BACKGROUND REPORT

AP-42 SECTION 12.16

LEAD OXIDE AND PIGMENT PRODUCTION

Prepared for

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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, North Carolina 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 (the 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 for process information obtained from industry comment and literature search to support revision of the process description and/or emission factors for the lead oxide and pigment production industry.

Including the introduction (Chapter 1), this report contains four chapters. Chapter 2 gives a description of the lead oxide and pigment production processes. 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 lead oxide and pigment production.

Chapter 3 is a review of 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. Particle size determination and particle size data analysis methodology are described when applicable.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL

Lead oxide refers to lead monoxide or "litharge" (PbO), lead tetroxide or "red lead" (Pb_3O_4), and black or "gray" oxide which is a mixture of lead monoxide and metallic lead (an approximate 70:30 ratio)[1] for specific use in the manufacture of lead acid storage batteries. Due to the size of the lead acid battery industry, lead monoxide is the most important commercial compound of lead. Total oxide production in 1989 was 57,984 megagrams (64,000 tons)[7].

Litharge is used primarily in the manufacture of various ceramics products. Because of its electrical and electronic properties, litharge is also used in capacitors, Vidicon tubes, and electrophotographic plates, as well as in ferromagnetic and ferroelectric materials. It is also used as an activator in rubber, a curing agent in elastomers, a sulfur removal agent in the production of thioles and in oil refining, and as an oxidation catalyst in several organic chemical processes. It also has important markets in the production of many lead chemicals, dry colors, soaps (i.e. lead stearate), and driers for paint. Another important use of litharge is the production of lead salts, particularly those used as stabilizers for plastics, notably polyvinyl chloride materials[2].

The major lead pigment is red lead (Pb_3O_4), which is used principally in ferrous metal protective paints. Other lead pigments include white lead and lead chromates. There are several commercial varieties of white lead including leaded zinc oxide, basic carbonate white lead, basic sulfate white lead, and basic lead silicates. Of these, the most important is leaded zinc oxide, which is used almost entirely as white pigment for exterior oil-based paints.

2.2 PROCESS DESCRIPTION

Black oxide is usually produced by a Barton Pot process (SCC# 3-01-035-06). Basic carbonate white lead production (SCC# 3-01-035-15) is based on the reaction of litharge with acetic acid or acetate ions. This product is then reacted with carbon dioxide to form lead carbonate. White leads (other than carbonates) are made either by chemical, fuming, or mechanical blending processes. Red lead (SCC# 3-01-035-10) is produced by oxidizing litharge in a reverberatory furnace. Chromate pigments (SCC# 3-01-035-20) are generally manufactured by precipitation or calcination (SCC# 3-01-035-07) as in the following equation:

$$Pb(NO_3)_2 + Na_2(CrO_4) \rightarrow PbCrO_4 + 2\ NaNO_3 \qquad (1)$$

Commercial lead oxides can all be prepared by wet chemical methods. With the exception of lead dioxide, lead oxides are produced by thermal processes[8] (SCC# 3-01-035-99) in which lead is directly oxidized with air. The processes may be classified according to the temperature of the reaction: 1) low temperature, below the melting point of lead; 2) moderate temperature, between the melting point of lead and lead monoxide; and 3) high temperature, above the melting point of lead monoxide.

Low Temperature Oxidation

Low temperature oxidation of lead is accomplished by tumbling slugs of metallic lead in a ball mill equipped with an air flow. The air flow provides oxygen and is used as a coolant. If some form of cooling were not supplied, the heat generated by the oxidation of the lead plus the mechanical heat of the tumbling charge would raise the charge temperature above the melting point of lead. The ball mill product is a "leady" oxide with 20 to 50 percent free lead.

Moderate Temperature Oxidation

Three processes are used commercially in the moderate temperature range: 1) refractory furnace, 2) rotary tube furnace, and 3) the Barton Pot process. In the refractory furnace process, a cast steel pan is equipped with a rotating vertical shaft and a horizontal crossarm mounted with plows. The plows move the charge continuously to expose fresh surfaces for oxidation. The charge is heated by a gas flame on its surface. Oxidation of the charge supplies much of the reactive heat as the reaction progresses. A variety of products can be manufactured from piglead feed by varying the feed temperature, and time of furnacing. Yellow litharge (orthorhombic) can be made by cooking for several hours at 600 to 700°C (1112 to 1292°F) but may contain traces of red lead and/or free metallic lead.

In the rotary tube furnace process, molten lead is introduced into the upper end of a refractory-lined inclined rotating tube. An oxidizing flame in the lower end maintains the desired temperature of reaction. The tube is long enough so that the charge is completely oxidized when it emerges from the lower end. This type of furnace has been commonly used to produce lead monoxide (tetragonal type) but it is not unusual for the final product to contain traces of both free metallic and red lead.

The Barton Pot process (Figure 2.2.2-1) uses a cast iron pot with an upper and lower stirrer rotating at different speeds. Molten lead is fed through a port in the cover into the pot, where it is broken up into droplets by high-speed blades. Heat is supplied initially to develop an operating temperature from 370 to 480°C (698 to 896°F). The exothermic heat from the resulting oxidation of the droplets is usually sufficient to maintain the desired temperature. The oxidized product is swept out of the pot by an air stream.

The operation is controlled by adjusting the rate of molten lead feed, the speed of the stirrers, the temperature of the system, and the rate of air flow through the pot. The Barton Pot produces either litharge or leady litharge with 50 percent free lead. Since it operates at a higher temperature than a ball mill unit, the oxide portion will usually contain some orthorhombic litharge. It may also be operated to obtain almost entirely orthorhombic product.

High Temperature Oxidation

High temperature oxidation is a fume-type process. A very fine particle, high-purity orthorhombic litharge is made by burning a fine stream of molten lead in a special blast-type burner. The flame temperature is around 1200°C (2192°F). The fume is swept out of the chamber by an air stream, cooled in a series of "goosenecks" and collected in a baghouse. The median particle diameter is from 0.50 to 1.0 microns, as compared with 3.0 to 16.0 microns for lead monoxide manufactured by other methods.

2.3 EMISSIONS AND CONTROLS

Emission factors for lead oxide and pigment production processes are given in Table 2.3-1. The data presented were obtained from the previous AP-42 document (July 1979). Pacific Environmental Services was unable to update these emission factors due to the limited response received from the solicited sources of information. Only one new source test was obtained for this industry. The source test was not obtained from the solicited sources. PS evaluated the original references used to develop the existing emission factors. As a result of this revision, PES lowered the emission factor rating for the lead oxide production from a B to an E rating, because of inconsistent results, and nonisokinetic sampling. Pigment production emissions, both red and white lead oxide pigments, could not be verified because the cited references could not be obtained. The pigment data is presented without any modification.

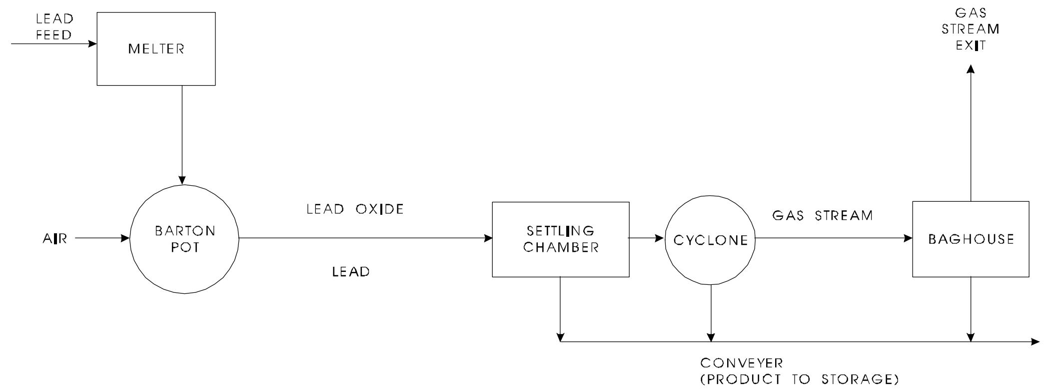

Figure 2.2.2-1. Lead Oxide Barton Pot Process.

TABLE 2.3-1 (METRIC UNITS)
LEAD OXIDE AND PIGMENT PRODUCTION EMISSION FACTORS

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

Process	Particulate		Lead		Reference
Lead Oxide Production:					
Barton pot[a] (SCC# 3-01-035-06)	0.21 - 0.43	E	0.22	E	4,6
Calcining Inlet furnace Outlet (SCC# 3-01-035-07)	7.13 0.032	E E	7.00 0.024	E E	6 6
Pigment Production:					
Red lead[a] (SCC# 3-01-035-10)	0.5[b]	B	0.50	B	4,5
White lead[a] (SCC# 3-01-035-15)			0.28	B	4,5
Chrome pigments (SCC# 3-01-035-20)			0.065	B	4,5

[a] Measured at baghouse outlet. Baghouse is considered process equipment.

[b] Only PbO and oxygen are used in red lead production, so particulate emissions are assumed to be about 90 percent lead.

TABLE 2.3-1 (ENGLISH UNITS)
LEAD OXIDE AND PIGMENT PRODUCTION EMISSION FACTORS

All Emission Factors in lb/ton Produced
Ratings (A-E) Follow Each Factor

Process	Particulate		Lead		Reference
Lead Oxide Production:					
Barton pot[a] (SCC# 3-01-035-06)	0.43 - 0.85	E	0.44	E	4,6
Calcining furnace Inlet Calcining furnace Outlet (SCC# 3-01-035-07)	14.27 0.064	E E	14.00 0.047	E E	6 6
Pigment Production:					
Red lead[a] (SCC# 3-01-035-10)	1.0[b]	B	0.90	B	4,5
White lead[a] (SCC# 3-01-035-15)			0.55	B	4,5
Chrome pigments (SCC# 3-01-035-20)			0.13	B	4,5

[a] Measured at baghouse outlet. Baghouse is considered process equipment.

[b] Only PbO and oxygen are used in red lead production, so particulate emissions are assumed to be about 90 percent lead.

Storage battery production facilities produce lead oxide using the barton pot, therefore, a comparison of the lead emission factor from both industries was performed. The lead oxide emission factors from the battery plants were found to be considerably lower than the emission from the lead oxide and pigment industry. Note that battery production plants are covered under federal regulations (NESHAP), therefore one would expect lower emissions from these sources. This comparison indicates the necessity to perform new stack testing of lead oxide and pigment production facilities in order to develop accurate emission factors.

Automatic shaker-type fabric filters, often preceded by cyclone mechanical collectors or settling chambers, are the common choice for collecting lead oxides and pigments. Control efficiencies of 99 percent are achieved for this control device combination[3]. Where fabric filters are not appropriate scrubbers are used, which achieve control efficiencies of 70 to 95 percent[4]. The ball mill and Barton processes of black oxide manufacturing recover the lead product by these two means. Collection of dust and fumes from the production of red lead is likewise an economic necessity, since particulate emissions, although small, are about 90 percent lead. Emissions data from the production of white lead pigments are not available, but they have been estimated (References 4, 5) because of health and safety regulations. The emissions from dryer exhaust scrubbers account for over 50 percent of the total lead emitted in lead chromate production.

The TNMOC/PM Speciation Database (SPECIATE) characterizes emissions from Barton Pots, calcining furnaces, and ore dryers, as well as, from the production of red and white lead, and lead chromate pigments as containing several metals/chemicals listed as Clean Air Act (CAA) Title III hazardous air pollutant (HAPs). These HAPs include phosphorus, chlorine, chromium, manganese, nickel, selenium, cadmium, and antimony, as well as lead. Emission factors for these pollutants are not presented due to lack of data.

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) Hammond Lead Products, Pottstown, PA
2) Cookson America (ANZON Inc.), Philadelphia, PA
3) Oxide & Chemical Co., Cincinnati, OH
4) Morgan, Louis, & Bockius, Philadelphia, PA
5) Eagle-Picher, Joplin, MO
6) ASARCO Inc., Denver, CO

No responses were received from any of the solicited sources. PES has incorporated the information obtained through a literature search into the AP-42 chapter revision. The information gathered from this search helped in updating the process and emission control information of the lead oxide and pigment production industry. The source test obtained for this industry was from files at PES. The information used in updating the current section is described below:

<u>Reference 6, Gould Inc., ST. Paul, Minnesota, 1973</u>

This reference was used in verifying emission factors from the Barton pot process of a lead oxide production plant. Reference 6, is an air pollution emission test conducted by Monsanto Research Corporation under contract number, 68-02-0226. Emission factors for the Barton Pot and the calcining furnace processes were included in this source test. The Barton Pot lead and particulate emissions were verified, and it appears that the emissions presented for the calcining furnace represent the inlet furnace baghouse. PES has developed outlet emission factors for the calcining furnace, and presented both the inlet and outlet emission factors for this process in Table 2.3-1. This modification is discussed in Section 4.1. The emission factor ratings for data developed from this reference were lowered to an E rating due to nonisokinetic sampling and high variabilities between runs.

<u>Reference 7, Mineral Yearbook Volume I, 1989</u>

Reference 7, provided general lead oxide industry characteristics and usage. Industry's total production, differences between the available types of lead oxide, and current application of each product type and their characteristics were obtained from this reference.

Reference 8, Lead Oxide Properties and Applications

Reference 8, was used to update the process description in more detail. It provided process classification according to its oxidation temperature, details of the processes used in each classification, as well as control device efficiencies.

Reference 9, AIRS Facility Subsystem Source Classification Codes and Emission Factors

Reference 9, was used to perform emission factor comparison with equivalent processes from battery production plants, and to identify process SCC codes.

2.5 REFERENCES FOR CHAPTER 2

1. E.J. Ritchie, Lead Oxides, Independent Battery Manufacturers Association, Inc., Largo, FL. 1974.

2. W.E. Davis, Emissions Study of Industrial Sources of Lead Air Pollutants, 1970, EPA Contract No. 68-02-0271, W. E. Davis and Associates, Leawood, KS. April 1973.

3. Background Information in Support of the Development of Performance Standards for the Lead Additive Industry, EPA Contract No. 68-02-2085, PEDCo Environmental Specialists, Inc., Cincinnati, OH. January 1976.

4. Control Techniques for Lead Air Emissions, EPA-450/2-77-012A. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.

5. R.P. Betz, et al., Economics of Lead Removal in Selected Industries, EPA Contract No. 68-02-0299. Battelle Columbus Laboratories, Columbus OH. December 1972.

6. Air Pollution Emission Test, Project No. 74-PB-0-1, Task No. 10, Office of Air Quality Planning and Standards,Contract No. 68-02-0226. U.S. Environmental Protection Agency, Research Triangle Park, NC. August 1973.

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

8. Harvey E. Brown, Lead Oxide. Properties and Applications, International Lead Zinc Research Organization, Inc. 1985.

3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING SOURCE TESTS

The first step in the investigative process involved a search of available literature relating to criteria and noncriteria pollutant emissions associated with lead oxide and pigment production. This search included, but was not limited to the following references:

1) AP-42 background files maintained by the Emission Factor and Methodologies Section.
2) Files maintained by the Emission Standards Division.
3) "Locating and Estimating" reports (as applicable) published by the Emission Factor and Methodologies Section.
4) PM_{10} "gap filling" documents as listed below (if applicable).
5) "PM_{10} Emission Factor Listing Developed by Technology Transfer (EPA-450/4-89-022).
6) "Gap Filling PM_{10} Emission Factors for Selected Open Area Dust Sources" (EPA-450/88-003).
7) "Generalized Particle Size Distributions for Use in Preparing Size Specific Particulate Emission Inventories" (EPA-450/4-86-013).
8) Background Information Documents for NSPS and NESHAPS.
9) Publications generated by and available through the EPA Control Technology Center (CTC).
10) Reports and project summaries from the EPA Office of Research and Development Standards Division.
11) Information in the *Air Facility Subsystems* (AFS) of the EPA *Aerometric Information Retrieval System* (AIRS).
12) References in the National Technical Information Service (NTIS).
13) Handbook of Emission Factors, Parts I and II, Ministry of Health and Environmental Protection, The Netherlands, 1980/1983.
14) The EPA *Clearinghouse for Inventories and Emission Factors* (CHIEF) and *National Air Toxics Information Clearinghouse* (NATICH).

15) The EPA databases, including but not limited to the *TNMOC/Particulate Matter* (PM) *Speciation Database Management System* (SPECIATE), the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF), and the Emission Measurement Technical Information Center's *Test Methods Storage and Retrieval System* (TSAR).

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.
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 was found and the previous update utilized secondary data, this secondary data was 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 given 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 (i.e., 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 Rating

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 either the inhalable particulate (IP) protocol documents or the EPA reference test methods, although these documents and methods were certainly used as a guide for the methodology actually used.

B Rating

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

C Rating

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

D Rating

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. <u>Source operation</u>. 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. <u>Sampling procedures</u>. 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. <u>Sampling and process data</u>. 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.

4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT

4.1 CRITERIA POLLUTANT EMISSIONS DATA

Volatile organic compounds.

No data on emissions of these pollutants were found for the lead oxide and pigment industry.

Lead.

One new source test, Reference 10, was received for the lead oxide industry. This test contained lead emissions from the Barton Pot process #11 mill, the dust collecting system of the secondary mill, and from the industrial hygiene dust collector system of the Super Sac Packer and the Bag Packer. Lead emission factors for all three sources were documented and the results are presented in Table 4.1-1. Since this is the only source test received from the industry where more than ten facilities are in operation, the data gathered is not sufficient to update the lead emission factor of the Barton Pot and the packaging processes, however they are presented to give the reader an estimate of the current achievable emissions from these sources. The emissions from the Barton Pot process (Reference 10) are found to be much lower than the emissions presented in the previous version (7, 1979) of AP-42 Section 12.16. Also, the previous AP-42 section has no emission factors for the packaging process, therefore PES was unable to perform a comparison for this source.

No new source tests were received for the calcining furnace operation; however, by reviewing the references cited (Reference 6) in the previous AP-42 Section 12.16, it appears that the emission factors for the calcining furnace represents the inlet furnace baghouse and not the outlet. Therefore, PES has correctly identified the outlet furnace baghouse emission factor, and modified the emission factor Table (Table 2.3-1) to represent both the inlet and outlet furnace baghouse emission factors.

Also, no new data was received for the pigment production emissions. PES could not obtain the references cited in the previous AP-42 document (7, 1979) used for this process (References 4, and 5). Therefore, the emission factors for the pigment production are presented unchanged and unverified.

In conclusion, the emission factors presented in Table 2.3-1 were obtained from the previous AP-42 document with a modification for the calcining furnace emission factors (the addition of an outlet furnace baghouse emission factor). References 4, 5, and 6 were used in developing these emission factors. PES could not obtain References 4 or 5. Reference 6 contained nonisokinetic sampling and inconsistent data which led PES to lower the lead oxide production (Barton Pot and calcining furnace) emission factor rating from a B to an E rating.

Comparison of the industry emission factors with similar processes from battery production plants that are covered under federal regulation (NESHAP), and the new source test reviewed for the Barton Pot process, shows clearly that the current emission factors for the lead oxide and pigment industry are much higher than the achievable factors and are not an accurate representation of the current industry.

TABLE 4.1-1 (METRIC UNITS)
LEAD

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1. Reference 10. No. 11 Mill 1/25/89	A	12	1	1036	2.14×10^{-4}	2.07×10^{-4}
			2	1036	4.3×10^{-3}	4.17×10^{-3}
			3	1036	5.67×10^{-3}	5.45×10^{-3}
			Average	1036	3.39×10^{-3}	3.27×10^{-3}
Control device: Baghouse						
1. Reference 10. No. 11 Mill 8/11/89	A	12	1	1381	3.8×10^{-3}	2.75×10^{-3}
			2	1385	1.83×10^{-3}	1.32×10^{-3}
			3	1378	1.42×10^{-3}	1.03×10^{-3}
			Average	1381	2.35×10^{-3}	1.7×10^{-3}
OVERALL AVERAGE:				1209	2.87×10^{-3}	2.49×10^{-3}
Control device: Baghouse						
1. Reference 10. Mill dust collector 1/30/89	A	12	1	1212	6.48×10^{-3}	5.35×10^{-3}
			2	726	3.12×10^{-3}	4.29×10^{-3}
			3	1208	2.4×10^{-3}	1.99×10^{-3}
			Average	1049	4.0×10^{-3}	3.88×10^{-3}
Control device: Baghouse						
1. Reference 10. Mill dust collector 8/8/89	A	12	1	1376	3.65×10^{-3}	2.65×10^{-3}
			2	1478	1.6×10^{-3}	1.08×10^{-3}
			3	1491	2.07×10^{-3}	1.39×10^{-3}
			Average	1448	2.44×10^{-3}	1.71×10^{-3}
OVERALL AVERAGE:				1248	3.22×10^{-3}	2.79×10^{-3}

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

TABLE 4.1-1 (METRIC UNITS)
LEAD
(continued)

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1. Reference 10. Hygiene dust collector 1/28/89	A	12	1	1248	2.43×10^{-3}	1.95×10^{-3}
			2	1249	2.67×10^{-3}	2.13×10^{-3}
			3	1247	1.76×10^{-3}	1.42×10^{-3}
			Average	1248	2.29×10^{-3}	1.83×10^{-3}
Control device: Baghouse						
1. Reference 10. Hygiene dust collector 8/9/89	A	12	1	1583	8.07×10^{-3}	5.1×10^{-3}
			2	1238	2.17×10^{-3}	1.76×10^{-3}
			3	1558	1.88×10^{-3}	1.21×10^{-3}
			Average	1460	4.04×10^{-3}	2.69×10^{-3}
OVERALL AVERAGE:				1354	3.16×10^{-3}	2.26×10^{-3}

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

TABLE 4.1-1 (ENGLISH UNITS)
LEAD

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1. Reference 10. No. 11 Mill 1/25/89	A	12	1	2285	4.71 x 10^{-4}	4.12 x 10^{-4}
			2	2285	9.53 x 10^{-3}	8.34 x 10^{-3}
			3	2285	1.25 x 10^{-2}	1.09 x 10^{-2}
			Average	2285	7.5 x 10^{-3}	6.56 x 10^{-3}
Control device: Baghouse						
1. Reference 10. No. 11 Mill 8/11/89	A	12	1	3044	8.37 x 10^{-3}	5.5 x 10^{-3}
			2	3053	4.03 x 10^{-3}	2.64 x 10^{-3}
			3	3039	3.13 x 10^{-3}	2.06 x 10^{-3}
			Average	3047	5.18 x 10^{-3}	3.4 x 10^{-3}
OVERALL AVERAGE:				2666	6.34 x 10^{-3}	4.9 x 10^{-3}
Control device: Baghouse						
1. Reference 10. Mill dust collector 1/30/89	A	12	1	2673	1.43 x 10^{-2}	1.07 x 10^{-2}
			2	1601	6.87 x 10^{-3}	8.56 x 10^{-3}
			3	2663	5.30 x 10^{-3}	3.98 x 10^{-3}
			Average	2312	8.82 x 10^{-3}	7.75 x 10^{-3}
Control device: Baghouse						
1. Reference 10. Mill dust collector 8/8/89	A	12	1	3034	8.04 x 10^{-3}	5.3 x 10^{-3}
			2	3259	3.52 x 10^{-3}	2.16 x 10^{-3}
			3	3288	4.57 x 10^{-3}	2.78 x 10^{-3}
			Average	3194	5.38 x 10^{-3}	3.41 x 10^{-3}
OVERALL AVERAGE:				2753	7.1 x 10^{-3}	5.58 x 10^{-3}

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

TABLE 4.1-1 (ENGLISH UNITS)
LEAD

(continued)

Source Test #	Test Rating	Test Method	Run #	Production Rate[a]	Emission Rate[b]	Emission Factor[c]
Control device: Baghouse						
1. Reference 10. Hygiene dust collector 1/28/89	A	12	1	2751	5.35 x 10^{-3}	3.89 x 10^{-3}
			2	2754	5.88 x 10^{-3}	4.27 x 10^{-3}
			3	2749	3.89 x 10^{-3}	2.83 x 10^{-3}
			Average	2751	5.04 x 10^{-3}	3.66 x 10^{-3}
Control device: Baghouse						
1. Reference 10. Hygiene dust collector 8/9/89	A	12	1	3490	1.78 x 10^{-2}	1.02 x 10^{-2}
			2	2729	4.79 x 10^{-3}	3.51 x 10^{-3}
			3	3436	4.14 x 10^{-3}	2.41 x 10^{-3}
			Average	3218	8.91 x 10^{-3}	5.36 x 10^{-3}
OVERALL AVERAGE:				2985	6.98 x 10^{-3}	4.51 x 10^{-3}

[a] Units in lb/hr.

[b] Units in lb/hr.

[c] Units in lb/ton.

Sulfur dioxide.

No data on emissions of these pollutants were found for the lead oxide and pigment processes.

Nitrogen oxides.

No data on emissions of these pollutants were found for the lead oxide and pigment production.

Carbon monoxide.

No data on emissions of these pollutants were found for the lead oxide and pigment production.

Total Suspended Particulate.

No new source tests were received to update the particulate emission factors for the lead oxide and pigment production industry. The presented emission factors in Table 2.3-1 were developed from Reference 6 of the previous AP-42 document (7, 1979). The calcining furnace emission factors were modified to represents both the inlet and outlet furnace baghouses. The inlet and outlet emission factors were represented as 7.13 kg/Mg (14.27 lb/ton) and 0.032 kg/Mg (0.064 lb/ton) respectively. These factors were developed in the source test. The source test used in developing these emission factors showed nonisokinetic sampling and large emission variability. As a result, the emission factor ratings were lowered from a B rating to an E rating.

4.2 NONCRITERIA POLLUTANT EMISSIONS DATA

Hazardous Air Pollutants.

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 Chapter 4.1. PES knows of no other HAPs used in the lead oxide production industry.

Global Warming Gases.

Pollutants such as methane, carbon dioxide, and N_2O have been found to contribute to overall global warming. No data on emissions of these pollutants were found for the lead oxide and pigment production process.

Ozone Depletion Gases.

Chlorofluorocarbons have been found to contribute to stratospheric ozone depletion. No data on emissions of these pollutants were found for the lead oxide and pigment production process. Pacific Environmental Services knows of no CFCs used in this industry.

4.3 REVIEW OF SPECIFIC DATA SETS

Only one source test was received from the lead oxide and pigment production industry. This is not sufficient to change the current emission factors for this section, therefore, the emission factors presented were obtained from the references used in the previous AP-42 document (7, 1979). Reference 6 was used to verify the lead oxide production emission factors. Upon reviewing this reference, the calcining furnace emission factors were modified to represent both the inlet and outlet furnace emission sources. Also, the emission factors rating was lowered to an E rating due to high emission variability between each run, and nonisokinetic sampling. No other emission adjustments were made because PES was unable to obtain References 4, and 5 which were used in determining the remaining emission factors. A comparison of the current emission factors with the emissions reported in the new source test (Reference 10), and similar processes of the battery production industry (covered under federal (NESHAP) regulations) indicates that the current emission factors are much higher than the achievable levels. The following is a description of the sources utilized in revising the emission factors presented.

Reference 6, Gould Inc., ST. Paul, MN, 1973

Reference 6 is a source test conducted by Monsanto research Corporation to obtain process data and analyze material samples necessary to develop emission factors for the Gould, Inc. lead oxide manufacturing plant. Field data and detailed calculations were presented in the test. Location of sampling points and the test procedures as well as emission calculations were conducted according to Methods 1 through 5. Lead content was determined by analyzing the particulate samples by Atomic Absorption Spectrophotometry. Furnace efficiency was determined by simultaneously sampling the inlet and outlet of the device. Seven emission point sources were examined, these include the outlet of the Barton Pot control baghouse; the inlet and outlet of the calcining furnace control baghouse; the inlet and outlet of the #2 environmental control baghouse; the outlet of the #1 environmental control baghouse; and the atmospheric furnace vent. The environmental control baghouses, control dust and effluent from the various screw conveyors, elevators, drumming, and dumping operations from station to station. The emission factors calculated from the filterable particulate catches of the Barton pot baghouse and the calcining furnace baghouse (inlet and exit) were 0.281 kg/Mg (0.561 lb/ton), 7.355 kg/Mg (14.17 lb/ton), and 0.029 kg/Mg (0.058 lb/ton), respectively. The total particulate emission factors for the Barton Pot baghouse and the calcining furnace baghouse (inlet and exit) were 0.286 kg/Mg (0.571 lb/ton), 7.135 kg/Mg (14.27 lb/ton), and 0.032 kg/Mg (0.064 lb/ton), respectively. The lead portion of the filterable particulate emission factors were 0.22 kg/Mg (0.44 lb/ton), 6.69 kg/Mg (13.28 lb/ton), and 0.024 kg/Mg (0.047 lb/ton) for the Barton pot, and the calcining furnace inlet and outlet, respectively. The total lead emission factors for these sources are 0.221 kg/Mg (0.442 lb/ton), 7 kg/Mg (14 lb/ton), and 0.024 kg/Mg (0.047 lb/ton), respectively. The source test was complete and detailed; however, it reflected nonisokinetic sampling, and showed high variability between separate runs which led PES to lower the test rating to D, and the emission factor rating to E. The stack gas was at ambient temperature, and the carbon dioxide concentration was assumed to be zero.

Reference 10, ANZON Inc, 1989

This source test is a lead emission evaluation of ANZON Barton process Mill # 11, the mill dust collector, and the hygiene dust collector. The facility is located in Philadelphia, Pennsylvania and the test was conducted by TRC Environmental Consultants. Emissions from both mills corresponded to the Barton process. Two stack tests with three runs each were conducted seven months apart. Only lead samples were tested for and the data was consistent in both tests. Method 12 was used in determining lead emissions, and testing Methods 1 through 5 were discussed in detail, and full documentation of field and calibration data was provided. For the test conducted in January 1989, the average lead emission factors from the filterable catch of the #11 mill, the mill dust collector, and the hygiene dust collector were 0.003 kg/Mg (0.006 lb/ton), 0.0026 kg/Mg

(0.0054 lb/ton), and 0.0017 kg/Mg (0.0034 lb/ton) respectively, and from the total catch were 0.0033 kg/Mg (0.0066 lb/ton), 0.003 kg/Mg (0.006 lb/ton), and 0.0018 kg/Mg (0.0037 lb/ton), respectively. On the other hand, the test conducted on August 1989, resulted in lead filterable emissions of 0.0015 kg/Mg (0.003 lb/ton), 0.0015 kg/Mg (0.0029 lb/ton), and 0.0025 kg/Mg (0.005 lb/ton) and total catch were 0.0017 kg/Mg (0.0034 lb/ton), 0.003 kg/Mg (0.006 lb/ton), and 0.0018 kg/Mg (0.0037 lb/ton) for the same sources, respectively. The carbon dioxide concentration of the stack gas, which was at ambient temperature, was assumed to be zero. The source test was assigned an A rating, and the data is presented in Table 4.1-1. Recall that the data gathered from this source test was not used in updating the emission factors of the AP-42 Section 12.16 because this was the only new source test obtained from an industry of more than 10 plants.

4.4 DATAGAP ANALYSIS

Based on the new source test (Reference 10), and the current emissions of similar processes from battery plants, it is clear that the presented emission data is not an accurate representation of the current industry. More source tests are needed for all the processes in the lead oxide and pigment industry. PES is unaware of any federal regulations for the specialized lead oxide industry which could explain the reasons why limited data is available.

4.5 REFERENCES FOR CHAPTER 4

1. E.J. Ritchie, Lead Oxides, Independent Battery Manufacturers Association, Inc., Largo, FL. 1974.

2. W.E. Davis, Emissions Study of Industrial Sources of Lead Air Pollutants, 1970, EPA Contract No. 68-02-0271, W. E. Davis and Associates, Leawood, KS. April 1973.

3. Background Information in Support of the Development of Performance Standards for the Lead Additive Industry, EPA Contract No. 68-02-2085, PEDCo Environmental Specialists, Inc., Cincinnati, OH. January 1976.

4. Control Techniques for Lead Air Emissions, EPA-450/2-77-012A. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.

5. R.P. Betz, et al., Economics of Lead Removal in Selected Industries, EPA Contract No. 68-02-0299. Battelle Columbus Laboratories, Columbus OH. December 1972.

6. Air Pollution Emission Test, Project No. 74-PB-0-1, Task No. 10. Office of Air Quality Planning and Standards,Contract No. 68-02-0226. U.S. Environmental Protection Agency, Research Triangle Park, NC. August 1973.

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

8. Harvey E. Brown, Lead Oxide. Properties and Applications, International Lead Zinc Research Organization, Inc. 1985.

9. 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.

10. TRC Environmental Consultants, Performance Test Program, Lead Emission Evaluation, ANZON Incorporated, Philadelphia, Pennsylvania, 1989.

TABLE 4.5-1

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:

$$°F = 1.8(°C) + 32$$