lbs/ton / 5

= 0.0278 lbs/ton.

EF_4 (Emission Factor, Plate Curing)

= [(0.00203 + 0.0185 + 0.0209) / 3 + 0.0748 lbs/ton] / 2

= 0.0443 lb/ton.

EF_5 (Emission Factor, Storing) = 0.00060 lb/ton.

Total Pasting emissions $EF_6 = EF_3 + EF_4 + EF_5 =$ 0.073 lbs/ton.

Four other references (References 19, 35, 56, and 62) contain results from emission testing performed on paste mixing processes. Their data were not included in the development of the process emission factor, because References 35 and 56 did not include grid pasting and parting, and References 19 and 62 presented the data in lbs/1000 plates and lbs/cell, respectively, without giving an average weight for each plate or cell. Tables 4.1-3, 4.1-4, and 4.1-5 present the data gathered from each source test used in developing the pasting process emission factor. Since all the source tests used in developing the emission factor were rated "A" and "B", and the data are felt to be representative of the industry in general, the emission factor developed is rated "B."

TABLE 4.1-3 (METRIC UNITS)
LEAD
Source: Pasting Process-Paste Mixing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
49 Paste Mixing	A	12	1	2849.9	0.0206	0.00725
			2	2849.9	0.0103	0.00359
			3	2849.9	0.0101	0.00353
			Average	2849.9	0.0137	0.00479
Control device: Baghouse						
50 Paste Mixing	B	12	1	2639.9	0.00871	0.00330
			2	2639.9	0.0549	0.0208
			3	2639.9	0.0699	0.0265
			Average	2639.9	0.0431	0.0163
Control device: Baghouse						
57 Past Mixing	B	12	1	3401.9	0.0105	0.00308
			2	3401.9	0.0243	0.00715
			3	3401.9	0.00703	0.00207
			Average	3401.9	0.0139	0.00410
Control device: Baghouse						
54 Paste Mixing			1	1156.7	0.0175	0.0152
			2	1156.7	0.0108	0.00935
			3	1156.7	0.0132	0.0114
			Average	1156.7	0.0138	0.0119
Control device: Baghouse						
55 Past Mixing			1	1200.7	0.0186	0.0155
			2	1200.7	0.0394	0.0328
			3	1200.7	0.0581	0.0484
			Average	1200.7	0.0387	0.0323

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-3 (ENGLISH UNITS)
LEAD
Source: Pasting Process-Paste Mixing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
49 Paste Mixing	A	12	1	6283	0.0454	0.0145
			2	6283	0.0226	0..00719
			3	6283	0.0222	0.00707
			Average	6283	0.0301	0.00958
Control device: Baghouse						
50 Paste Mixing	B	12	1	5820	0.0192	0.00660
			2	5820	0.121	0.0416
			3	5820	0.154	0.0529
			Average	5820	0.0951	0.0326
Control device: Baghouse						
57 Past Mixing	B	12	1	7500	0.0231	0.00616
			2	7500	0.0536	0.0143
			3	7500	0.0155	0.00413
			Average	7500	0.0307	0.00819
Control device: Baghouse						
54 Paste Mixing	A	12	1	2647	0.0386	0.0303
			2	2647	0.0238	0.0187
			3	2647	0.0291	0.0228
			Average	2647	0.0305	0.0239
Control device: Baghouse						
55 Past Mixing	A	12	1	2647	0.0411	0.0311
			2	2647	0.0868	0.0656
			3	2647	0.128	0.0967
			Average	2647	0.0853	0.0645

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-4 (METRIC UNITS)
LEAD
Source: Pasting Process-Plate Curing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
20 Plate Curing OSI Oven	B	12	1	1513.6	0.00166	0.00110
			2	1513.6	0.00163	0.00108
			3	1513.6	0.00131	0.000865
			Average	1513.6	0.00153	0.00102
Control device: None						
21 Plate Curing OSI Oven	A	12	1	1913.7	0.0137	0.00715
			2	1913.7	0.0213	0.0111
			3	1913.7	0.0181	0.00945
			Average	1913.7	0.0177	0.00925
Control device: None						
27 Plate Curing OSI Oven	A	12	1	1879.7	0.0254	0.0135
			2	1879.7	0.0188	0.0100
			3	1879.7	0.0148	0.000785
			Average	1879.7	0.0197	0.0105
Control device: None						
42 Plate Curing OSI Oven	A		1	1875.5	0.00685	0.00368
			2	1875.5	0.00753	0.00402
			3	1875.5	0.00667	0.00356
			Average	1875.5	0.00703	0.00374

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-4 (ENGLISH UNITS)
LEAD
Source: Pasting Process-Plate Curing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
20 Plate Curing OSI Oven	B	12	1	3337	0.00367	0.00220
			2	3337	0.00360	0.00216
			3	3337	0.00288	0.00173
			Average	3337	0.00338	0.00203
Control device: None						
21 Plate Curing OSI Oven	A	12	1	4219	0.0302	0.0143
			2	4219	0.0469	0.0222
			3	4219	0.0398	0.0189
			Average	4219	0.0390	0.0185
Control device: None						
27 Plate Curing OSI Oven	A	12	1	4144	0.0560	0.0270
			2	4144	0.0415	0.0200
			3	4144	0.0326	0.0157
			Average	4144	0.0434	0.0209
Control device: None						
42 Plate Curing OSI Oven	A	12	1	4134.8	0.0151	0.00730
			2	4134.8	0.0166	0.00803
			3	4134.8	0.0147	0.00711
			Average	4134.8	0.0155	0.00748

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-5 (METRIC UNITS)
LEAD
Source: Pasting Process-Storing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
42 Storing	A	12	1	2328.4	0.0012	0.00055
			2	2328.4	0.00068	0.00029
			3	2328.4	0.0032	0.0014
			Average	2328.4	0.0073	0.00030

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-5 (ENGLISH UNITS)
LEAD
Source: Pasting Process-Storing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Radco Unit						
42 Storing	A	12	1	5133.2	0.0027	0.0011
			2	5133.2	0.0015	0.00058
			3	5133.2	0.0070	0.0027
			Average	5133.2	0.0016	0.00060

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

Three-Process Operation

Seven source tests were received for the three-process operation. Two of the sources tests (References 13 and 19) were conducted for the auto post burner operation, but the emissions were determined as a function of the number of batteries without providing information regarding the types of batteries produced (e.g., automotive or industrial). Therefore, the information contained in these tests was not included in the development of the new emission factor for this process. The emission factor was developed from the remaining five source tests, References 18, 23, 26, 29, and 34. References 18 and 29 reflected the Cast On Strap (COS) line, References 23 and 26 reflected the central vacuum system (CVS), and Reference 34 was used for the assembly operation. The COS line includes an element stacking system which properly aligns and squares up each element, a flux station, a casting station, and an unloading station. The CVS cleans the area around the COS machines, and the assembly operations assembles the elements together and in some cases into the battery case. Baghouses are used for emissions control. The data are presented in Table 4.1-6, and the following illustrates the procedure used in developing the controlled lead emission factor for the three-process operation. The emission factor is rated "B".

EF_7 (Emission Factor, COS line)

= (0.0164 + 0.0114) lbs/ton / 2

EF_7 = 0.0139 lbs/ton.

EF_8 (Emission Factor, CVS)

= (0.0082 + 0.0071) lbs/ton / 2

EF_8 = 0.0077 lbs/ton.

EF_9 (Emission Factor, Assembly) = 0.0021 lbs/ton.

Total Three-Process Operation $EF_{10} = EF_7 + EF_8 + EF_9 = 0.024$ lbs/ton.

TABLE 4.1-6 (METRIC UNITS)
LEAD
Source: Three-Process Operation

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
18 COS Line	A	12	1	929.9	0.00907	0.00975
			2	929.9	0.00361	0.00389
			3	929.9	0.00317	0.00341
			Average	929.9	0.00531	0.00570
Control device:						
29 COS Line	B	12	1	1035.1	0.0101	0.00975
			2	1035.1	0.00690	0.00665
			3	1035.1	0.00853	0.00845
			Average	1035.1	0.00848	0.00820
Control device:						
23 Past Mixing	A		1	29.5	0.000091	0.0031
			2	29.5	0.000091	0.0031
			3	29.5	0.00018	0.0060
			Average	29.5	0.00012	0.0041
Control device:						
26 Central Vacuum System	A		1	21.26	0.000045	0.0022
			2	21.26	0.000091	0.0043
			3	21.26	0.000091	0.0043
			Average	21.26	0.000077	0.0036
Control device:						
34 Assembly	B		1	1745.1	0.00175	0.00100
			2	1745.1	0.00058	0.000330
			3	1745.1	0.00319	0.00183
			Average	1745.1	0.00184	0.00105

[a]Units in kg/hr.
[b]Units in kg/hr.

[c]Units in kg/Mg.

TABLE 4.1-6 (ENGLISH UNITS)
LEAD
Source: Three-Process Operation

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
18 COS Line	A	12	1	2050	0.0200	0.0195
			2	2050	0.00796	0.00777
			3	2050	0.00699	0.00682
			Average	2050	0.0117	0.0114
Control device: Baghouse						
29 COS Line	B	12	1	2282	0.0222	0.0195
			2	2282	0.0152	0.0133
			3	2282	0.0188	0.0169
			Average	2282	0.0187	0.0164
Control device: Baghouse						
23 Central Vacuum System CVS	A	12	1	65	0.00020	0.0062
			2	65	0.00020	0.0062
			3	65	0.00040	0.012
			Average	65	0.00027	0.0082
Control device: Baghouse						
26 Central Vacuum System CVS	A	12	1	46.88	0.00010	0.0043
			2	46.88	0.00020	0.0085
			3	46.88	0.00020	0.0085
			Average	46.88	0.00017	0.0071
Control device: Baghouse						
34 Assembly	B	12	1	3847.4	0.00385	0.00200
			2	3847.4	0.00127	0.000660
			3	3847.4	0.00703	0.00365
			Average	3847.4	0.00405	0.00210

[a]Units in lb/hr.

[b]Units in lb/hr.
[c]Units in lb/ton.

Lead Oxide Production

The lead oxide system has three processes that vent to the atmosphere. The melting pot process melts the lead ingots and is completed when the emissions are vented to the atmosphere uncontrolled. The molten lead is then stirred by paddles and the process discharge is controlled by a baghouse. Finally, the ventilation baghouse filters the lead oxide while it is being stored for use in the battery plant. PES received four sources (References 15, 17, 31, and 32) for lead oxide production. Reference 32 was omitted due to missing raw test data and high variability between runs. References 15 and 17 corresponded to the same plant, and in Reference 15, separate emissions were documented for each operation of the oxide production. The emission data are presented in Table 4.1-7, and the emission factor is assigned a "B" rating. The following shows the methods used in developing the lead emission factor for the oxide production process.

EF_{11} (Emission Factor, Lead Oxide Production)

= [(0.000687 + 0.000735 + 0.00819 + 0.0112) /4 + (0.016 + 0.0068 + 0.0064) / 3] lbs/ton / 2

= 0.00743 lbs/ton.

Three other source tests (References 30, 37, and 42) were received for the lead oxide storage tanks. Their emission data were not included in the lead oxide production process because the storage operation was accounted for in the developed emission factor, EF_{11}. The data obtained from these sources is presented in Table 4.1-8 for background information.

Dry Formation

One source test was received for the dry formation process, Reference 34. This is not sufficient to justify a change in the emission factor currently in the AP-42 section. Since the previous AP-42 section (August/1982) did not have any data for the dry formation process, PES updated the emission factor for this process with the data developed from Reference 34. This emission factor has been assigned a rating of "D", and the data are presented in Table 4.1-9. The emission factor for the formation process is EM_{12} = 0.00022 lb/ton.

TABLE 4.1-7 (METRIC UNITS)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
15 North Ventilation Process Baghouse	A	12	1	957.5	$2.8x10^{-5}$	$2.95x10^{-5}$
			2	957.5	$2.0x10^{-5}$	$2.10x10^{-5}$
			3	927.5	$2.5x10^{-5}$	$2.60x10^{-5}$
			Average	947.5	$2.4x10^{-5}$	$2.55x10^{-5}$
Control device: Baghouse						
15 North Melting Pot	A	12	1	957.5	$12.80x10^{-5}$	$8.10x10^{-5}$
			2	957.5	$9.80x10^{-5}$	$1.03x10^{-4}$
			3	957.5	$3.30x10^{-4}$	$3.50x10^{-4}$
			Average	957.5	$1.70x10^{-4}$	$1.78x10^{-4}$
Control device: Baghouse						
15 North Process Baghouse	A	12	1	957.5	$1.21x10^{-4}$	$1.26x10^{-5}$
			2	957.5	$5.80x10^{-5}$	$6.05x10^{-5}$
			3	957.5	$2.25x10^{-4}$	$2.35x10^{-4}$
			Average	957.5	$1.35x10^{-4}$	$1.41x10^{-4}$
					Total:	$3.44x10^{-4}$

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-7 (METRIC UNITS) (*continued*)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
15[d] South Ventilation Process Baghouse	A	12	1	1098.1	$2.60x10^{-5}$	$2.35x10^{-5}$
			2	1098.1	$2.00x10^{-5}$	$1.95x10^{-5}$
			3	1098.1	$3.50x10^{-5}$	$3.15x10^{-5}$
			4	1098.1	$1.00x10^{-5}$	$9.5x10^{-6}$
			Average	1098.1	$2.30x10^{-5}$	$2.1x10^{-5}$
Control device: Baghouse						
15 South Melting Pot	A	12	1	963.9	$7.90x10^{-5}$	$8.20x10^{-5}$
			2	963.9	$2.98x10^{-4}$	$3.09x10^{-4}$
			3	963.9	$3.90x10^{-4}$	$4.05x10^{-4}$
			Average	963.9	$2.56x10^{-4}$	$2.65x10^{-4}$
Control device: Baghouse						
15 South Process Baghouse	A	12	1	963.9	$5.10x10^{-5}$	$5.25x10^{-5}$
			2	963.9	$8.20x10^{-5}$	$8.45x10^{-5}$
			3	963.9	$1.03x10^{-4}$	$1.60x10^{-4}$
			Average	963.9	$7.80x10^{-5}$	$8.15x10^{-5}$
					Total:	$3.68x10^{-4}$
Control device: Baghouse						
17 Lead Oxide Production	B	12	1	1089.2	0.00440	0.00404
			2	1089.2	0.00481	0.00442
			3	1089.2	0.00417	0.00383
			Average	1089.2	0.00446	0.00410
Control device: Baghouse						
17 Lead Oxide Production	B	12	1	774.7	0.00653	0.00845
			2	774.7	0.00417	0.00540
			3	774.7	0.00231	0.00299
			Average	774.7	0.00434	0.00560

[a]Units in kg/hr. [c]Units in kg/Mg.
[b]Units in kg/hr. [d]Performed on a different date.

TABLE 4.1-7 (METRIC UNITS) (*concluded*)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device:						
31 Oxide Mill #1	A	12	1	680.4	0.0077	0.012
			2	680.4	0.0050	0.0075
			3	680.4	0.0033	0.0048
			Average	680.4	0.0054	0.0080
Control device: Baghouse						
31 Oxide Mill #2	A	12	1	680.4	0.0023	0.0034
			2	680.4	0.0021	0.0031
			3	680.4	0.0026	0.0038
			Average	680.4	0.0023	0.0034
Control device: Baghouse						
31 Oxide Mill #3	A	12	1	680.4	0.0014	0.0021
			2	680.4	0.0029	0.0044
			3	680.4	0.0022	0.0032
			Average	680.4	0.0022	0.0032

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-7 (ENGLISH UNITS)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
15 North Ventilation Process Baghouse	A	12	1	2111	0.0000625	$5.90x10^{-5}$
			2	2111	0.0000444	$4.20x10^{-5}$
			3	2111	0.0000547	$5.20x10^{-5}$
			Average	2111	0.0000538	$5.10x10^{-5}$
Control device: Baghouse						
15 North Melting Pot	A	12	1	2111	0.000171	$1.62x10^{-4}$
			2	2111	0.000216	$2.05x10^{-4}$
			3	2111	0.000738	$6.99x10^{-4}$
			Average	2111	0.000375	$3.55x10^{-4}$
Control device: Baghouse						
15 North Process Baghouse	A	12	1	2111	0.000266	$2.52x10^{-4}$
			2	2111	0.000128	$1.21x10^{-4}$
			3	2111	0.000496	$4.70x10^{-4}$
			Average	2111	0.000297	$2.81x10^{-4}$
					Total	$6.87x10^{-4}$

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-7 (ENGLISH UNITS) (*continued*)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
15[d] South Ventilation Process Baghouse	A	12	1	2421	0.0000563	$4.70x10^{-5}$
			2	2421	0.0000471	$3.10x10^{-5}$
			3	2421	0.0000761	$6.30x10^{-5}$
			4	2421	0.0000229	$1.90x10^{-5}$
			Average	2421	0.0000510	0.0000420
Control device: Baghouse						
15 South Melting Pot	A	12	1	2125	0.000174	$1.64x10^{-4}$
			2	2125	0.000656	$6.17x10^{-4}$
			3	2125	0.000860	$8.09x10^{-4}$
			Average	2125	0.000563	$5.30x10^{-4}$
Control device: Baghouse						
15 South Processes Baghouse	A	12	1	2125	0.000112	0.000105
			2	2125	0.000180	0.000169
			3	2125	0.000226	0.000213
			Average	2125	0.000173	0.000163
					Total:	0.000735
Control device: Baghouse						
17 Lead Oxide Production	B	12	1	2401.3	0.00970	0.00808
			2	2401.3	0.0106	0.00883
			3	2401.3	0.00920	0.00766
			Average	2401.3	0.00983	0.00819
Control device: Baghouse						
17 Lead Oxide Production	B	12	1	1707.9	0.0144	0.0169
			2	1707.9	0.00920	0.0108
			3	1707.9	0.00510	0.00597
			Average	1707.9	0.00957	0.0112

[a]Units in lb/hr. [c]Units in lb/ton.
[b]Units in lb/hr. [d]Performed on a different date.

TABLE 4.1-7 (ENGLISH UNITS) (*concluded*)
LEAD
Source: Lead Oxide Production

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
31 Oxide Mill #1	A	12	1	1500	0.017	0.023
			2	1500	0.011	0.015
			3	1500	0.0072	0.0096
			Average	1500	0.012	0.016
Control device: Baghouse						
31 Oxide Mill #2	A	12	1	1500	0.0050	0.0067
			2	1500	0.0047	0.0062
			3	1500	0.0057	0.0076
			Average	1500	0.0051	0.0068
Control device: Baghouse						
31 Oxide Mill #3	A	12	1	1500	0.0031	0.0041
			2	1500	0.0065	0.0087
			3	1500	0.0048	0.0064
			Average	1500	0.0048	0.0064

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-8 (METRIC UNITS)
LEAD
Source: Oxide Storage

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Flex-Keen						
30	B	12	1	14741.7	0.0162	0.00110
			2	14741.7	0.00662	0.000459
			3	14741.7	0.00563	0.000380
			Average	14741.7	0.00939	0.000650
Control device: Baghouse						
37	B	12	1	14061.3	0.00319	0.00023
			2	14061.3	0.00744	0.00053
			3	14061.3	0.00644	0.00046
			Average	14061.3	0.00567	0.00041
Control device: Baghouse						
42	A	12	1	1746.3	0.000091	0.000050
			2	1746.3	0.000045	0.000026
			3	1746.3	0.000091	0.00005
			Average	1746.3	0.000077	0.000045

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-8 (ENGLISH UNITS)
LEAD
Source: Oxide Storage

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Flex-Keen						
30	B	12	1	32500	0.0357	0.00220
			2	32500	0.0146	0.000898
			3	32500	0.0124	0.000763
			Average	32500	0.0207	0.00130
Control device: Flex-Keen						
37	B	12	1	31000	0.00704	0.000454
			2	31000	0.0164	0.00106
			3	31000	0.0142	0.000916
			Average	31000	0.0125	0.000810
Control device: Baghouse						
42	A	12	1	3850	0.00020	0.00010
			2	3850	0.00010	0.00052
			3	3850	0.00020	0.00010
			Average	3850	0.00017	0.000090

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-9 (METRIC UNITS)
LEAD
Source: Formation

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device:						
34	B	12	1	1745.1	0.000140	0.0000810
			2	1745.1	0.000244	0.000140
			3	1745.1	0.000187	0.000108
			Average	1745.1	0.000191	0.000110

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-9 (ENGLISH UNITS)
LEAD
Source: Formation

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device:						
34	B	12	1	3847.4	0.000309	0.000161
			2	3847.4	0.000538	0.000280
			3	3847.4	0.000413	0.000215
			Average	3847.4	0.000420	0.000220

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

Particulate Matter.

Particulate emission factors were revised for the grid casting process only. Not enough information was received justify a change in these factors for the remaining processes of the battery manufacturing industry. Six source tests were used in developing the new particulate emission factor for the grid casting process, five of which (References 44, 45, 46, 47, and 48) were performed on the same facility. This facility was equipped with either a baghouse or a Roto-Clone control device. The sixth test, Reference 43, was conducted on a different facility with uncontrolled emissions. The data obtained from these sources are presented in Tables 4.1-10 and 4.1-11 for the controlled and uncontrolled grid casting processes, respectively. The controlled emission factor was developed according to the following calculation.

EF_{13} (Emission Factor, Grid Casting controlled)

= (0.138 + 0.198 + 0.279 + 0.32 + 0.20) lbs/ton / 5

= 0.23 lbs/ton.

The uncontrolled emission factor for the grid casting process was developed from Reference 43 as,

EF_{14} (Emission Factor, Grid Casting uncontrolled) = 0.0655 lbs/ton.

As discussed earlier in the lead emission section, the controlled emission data were developed from source tests conducted for a single facility. Therefore, higher emissions from the controlled process could be a result of the product or procedures used at that facility, or a result of other operations performed on the product, such as cleaning and shaping. No information was obtained from the source tests to verify any of these possibilities. Therefore, the emission factor is rated "C" for the controlled grid casting process. The uncontrolled emission factor was not used in the section revision because one source test is not sufficient to justify a change of emission factors in the AP-42 section.

From the remaining source tests received for the battery manufacturing industry, one other source test contained particulate data. Reference 51 corresponded to a controlled paste mixing operation, and the data obtained are presented in Table 4.1-12.

TABLE 4.1-10 (METRIC UNITS)
PARTICULATE: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
44	B	12	1	631.4	0.0531	0.0840
			2	631.4	0.0376	0.0595
			3	631.4	0.0402	0.0635
			Average	631.4	0.0436	0.0690
Control device: Roto-Clone						
45	A	12	1	593.3	0.0803	0.136
			2	593.3	0.0544	0.0915
			3	593.3	0.0420	0.0705
			Average	593.3	0.0590	0.0990
Control device: Roto-Clone						
46	A	12	1	610.1	0.0835	0.137
			2	610.1	0.0276	0.0452
			3	610.1	0.144	0.237
			Average	610.1	0.0853	0.140
Control device: Roto-Clone						
47	A	12	1	575.2	0.136	0.237
			2	575.2	0.0975	0.170
			3	575.2	0.0383	0.0670
			Average	575.2	0.0907	0.158
Control device: Baghouse						
48	A	12	1	631.4	0.106	0.168
			2	631.4	0.0526	0.0835
			3	631.4	0.0318	0.0505
			Average	631.4	0.0635	0.100

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-10 (ENGLISH UNITS)
PARTICULATE: CONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
44	B	12	1	1392	0.117	0.168
			2	1392	0.0830	0.119
			3	1392	0.0887	0.127
			Average	1392	0.0962	0.138
Control device: Roto-Clone						
45	A	12	1	1308	0.177	0.271
			2	1308	0.120	0.183
			3	1308	0.0925	0.141
			Average	1308	0.130	0.198
Control device: Roto-Clone						
46	A	12	1	1345	0.184	0.274
			2	1345	0.0608	0.0904
			3	1345	0.318	0.473
			Average	1345	0.188	0.279
Control device: Roto-Clone						
47	A	12	1	1268	0.300	0.473
			2	1268	0.215	0.339
			3	1268	0.0845	0.134
			Average	1268	0.200	0.3151
Control device: Baghouse						
48	A	12	1	1392	0.233	0.335
			2	1392	0.116	0.167
			3	1392	0.070	0.101
			Average	1392	0.140	0.200

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-11 (METRIC UNITS)
PARTICULATE: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: None						
43	A	12	1	1551.3	0.0440	0.0284
			2	1551.3	0.0577	0.0370
			3	1551.3	0.0508	0.0328
			Average	1551.3	0.0508	0.0328

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-11 (ENGLISH UNITS)
PARTICULATE: UNCONTROLLED
Source: Grid Casting

Source Test #	Test Rating	Test Method	Run #	Production Rate lb/hr	Emission Rate lb/hr	Emission Factor lb/ton
Control device: None						
43	A	12	1	3420	0.0970	0.0567
			2	3420	0.127	0.0743
			3	3420	0.112	0.0655
			Average	3420	0.112	0.0655

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

TABLE 4.1-12 (METRIC UNITS)
PARTICULATE
Source: Grid Pasting-Paste Mixing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
51 Paste Mixing			1	3401.9	0.209	0.0615
			2	3401.9	0.321	0.0945
			3	3401.9	0.232	0.0680
			Average	3401.9	0.254	0.0745

[a]Units in kg/hr.
[b]Units in kg/hr.
[c]Units in kg/Mg.

TABLE 4.1-12 (METRIC UNITS)
PARTICULATE
Source: Grid Pasting-Paste Mixing

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
51 Paste Mixing			1	7500	0.462	0.123
			2	7500	0.707	0.189
			3	7500	0.512	0.136
			Average	7500	0.560	0.149

[a]Units in lb/hr.
[b]Units in lb/hr.
[c]Units in lb/ton.

These data were not included in the emission factor revision of the AP-42 section because one source test is not sufficient to justify a change in the emission factors.

The particulate emission factors presented in Table 2.3-1 were all obtained from the previous AP-42 Section (August/1982) except for the grid casting process. PES attempted to verify the presented emission factors by reviewing the references cited, References 2 - 7. The emission factors could not be verified or developed because Reference 4 consisted of a combination of processes, Reference 5 was not obtained, Reference 6 was not legible, and Reference 7 did not include lead or particulate emissions. PES downrated these emission factors to an "E" rating, not only because they could not be verified, but the new processes implemented in the battery industry are mostly controlled processes. As mentioned previously, the previous emission factors in the AP-42 section corresponded to uncontrolled emissions.

Other Criteria Pollutants.

No data on emissions of sulfur dioxide, nitrogen oxides, or non-methane organic compounds, all of which are criteria pollutants, were found for the lead-acid battery production industry.

4.2 NONCRITERIA POLLUTION EMISSION DATA

Hazardous air pollutants (HAPs) are defined in the 1990 Clean Air Act Amendments. Lead compounds are identified as HAPs. Lead emissions were previously discussed in Section 4.1. PES knows of no other HAPs used or produced in the battery manufacturing industry.

Chlorofluorocarbons have been found to contribute to stratospheric ozone depletion. No data on emissions of these pollutants were found for the lead-acid battery production industry. PES knows of no CFC's used in this industry.

Global Warming Gases.

Pollutants such as methane CH_4, carbon dioxide CO_2, and nitrogen oxide N_2O have been found to contribute to overall global warming. Carbon dioxide emissions were documented in Reference 42 for the OSI ovens. The OSI ovens are propane fired and are used for drying the lead grids. The combustion of fossil fuels is one of the main anthropogenic sources of CO_2 emissions. For source testing purposes, the concentration of CO_2 in the stack gas being tested is measured in order to approximate the molecular weight of the stack gas. The CO_2 concentration measurement is performed in such a way that its level of accuracy is less than that of the primary pollutants of interest. It is for this reason that the concentration for CO_2 is usually undocumented as shown in this industry. The emission rate of a gas such as carbon dioxide can readily be calculated, given the volumetric flow rate of the stack gas at standard conditions and the concentration of carbon dioxide in the stack gas, and using ideal gas laws. The carbon dioxide emission data obtained from Reference 42 are summarized in Table 4.2-1.

4.3 REVIEW OF SPECIFIC DATA SETS

Evaluation of 50 source tests resulted in the revision of several emission factors for the lead-acid battery production industry. Lead emissions were quantified in all the source tests received, but particulate emissions were quantified in only a few tests. The evaluation of these tests resulted in updating most of the lead emission factors and one of the particulate emission factors. These emission factors were previously listed in Section 2.3. For the remainder of the emission factors presented in the AP-42 section (Table 2.3-1), References 1 through 7 were evaluated for verification purposes. PES could not develop the presented emission factors for these processes, because the references were either missing, illegible, or consisted of a combination of processes. Also, the unverified emissions corresponded to uncontrolled emissions. Currently, most of the processes (if not all) are controlled processes. Therefore, it is for these reasons the emission factor ratings for most of the particulate emissions were downgraded to an "E" rating.

The following section provides a more detailed discussion of the source tests used in developing the new emission factors for the battery manufacturing industry. The section is divided into five parts to present a brief discussion of the tests used in developing the average emission factors for grid casting, pasting operation, three-process operation, lead oxide production, and the dry formation process.

TABLE 4.2-1 (METRIC UNITS)
GLOBAL WARMING GASES

Source Test #	Test Rating	Test Method	Run #	CO_2 Concentration[a]	Volumetric Flow Rate[b]	Process Rate[c]	Emission Factor[d]
Control device: None							
42	B	12	1	2.0	19.8	1.91	25
			2	2.2	20.2	1.91	28
			3	2.2	19.4	1.91	27
			Average	2.13	19.8	1.91	27

[a]Concentration in percent.
[b]Units in dry standard cubic meters per minute.
[c]Units in Mg/hr.
[d]Units in kg/Mg.

TABLE 4.2-1 (ENGLISH UNITS)
GLOBAL WARMING GASES

Source Test #	Test Rating	Test Method	Run #	CO_2 Concentration[a]	Volumetric Flow Rate[b]	Process Rate[c]	Emission Factor[d]
Control device: None							
42	B	12	1	2.0	700.9	2.1	50
			2	2.2	712.1	2.1	56
			3	2.2	684.2	2.1	53
			Average	2.13	699.1	2.1	53

[a]Concentration in percent.
[b]Units in dry cubic feet per minute.
[c]Units in ton/hr.
[d]Units in lbs/ton

Grid Casting Process

Reference 45: Johnson Controls Inc, Globe Battery Division, Tampa, Fl, March 1986

Lead and particulate emission factors were developed from this source test. The lead and particulate emissions were tested for grid casters #5 and #6. Both grid casters are controlled by Roto-clone devices. PES received five other source tests for the same process at this facility. The grid casters are used to mold lead grids for use in the manufacture of lead-acid storage batteries. Lead pigs are melted and transferred into grid mold. Both operations were ducted to the same control device. All EPA sampling and testing methods were discussed, and lead emissions were calculated according to Method 12. Method 5 was used for the particulate emissions. Both lead and particulate emissions were presented in lbs/hr units. Production data were included in the test, and the emission factor was determined. The emission factor for each run is calculated as follows and is rated "A."

EF = (ER x 2000) / PR

where EF = Emission Factor in lbs/ton,

ER = Emission Rate in lbs/hr, and

PR = Production Rate in lbs/hr.

The data are then converted to metric units when needed.

Reference 16: Johnson Controls, Inc., Winston-Salem, NC, December, 1987

Only lead emissions were determined from this source test. Two tests were conducted on separate grid casters. The grid casters exhaust was vented to the atmosphere uncontrolled. Both melting and casting operations are included in the grid casting process. EPA Methods 1 through 4 were used for sampling locations and flue gas specifications, and Method 12 was used for determining the lead emissions. All calibration and sampling data were included. CO_2 concentrations in the flue gases were determined to be less than 0.4 percent. The lead emission rate was presented in lbs/hr, and the process production rate was given in pigs/hr. The emission factor was determined as follows:

EF = (ER / PR) x 20 Pigs/ton,

where EF = Emission Factor in lbs/ton,

ER = Emission Rate in lbs/hr, and

PR = Production Rate in Pigs/hr.

Conversion to metric units can be performed when needed. The lead emission factor from this test is rated "A."

Reference 52: Johnson Controls, Inc., Tampa, Fl, Feb. 1988

Reference 52 is a lead emission rate test report performed by PACE laboratories, Inc. For this facility, emissions from the lead pot and the grid casting area are discharged through the roof through a 19-inch circular duct. The emissions are vented uncontrolled. All corresponding EPA testing methods, calibration information, and field data were fully discussed. Lead emission rates and process production rates were presented in lbs/hr. The emission factor was developed by similar procedures as in Reference 45. No particulate data were documented in the report. The emission factor is rated "B" because isokinetic levels reach a high of 110 percent.

Reference 36: Johnson Controls, Inc., Toledo, OH, Dec. 1988

The grid casting process at this facility is similar to the previous references. Testing included uncontrolled emissions from the melting pot operation and the casting operation. Sampling and testing methods were in accordance with EPA methods. CO_2 concentrations in the flue gases were calculated to be less than 0.35 percent, and the test did not include any particulate emissions. Calibration and field data, and copies of EPA methods used were included in the test report. All necessary process data for the emission factor development were documented. The test was performed by Environmental Testing, Inc.. The emission factor is calculated according to Reference 45, and is rated "A."

Pasting Process

Reference 50: Johnson Controls, Inc., Tampa, FL., May, 1988

This test was performed in accordance with EPA Methods 1 - 5, and lead emissions were calculated according to Method 12. The test was conducted on the paste mixing process, which included emissions from the lead paste mixing, grid pasting, and grid parting operations. No particulate emissions were determined in the report. The lead emission factors developed from this report are rated "B", because of variabilities between runs. All field and calibration data were included, and the emission factor was determined in similar fashion to Reference 45.

Reference 20: Johnson Controls, Inc., Tampa, FL., March, 1988

This test was conducted on the OSI ovens which are used for drying plates after a lead paste is applied. This operation is part of the paste mixing process and has no pollution control equipment. The test was performed according to EPA Methods 1 through 5, and lead emissions were calculated according to Method 12. No particulate or CO_2 emissions were developed. Opacity, calibration, and process rate data were discussed. The uncontrolled lead emission factor from this reference is rated "B."

Reference 42: Johnson Controls, Inc., Winston-Salem, NC., October, 1987

The emissions developed from this reference consisted of the clean-up/storage area after the grids are dried. Only lead emissions were tested for in this test. The test was conducted using EPA Reference Methods 1 through 5, contains all necessary documentation for validation, and has consistent results. The lead emission factor developed from this reference is thus rated "A." It was calculated according to the procedures shown in Reference 45.

Three-Process Operation

Reference 18: Johnson Controls, Inc., Tampa, FL., March, 1988

The test was conducted on the Cast-On-Strap (COS) line. The COS line includes element stacking, a flux station, a casting station, and an unloading station. The COS line is controlled by a Ruemelin baghouse. No unusual conditions were recorded during the test, and the test methods were performed according to EPA Reference Methods 1 through 5. Only lead emissions were determined, and EPA Method 12 was used in the development of the lead emission rate. The test contains all necessary documentation for validation, and has consistent results. The lead emission factor is therefore rated "A". Similar methods as shown in Reference 45 were used for developing the lead emission factor.

Reference 26: Johnson Controls, Inc., Tampa, FL., July, 1988

Lead emissions from the central vacuum system (CVS) were determined. The CVS is considered part of the three-process operation, and it is used to clean the COS machines and the area around them. All corresponding EPA testing methods, calibration information, and field data were discussed. The lead emission factor developed is thus rated "A." The CVS emissions are controlled by two baghouses connected in series and then discharged to the atmosphere. Again, the calculations used in Reference 45 were utilized in developing the emission factor.

Reference 34: GNB Inc., Industrial battery Division, Fort Smith, AK

This test was performed on the ambient room air of the assembly area. The air is ducted to a baghouse. The test was performed according to EPA Methods for emission testing and sampling. Particulate and calibration data were not included. The lead emission factor is rated "B," and the production rate was determined according to the following:

PR = 97,000 batt/yr x 165 lbs/batt / (52 wks/yr x 5 days/wk x 16 hrs/day)

= 3,847.4 lbs/hr.

The EF was then determined according to Reference 45.

Lead Oxide Production

Reference 15: Johnson Controls, Inc., Middletown, DL, November, 1988

This reference corresponded to the lead oxide system. Two separate tests were performed on each operation of the lead oxide production. The measurements of stack gas flow rate and pollutant concentrations were made according EPA Methods 1 - 5. The test included all the necessary calibration, laboratory, field, and process data. Thus, the emission factors developed from this reference are rated "A." The emission factors were developed in accordance with Reference 45.

Reference 31: General Battery Corporation, Salina, KN., May, 1986.

This report presented the results of the sources emission testing performed on the lead oxide mill of the lead acid battery manufacturing plant. Three separate tests were performed for each of the oxide mills used at the plant. The sources were tested in accordance with EPA Reference Methods 1, 2, 3, and 12. The testing equipment, sampling and analytical procedures, raw field data, plant process data, equipment calibration, and lab analysis were discussed in the report. The oxide mills tested are protected by two ICA baghouses and one Reece baghouse. The oxide process includes all operations from the melting pot to the storage tank. The CO_2 concentrations were determined to be less than 0.2 percent, and only lead emissions were calculated. The lead emission factor developed is rated "A." Calculation procedures for the emission factor are similar to Reference 45.

Formation

Reference 34: GNB Inc., Industrial Battery Division, Fort Smith, AK

Reference 34 was used for developing the dry formation emission factor. This reference was discussed earlier in this section. The emission factor developed from this source is rated "A."

The tests described in References 25, 40, and 57 were conducted according to EPA Methods, and were in general good references. However, because the stack tested contained the emissions from several processes, the tests were not used in the emission factor development for the lead acid battery production.

4.4 DATA GAP ANALYSIS

The battery industry is a large industry, consisting of several processes. Although PES received 50 source tests for the industry, there are several emission factors that were not revised because the obtained information was not sufficient to cause a change in the emission factors. In particular, data for particulate emissions were very limited. PES is uncertain as to whether particulate data exist; however, the information received from the Battery Council International consisted of new lead and particulate emission factors. PES was unable to use these emission data because no original tests were received to verify the data. For lead emissions, the lead reclaim emission factor was not revised. PES did not receive any information regarding the percentage of lead reclaimed in the current industry, but expects that current plants are more efficient than in 1982, and recommends that a new percentage be determined and then used for calculating the lead reclaim emission factor.

In conclusion, PES recommends that data for particulate emissions be obtained. Also, the percentages of PM_{10} emissions and the lead reclaimed from the total plant lead consumption should be verified. PES is aware that some lead-acid battery manufacturing plants are subject to New Source Performance Standards. PES could not determine how many of the emission tests received correspond to an NSPS facility or whether the revised emission factors are representative of either segment of the industry.

TABLE 4.4-1.

LIST OF CONVERSION FACTORS

Multiply:	**by:**	**To obtain:**
mg/dscm	4.37×10^{-4}	gr/dscf
m^2	10.764	ft^2
acm/min	35.31	acfm
m/s	3.281	ft/s
kg/hr	2.205	lb/hr
kPa	1.45×10^{-1}	psia
kg/Mg	2.0	lb/ton
Mg	1.1023	ton

Temperature conversion equations:

Fahrenheit to Celsius:

$$°C = \frac{(°F - 32)}{1.8}$$

Celsius to Fahrenheit:

$$°F = 1.8(°C) + 32$$

4.5 REFERENCES FOR CHAPTER 4.0

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